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The energy of sheet bending on a crank-type press

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S u m m a r y . The analytical method of power calculation of crank-type press working stroke is developed instead of graph analytical method. This analytical method allows substantially reducing working hours of calculation and promoting exactness of the results. Bending and coining are offered to execute separately. That will allow to make this processes more economically and to reduce depreciate charge.
K e y w o r d s . A crank-type press, a working stroke, a deformation, a sheet bending.

INTRODUCTION

Sheet bending is one of the most widespread operations of the sheet stamping. The technology of sheet bending is given in literature fully enough. At the same time the problems of energy losses on the sheet stamping process itself are not paid attention. So its hard to make the choice of equipment for automation the process.

ANALYSIS OF PUBLICATIONS

The sheet stamping, as well as sheet bending, belongs to most widespread operations of processing of metals forming. Sheet bending processes are quite fully presented in works [Malov 1969; Malov 1969; Forging and stamping 1987; Evstratov, Pivova, 2007].

The most fully sheet bending operations are given by Zubov M.E. in his work. The descriptions of bending and coining processes which allows to decrease springing of material and to improve quality of good. The example of determination the sheet bending efforts of the steel staple is given [Zubov 1980].

It is shown that the sheet bending effort makes 60,15kN, coining effort at the end of slide-block stroke of the press – 816 kN. Coining effort is in 16,3 times more than sheet bending effort. Sheet bending is the most common conjointly with coining on mechanical crank-type presses. The description of function and the construction of which led in monographs and literature on blacksmith-stamping equipment [Zaleskiy 1964; Zaleskiy 1973, Lanskoy, Banketov 1966; Banketov, Bocharov, Dobrinskiy, Lanskoy 1982; Zhivov, Ovchinnikov 1966; Stoyanov, Shenkman 2010; Zhivov, Ovchinnikov 1981; Zhivov, Ovchinnikov, Skladchikov 2006; Ryabicheva,Tsirkin, Usatyuk 2010; Bocharov 2008; Vlasov, Borzykin, Bukin-Batyrev 1982; Ray, Monyatovskiy 2000; Svistunov 2008].

Technical descriptions of crank-type presses are given in reference books on blacksmith's equipment [Rudman, Zinchuk, Marchenko 1989; Forging-press equipment 1982].

In technical literature methods are expounded in the general view for graph analytical calculation of power parameters of working stroke of crank-type presses, they are based on the graph of technological efforts of deformation. Bases of this method are resulted in works of Lanskoy [Lanskoy 1982]. In works [Lanskoy, Banketov 1966; Zhivov, Ovchinnikov 1981; Zhivov, Ovchinnikov 1966] is expound the same graph analytical method with insignificant clarifications. The indicated method is used without changes in works of other authors [Vlasov, Borzykin, Bukin-Batyrev 1982; Belyaev, Bogdanov, Tynyanov 1989; Bocharov 2008; Svistunov 2008].

The method of numeral integration of power parameters calculation of working stroke crank-type presses is given in work [Ray, Monyatovskiy 2000].

PURPOSE OF THE WORK

A purpose of work is the development of analytical method of calculation the energy expenses on the working stroke of crank-type presses that works making workpiece on sheet bending operations.

OBJECTS AND PROBLEMS

The energy expenses on a working stroke of the press is determined from the dependence

$$A = A_g + A_f + A_{fy}, \tag{1}$$

where: A_g – work of plastic deformation, contains two constituents

$$A_g = A_{g1} + A_{g2}, \tag{2}$$

A_{g1} – work on the bending area workpiece

$$A_{g1} = P_1 h_n, \tag{3}$$

h_n – moving the slider on the site of bending workpiece (fig.);

P_1 – permanent effort, it is accepted equal,

$$P_1 = 0{,}2P_n,$$

P_n – nominal effort of the press.

A_{g2} – work of plastic deformation in the coining area

$$A_{g2} = 0{,}5(P_1 + P_n)h_k, \tag{4}$$

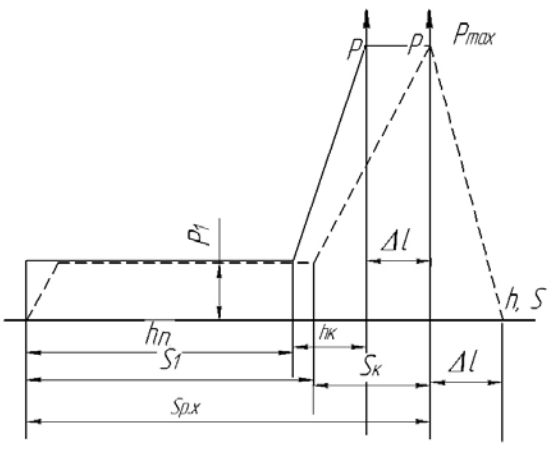

Fig. 1. The effort graph of plastic deformation – 1, the load graph of the press – 2

The start of the working stroke Zhivov L.I. [Zhivov, Ovchinnikov, Skladchikov 2006] offers to determine the rotation angle of the main shaft equal 60 degrees. According to [Yavtushenko 2008; Yavtushenko O.V., Glebenko T.O., 2012] absolute deformation on the coining area is equal to 0,03 Sн (Sн – nominal stroke of the press slide-block) and if one considers the increase of the closed height of the press in consequence of plastic deformation, these it is possible to express from the dependence

$$S_{(\alpha=60^o)} = h_n + 0{,}03S + P_n / C, \tag{5}$$

where: $S_{(\alpha=60^o)}$ – moving of slide-block is proper the corner $\alpha = 60^o$ turning of main billow of the slide-block counted off from extreme lower position;

$0{,}03S$ – absolute plastic deformation on the coining area, accepted aaccording to the recommendations [Yavtushenko, Glebenko 2012];

C – technological stiffness of crank press.

The energy losses on a friction are determined from the dependence

$$A_f = \int_{\alpha_n}^{\alpha_k} P_{(\alpha)} m_f d\alpha. \tag{6}$$

At the first bending area for solutions to (6) made:

$$\begin{cases} \alpha_n = 60^o;\ \alpha_p = \sqrt{\dfrac{2(0{,}03S + P_n / C)}{R(1+\lambda)}}, \\ m_f = \mu[\lambda(r_a + r_o)\cos\alpha + r_b + r_o], \end{cases}$$

where: μ – a coefficient of friction in kinematics pair;

λ – coefficient of multiplicity of bell crank;

α_p – angel of coining;

r_a, r_b, r_o – radiuses of bearings trunnion of articulation of crank-type shaft with connecting rod, crank-type shaft with a slide-block, supporting pin of main shaft.

After a substitution (7) in (6) and integrations we will get following expression for determination of losses on a friction on the bending area

$$A_f = \mu P_1 \begin{bmatrix} \lambda(r_b + r_a)(\sin\alpha_n - \sin\alpha_p) + \\ + (r_a + r_o)(\alpha_n - \alpha_p) \end{bmatrix}. \tag{7}$$

For determination of energy losses on a friction on the bending area are determined by dependences included in equalization (6).

Effort on a slide-block in the function of corner of the turn of main shaft would be

$$P_\alpha = P_{max} - \frac{P_{max} - P_1}{S_p} S_{(\alpha)}, \qquad (8)$$

where: $S_{(\alpha)}$ – moving the slide-block in the function of the rotation angle of crank shaft,

S_p – moving the slide-block on the bending area considering to the plastic deformation of the press

$$S_p = h_k + P_{max} / C; \qquad (10)$$

Resulted shoulder of friction forces, taking into account the small values of corner α_k, in obedience to recommendations of Zhivov L.I. [Zhivov, Ovchinnikov, Skladchikov 2006] is accepted permanent, in formula (6) $\cos\alpha = 1{,}0$.

After a substitution (8) and (9) in (6) taking into account of constancy the resulted shoulder of friction forces and limits of integration, we will find dependence for determination of energy losses on a friction on the bending area

$$A_f = m_f \left\{ \begin{array}{l} P_{max}\alpha_p - \frac{P_{max} - P_1}{S_p} R \cdot \\ \cdot \left[\left(1 + \frac{\lambda}{4}\right)\alpha_p - \sin\alpha_p - \frac{\lambda}{8}\sin 2\alpha_p \right] \end{array} \right\}. \qquad (11)$$

If we express $\sin 2\alpha_p = 2\sin\alpha_p \cos\alpha_p$ and accept $\cos\alpha_p = 1$, equalization (11) for determination of energy losses on a friction on the bending area it is possible to present like

$$A_{f2} = m_f \left\{ \begin{array}{l} P_{max}\alpha_p - \frac{P_{max} - P_i}{S_к} R \cdot \\ \cdot \left[\left(1 + \frac{\lambda}{4}\right)\left(\alpha_p - \sin\alpha_p\right) \right] \end{array} \right\}. \qquad (12)$$

For determination of losses on a friction at the plastic unloading press in equation (12) $P_{max} = P_n$ $S_k = \Delta\ell$; $\alpha_k = \alpha_y$; $P_i = 0$ is accepted and we will get

$$A_{fy} = m_f P_n \left\{ \alpha_y - \frac{R}{\Delta\ell} \left[\left(1 + \frac{\lambda}{4}\right)\left(\alpha_y - \sin\alpha_y\right) \right] \right\}, \qquad (13)$$

In (13) constituents are determined as following:

the size of plastic deformation of the press on the closed height

$$\Delta\ell = P_n / C, \qquad (14)$$

the rotation of an angel of crank shaft is appropriate for plastic deformation of the press

$$\alpha_y = \sqrt{2\Delta\ell / \left(R\left(1 + \lambda\right)\right)}. \qquad (15)$$

For the evaluation of energy losses on a friction at the plastic press unloading is determined by plastic deformation of the press on dependence

$$A_y = P_n^2 / \left(2C\right). \qquad (16)$$

Efficiency of the press on the bending area and efficiency of the working stroke determined on the generally accepted method as attitude of ratio of the plastic deformation (useful work) to expended (expressed as the sum of the energy lost to friction and useful work). The basic parameters and results of the calculation of the energy parameters of the working stroke are given (table. 1, table. 2).

Table 1. The basic parameters of the calculation of the energy parameters of the working stroke

№	1	2	3	4	5	6
P_n, MN	1,6	3,15	6,3	10,0	16,0	25,0
S, mm	160	400	320	400	400	600
$C{\cdot}10^9$ MN/m	0,6	0,9	1,2	1,5	1,9	2,4
λ	0,085	0,095	0,105	0,115	0,120	0,125
r_a, mm	230	335	375	430	470	475
r_b, mm	90	90	125	160	190	190
r_o, mm	90	125	160	180	190	200
m_f, mm	21	29	36	42	44	46

The analysis of the results shows the high economy of bending process compared with the process of coining. This can be explained by the occurrence of precipitation process at high angles of rotation of the main shaft 60 ° ... 25 °, and 25 ° ... 0 ° bending process as kinematical efficiency slider-crank mechanism with decreasing angle of the main shaft. Since the efficiency of the working stroke in the bending area is 0,84 ... 0,91, in the coining area 0,30 ... 0,44. The efficiency of full working stroke include the bending area and coining is at 0,47 ... 0,62, that is, at the level of efficiency of the crank presses stroke working in punching and cutting operations with sheet metal. Significant energy losses observed in the plastic unloading of the press, the energy expended to overcome friction is 53 ... 116% of the plastic work during coining.

Analysis of the load graph of the press shows that the bending should perform on press in several times lower than the nominal force, which would reduce energy costs and depreciate charge.

Table 2. The results of the calculated parameters of the bending process

№	1	2	3	4	5	6
$\Delta\ell_y$, mm	2,7	3,5	5,3	6,7	8,4	10,4
α_y, deg	10,3	10,3	14,0	14,0	15,7	13,9
α_k, deg	0,42	0,38	0,41	0,43	0,43	0,41
A_y, kJ	2,1	5,5	13,2	33,3	67,4	130,2
A_{fy}, kJ	5,11	11,4	38,7	72,4	135,1	195,7
h_1, mm	35,5	91,5	71,0	91,0	89,1	112,7
S_n, mm	43	107	86	109	09	168
S_k, mm	7,5	15,5	15	19	20,5	29,3
h_k, mm	4,8	12	9,6	12	12	18,9
h_n, mm	3,5	91,5	71,5	90,3	88,6	138,7
A_{f1}, kJ	2,1	5,6	10,9	18,0	32,7	58,4
A_{f2}, kJ	10,5	25,9	70,4	131,8	228,4	355,3
A_{g1}, kJ	11,4	57,6	90,1	182	285	694
A_{g2}, kJ	4,6	22,7	36,7	72,0	115,0	284,0
ΣA_g, kJ	16,0	80,3	126,8	254,0	400,0	978,0
ΣA_f, kJ	17,7	42,9	124	223	396	609
η_1	0,84	0,91	0,89	0,91	0,89	0,91
η_2	0,3	0,53	0,34	0,36	0,34	0,44
$\eta_{1,2}$	0,47	0,65	0,51	0,53	0,50	0,62
A_{fy} / A_g	1,1	0,5	1,1	1,0	1,2	0,7
A_{fy} / A_y	2,4	2,1	2,9	2,2	2,0	1,5

It is desirable to perform coining on presses with less speed slider and more technological rigidity, such as embossing. Making bending or coining on universal crank presses substantial economic savings can be achieved by improving the conditions of friction in the joints of the main actuator, friction coefficient from 0,06 to 0,03 will allow to increase 30% in efficiency of the working stroke press.

CONCLUSIONS

1. The proposed method of analytical calculation of energy on the working stroke of the press instead of the graph analytical on the operations of coining can reduce the complexity of calculation and improve the accuracy of its results.

2. Bending operations should be carried out separately from the coining, which allows in a few times to reduce the power of the press. We suggest coining operations to make on presses with less speed slider and more rigid, such as embossing presses.

3. The use of hydrodynamic lubrication conditions will significantly reduce the energy losses on friction and increase the efficiency of the working stroke of the press on 30%.

REFERENCES

1. **Banketov A.N., Bocharov Y.A., Dobrinskiy N.S., Lanskoy E.N., 1982.:** Blacksmith-stamping equipment. Moscow, Machinbuilding, 576p.
2. **Belyaev S.I., Bogdanov E.F., Tynyanov V.N, 1989.:** Determination of the rational productivity of heavy crank-type presses. Blacksmith-stamping production, P.15–19.
3. **Bocharov Y.A., 2008.:** Blacksmith-stamping equipment. Moscow, Press Center «Academy», 480p.
4. **Evstratov V.A., Pivovar V.S., 2007.:** The state and prospects of development of production of the bent types and special equipment. Proceedings of international scientific technical conference of «Machine and plastic deformation of metals». 20–23 November, Zaporozhia, P. 92–93.
5. **Forging and stamping, 1987.:** A reference book is in 4th volumes. T.4. Sheet stamping. Moscow, Machinbuilding, 544p.
6. **Forging-press equipment, 1982.:** Reference book. Science research institute of information of machinbuilding. Moscow, 88p.
7. **Lanskoy E.N., Banketov A.N., 1966.:** Elements of calculation of details and knots of crank-type presses. Moscow, Machinbuilding, 380p.
8. **Malov A.N., 1969.:** Technology of the cold stamping. Moscow, Machinbuilding, 568p.
9. **Ray R.I., Monyatovskiy S.S., 2000.:** Blacksmith-stamping equipment. The press crank-type. Lugansk, The East-Ukrainian National university named after V.Dahl, 216p.
10. **Rudman L.I., Zinchuk A.M., Marchenko V.L., 1989.:** Reference book for the sheet stamping. Kiev, Technic, 231p.
11. **Ryabicheva L.,Tsirkin A., Ysatyuk D. 2010:** Warm deformation of copper porous powder billets. TEKA Commission of Motorization and Power industry, V.XB, p.134-140.
12. **Stoyanov A., Shenkman G. 2010:** Manufacturing technology of complicated shape parts of sintered metal powders. TEKA. Commission of motorization and power industry in agriculture, V. XB, P. 220-226.
13. **Svistunov V.E., 2008.:** Blacksmith-stamping equipment. Crank-type the press. Moscow, Machinbuilding, 698p.
14. **Vlasov V.I., Borzykin A.Y., Bukin-Batyrev I.K., 1982.:** Crank-type forging-press machines. Moscow, Machinbuilding, 576p.
15. **Yavtushenko O.V., 2008.:** Design and calculation crank presses. Textbook. Zaporozhia, ZNTU, 448p.
16. **Yavtushenko O.V., Glebenko T.O., 2012.:** Design and calculation crank presses. Course design. Textbook. Zaporozhia, ZNTU, 448p.
17. **Zaleskiy V.I., 1964.:** Equipment of forging-press workshops. Moscow, 600p.

18. **Zaleskiy V.I., 1973.:** Equipment of forging-press workshops. Moscow, 630p.
19. **Zhivov L.I., Ovchinnikov A.G., 1966.:** Blacksmith-stamping equipment. Presses. Kharkov, University, 456p.
20. **Zhivov L.I., Ovchinnikov A.G., 1981.:** Blacksmith-stamping equipment. Presses. Kiev, 376 p.
21. **Zhivov L.I., Ovchinnikov A.G., Skladchikov E.N., 2006.:** Blacksmith-stamping equipment : textbook for the machine-building institutes. Moscow, MSTI name of A.D. Baumana, 560p.
22. **Zubtsov M.E., 1980.:** Sheet stamping. Leningrad, 432p.

ЭНЕРГЕТИКА ГИБКИ ЛИСТОВОГО МЕТАЛЛА НА КРИВОШИПНОМ ПРЕССЕ

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Аннотация. Разработанный аналитический метод энергетического расчета рабочего хода кривошипного пресса вместо графоаналитического позволяет существенно снизить трудоемкость расчета и повысить точность его результатов. Предложено свободную гибку и правку (чеканку) выполнять раздельно, что позволит экономичность процессов и снизить амортизационные отчисления.

Ключевые слова. Кривошипный пресс, рабочий ход, деформация, гибка листового металла.

Parameter optimization dosator of the seeding of a sugar beet on the coefficient variation of intervals

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Summary. Results of multifactorial experiment by orthogonal planning for four factors: height and diameter of seed tube, rotary speed of seed disk and speed movement of seeder are presented. Experiment results were analyzed according to generally accepted methods. Adequate model was received. Influence of each factor on coefficient of variation intervals between seeds and optimal value of each factor were determined.

Key words. coefficient of variation intervals, sugar beet, influence of factors, optimization.

INTRODUCTION

The coefficient variation of intervals between seeds is one from characteristic of quality sowing. It is controlled by agrotechnical demands. The level of harvest depends on the value of coefficient variation [5-20].

OBJECTS AND PROBLEMS

The coefficient y of variation intervals between seeds in longitudinal direction was calculated on the formula [4]:

$$y_5 = \sigma / v_1 , \qquad (1)$$

where: σ, v_1 – middle square deviation (standart) and first initial moment of intervals correspondingly.

By processing experimental data were divided on the classes [2-4]; the data were processed in this way:

1. x — real value of the interval; 2. Real number of the intervals in given of class; 3. xm; 4. $\sum xm$; 5. $\sum m$; 6. $v_1 = \sum xm / \sum m$; 7. x^2; 8. $x^2 m$; 9. $\sum x^2 m$; 10. $v_2 = \sum x^2 m / \sum m$ (second initial moment); 11. v_1^2; 12. $\mu_2 = D = v_2 - v_1^2$ (dispersion – second central moment); 13. $\sigma = \sqrt{\mu_2} = \sqrt{D}$; 14. $y = v = \sigma / v_1$.

Experiments were produced on the apparatus with vertical disc of the seeder of CCT-type, which was installed on the special framework over a ribbon of the stand of a generally accepted construction.

Four factors were varied: $x_1(h)$, $x_2(D)$ – altitude and diameter of a seed tube; $x_3(v_0)$; $x_4(v_\Lambda)$ – velocities of the twirl of a seed disc and movement the ribbon of the stand. Levels of the factors (tab.1) were varied according to the orthogonal planning of the second order for four factors [1-4].

Table 1. Intervals of a variation of the factors $x_1(h)$, $x_2(D)$, $x_3(v_0)$; $x_4(v_\Lambda)$ for CCT-type seeder dosator

Characteristics	Factors			
	$x_1(h)$, мм	$x_2(D)$, мм	$x_3(v_0)$, м/с	$x_4(v_\Lambda)$, м/с
The basic level, x_i=0	425,0	60,0	0,350	2,000
The interval of variation, I	265,0	28,3	0,177	0,708
The upper level, x_i=1	690,0	88,3	0,527	2,708
The lower level, x_i=-1	160,0	31,7	0,173	1,292
The upper star point, x_i=1,4142	800,0	100,0	0,600	3,000
The lower star point, x_i=-1,4142	50,0	20,0	0,100	1,000

The seeds of sugar beet sort "Verhngachskaya-038" of fraction "4,5…5,5" mm by the disc H 125.04.006 of the seeder CCT-12A. Experimental data were treated accordingly with the generally accepted methods recommended for orthogonal planning: Kohren criterion (characterizing homogeneous of variances), Student criterion (causing the significance of regression coefficients) and Fisher criterion (pointing out on the adequacy of model) were defined. The adequate regression model of the second order with variables in a code designation is a result view:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_4x_4 + b_{12}x_1x_2 + b_{24}x_2x_4 + \\ + b_{34}x_3x_4 + b_{22}x_2^2 + b_{33}x_3^2, \qquad (2)$$

where $b_0 = 1{,}0517$; $b_1 = -0{,}076$; $b_2 = 0{,}0799$; $b_4 = -0{,}135$; $b_{12} = -0{,}0625$; $b_{24} = -0{,}0725$; $b_{34} = 0{,}0781$; $b_{22} = -0{,}086$; $b_{33} = -0{,}0885$.

Influence of each factor separately on the response function was defined at levels of other factors, equal 0 and $\pm 1{,}4142$; the equation (2) takes a view:

when $x_2 = x_3 = x_4 = -1{,}4142$;

$y_{1.1} = 0{,}7919 + 0{,}0124$;

when $x_2 = x_3 = x_4 = 0$;

$y_{1.2} = 1{,}0517 - 0{,}076x_1$;

when $x_2 = x_3 = x_4 = 1{,}4142$;

$y_{1.3} = 0{,}6359 - 0{,}1644x_1$;

when $x_1 = x_3 = x_4 = -1{,}4142$;

$y_{2.1} = 1{,}3294 + 0{,}2708x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = 0$;

$y_{2.2} = 1{,}0517 + 0{,}0799x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = 1{,}4142$;

$y_{2.3} = 0{,}7324 - 0{,}111x_2 - 0{,}086x_2^2$;

when $x_1 = x_3 = x_4 = -1{,}4142$;

$y_{3.1} = 0{,}7952 - 0{,}1105x_3 - 0{,}0885x_3^2$;

when $x_1 = x_2 = x_4 = 0$;

$y_{3.2} = 1{,}1205 - 0{,}0885x_3^2$;

when $x_1 = x_2 = x_4 = 1{,}4142$;

$y_{3.3} = 0{,}493 + 0{,}1105x_3 - 0{,}0885x_3^2$;

when $x_1 = x_3 = x_3 = -1{,}4142$;

$y_{4.1} = 0{,}5722 - 0{,}143x_4$;

when $x_1 = x_2 = x_3 = 0$;

$y_{4.2} = 1{,}0517 - 0{,}135x_4$;

when $x_1 = x_2 = x_3 = 1{,}4142$;

$y_{4.3} = 0{,}5832 - 0{,}127x_4$. (3)

Values of functions $y_{1.1} - y_{4.3}$ according (3) are computed on the points $x_i = 0$; ± 1; $\pm 1{,}4142$; calculation data are presented in tab.2.

Table 2. The sequence calculation of functions $y_{1.1} - y_{4.3}$

x_i	$x_i^2 - 0{,}8$	$0{,}0124x_1$	$y_{1.1} = 0{,}7919 + (3)$	$0{,}076x_1$	$y_{1.2} = 1{,}0517 - (5)$	$0{,}1644x_1$	$y_{1.3} = 0{,}6359 - (7)$	$0{,}2708x_2$
1	2	3	4	5	6	7	8	9
-1,4142	1,2	-0,0175	0,7744	-0,1075	1,1592	-0,2325	0,8684	-0,3830
-1,0	0,2	-0,0124	0,7795	-0,0760	1,1277	-0,1644	0,9003	-0,2708
0	-0,8	0	0,7919	0	1,0517	0	0,6359	0
1,0	0,2	0,0124	0,8043	0,0760	0,9757	0,1644	0,4715	0,2708
1,4142	1,2	0,0175	0,8094	0,1075	0,9442	0,2325	0,4034	0,3830
$0{,}086x_2^2$	$y_{2.1} = 1{,}3294 + (9) - (10)$	$0{,}0799x_2$	$y_{2.2} = 1{,}0577 + (12) - (10)$	$0{,}111x_2$	$y_{2.3} = 0{,}7324 - (14) - (10)$	$0{,}1105x_3$	$0{,}0885x_3^2$	$y_{3.1} = 0{,}7952 - (16) - (17)$
10	11	12	13	14	15	16	17	18
0,1032	0,8432	-0,1130	0,8355	-0,157	0,7862	-0,1563	0,1062	0,8453
0,0172	1,0414	-0,0799	0,9546	-0,111	0,8262	0,1105	0,0177	0,8880
-0,0688	1,3982	0	1,1205	0	0.8012	0	-0,0708	0,8660
0,0172	1,5830	0,0799	1,1144	0,111	0,6042	0,1105	0,0177	0,6670
0,1032	1,6092	0,1130	1,0615	0.157	0,4722	0,1562	0,1062	0,5328

$y_{3.2} = 1{,}1205 - (17)$	$y_{3.3} = 0{,}493 + (16) - (17)$	$0{,}143x_4$	$y_{4.1} = 0{,}5722 - (21)$	$0{,}135x_4$	$y_{4.2} = 1{,}0517 - (23)$	$0{,}127x_4$	$y_{4.3} = 0{,}5832 - (25)$
19	20	21	22	23	24	25	26
1,0143	0,2306	-0,2022	0,7744	-0,1909	1,2426	-0,1796	0,7212
1,1028	0,3648	-0,1430	0,7152	-0,1350	1,1867	0,1270	0,7102
1,1913	0,5638	0	0,5722	0	1,0517	0	0,5832
1,1028	0,5858	0,1430	0,4292	0,1350	0,9167	0,1270	0,4132
1,0143	0,5430	0,2022	0,3700	0,1909	0,8609	0,1796	0,4036

According to the tab.2 is built graphs, presented on the fig.1. From tab.2 and fig.1 is visible, that coefficient variation intervals between the seeds of sugar beet by sowing apparatus seeder CCT-type from factors $x_1(h)$, $x_4(v_\Lambda)$ was depended straight-line, but from factors $x_2(D)$, $x_3(v_0)$ — corvilinely; by that a response is diminishes by increase factors $x_1(h)$, $x_4(v_\Lambda)$ (the lines $y_{1.2}, y_{1.3}$, $y_{4.1} - y_{4.3}$); behind exclusion function $y_{1.1}$, which is increases by growing up the factor $x_1(h)$ ($x_2 = x_3 = x_4 = -1{,}4142$). Coefficient variation increases by growing factor $x_2(D)$ — the lines $y_{2.1}, y_{2.2}$, however by $x_1 = x_3 = x_4 = 1{,}4142$ function y is diminishes with increase the diameter of seed tube (line). The increase of velocity $x_3(v_0)$ of the twirl of a seed disc was stipulated the decrease the response y (by $x_1 = x_2 = x_4 = -1{,}4142$; the line $y_{3.1}$) and increase y (by $x_1 = x_2 = x_4 = 1{,}4142$; the line $y_{3.3}$), but also the presence of a maximum $y_{max} = 1{,}1913$ (by $x_1 = x_2 = x_4 = 0$; the line $y_{3.2}$, the column 19, tab. 2).

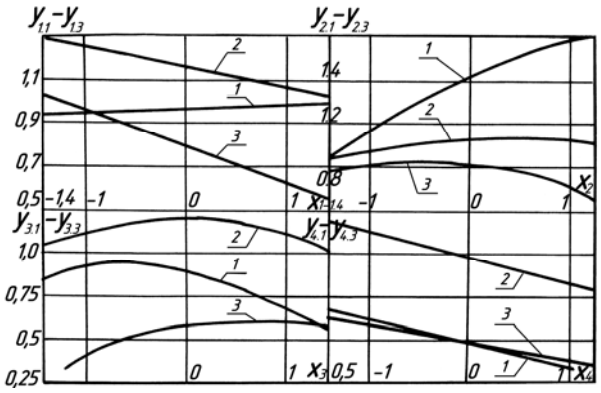

Fig. 1. Graphs of functions $y_{1.1} - y_{4.3}$ (the coefficient variation of intervals)

Optimization of the parameters the dosator with vertical disc on the coefficient variation intervals

The minimum importance function of response on the matrix of scheduling is observed in the experiment №9: $y'_{min} = 0{,}68$; $x_1 = x_2 = x_3 = -1$; $x_4 = 1$. We make the matrix for calculation of y_{min} by means of quantization of independent variables [2-4], tab.3.

The tab. 3 is constructed as follows: in the column 2 independent arguments x_i and their productions on the coefficients of regress are located; in heading — the coefficients of regress and their numerical importance. In line 1 conditions of experience and minimum importance of the function response y'_{min} from the matrix of planning are represented; further in even lines (2, 4) importance of arguments are represented, and in odd – their productions on corresponding coefficients of regress. In the right extreme column (12) the importance of function $\hat{y}$, foretell by the equation of regress, are placed. From it is visible, that minimum of the function response was placed in the line 5 ($\hat{y}$=0,2306); therefore by the coordinates of a special point S factorial space take conditions of line 4 tab. 3:

$$y_S = 0{,}2306;\ x_{1S} = x_{2S} = x_{4S} = 1{,}4142;$$
$$x_{3S} = -1{,}4142. \qquad (4)$$

The two-dimensional sections of the function y, necessary for research of "almost stationary" area, was carried out on the factors x_2, x_3 with using regress (2). Characteristic equation has the view [2-4]:

$$f(B) = \begin{vmatrix} b_{22} - B & 0{,}5b_{23} \\ 0{,}5b_{23} & b_{33} - B \end{vmatrix} = \begin{vmatrix} 0{,}086 - B & 0 \\ 0 & -0{,}0885 - B \end{vmatrix} =$$
$$= 0{,}0076 + 0{,}086B + 0{,}0885B + B^2 =$$
$$= B^2 + 0{,}1745B + 0{,}0076 = 0. \qquad (5)$$

Table 3. Calculation of the response y_{min} minimum

№	b_0 1,0517	b_1 -0,076	b_2 0,0799	b_3 0	b_4 -0,0625	b_{12} -0,0725	b_{24} +0,0781	b_{34} 0,0781	b_{22} -0,086	b_{33} -0,0885	$\hat{y}$
1	2	3	4	5	6	7	8	9	10	11	12
1	x_i	-1	-1	-1	1						0,68
2	x_i	1,4142	-1,4142	-1,4142	1,4142	-2	-2	-2	1,2	1,2	
3	$b_i x_i$	-0,1075	-0,113	0	-0,191	0,135	-0,145	-0,1562	-0,1032	-0,1062	0,5546
4	x_i	1,4142	1,4142	-1,4142	1,4142	2	2	-2	1,2	1,2	
5	$b_i x_i$	-0,1075	0,113	0	-0,191	-0,125	-0,145	-0,1562	-0,1032	-0,1062	0,2306
6	x_i	1,4142	-1,4142	1,4142	1,4142	-2	-2	2	1,4142	1,4142	
7	$b_i x_i$	-0,1075	-0,113	0	-0,191	0,135	0,145	0,1562	-0,1032	-0,1062	0,867

The roots equation (2, 3):

$$B_{23} = -0{,}08725 \pm \sqrt{0{,}0076126 - 0{,}0076} = \\ = -0{,}08725 \pm 0{,}08725; \quad (6)$$

$$B_{22} = 0; \quad B_{33} = -0{,}1745 .$$

The corner of turn coordinate axes:

$$\mathrm{tg}2a = b_{23} / (b_{22} - b_{33}) = 0 / (-0{,}086 + 0{,}0885) = 0. \quad (7)$$

The initial form has the view:

$$Y - Y_S = B_{22}X_2^2 + B_{33}9X_3^2; \; Y - 0{,}2306 = -0{,}1745X_3^2 . \quad (8)$$

From here:

$$X_3 = \sqrt{Y/(-0{,}1745) + 1{,}3215} . \quad (9)$$

The coordinates of the new centre $S(-1{,}4142; -1{,}4142)$; as coefficients $B_{22} = 0$, $B_{33} < 0$ ($B_{33} = -0{,}1745$), that the lines of an equal exit – the straights, but a surface of response is the stationary rise [2-4]. The coordinates of the lines of an equal exit were determined according (9) by an $y = 0{,}1; 0{,}15; 0{,}2$ and 0,2306; the sequence of calculation is presented in tab. 4.

Table 4. The sequence of calculation coordinates lines of equal exit for function Y

Y	$X_3(\pm)$	Y	$X_3(\pm)$	Y	$X_3(\pm)$	Y	$X_3(\pm)$
0,2306	0	0,2	0,42	0,15	0,68	0,1	0,865

In old system of coordinates x_20x_3 (fig. 2) the square with the sides $2 \cdot 1{,}4142$ is construction and new centre $S(-1{,}4142; -1{,}4142)$ is mark with axes X_2, X_3, which are parallel the axes $0x_2$, $0x_3$ (corner $\alpha = 0$ on the (7)). From fig. 2 is evidently, that a response diminishes by the movement along of axe X_3.

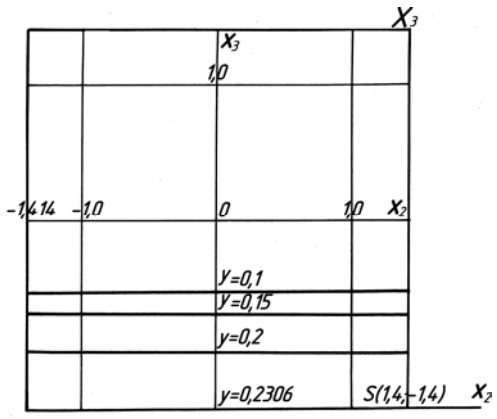

Fig. 2. Two-dimensional sections of "almost stationary" area of function Y (coefficient variation of intervals) by factors x_2, x_3 when $x_1 = x_4 = 1{,}4142$ (lines of an equal exit (straight) are shown)

CONCLUSIONS

1. The coefficient Y of variation an intervals between seeds in longitudinal direction was calculated on the formula:

$$Y_5 = \sigma / v_1, \quad (1)$$

where: σ, v_1 — middle square deviation (standart) and first initial moment of intervals correspondingly.

An experiments were produced on the apparatus with vertical disc of the seeder of CCT-type, which was installed on the special framework over a ribbon of the stand of a generally accepted construction.

Four factors were varied: $x_1(h)$, $x_2(D)$ — altitude and diameter of a seed tube; $x_3(v_0)$; $x_4(v_\Lambda)$ — velocities of the twirl of a seed disc and movement the ribbon of the stand. Levels of the factors (tab.1) were varied according to the orthogonal planning of the second order for four factors.

2. After implementation of the experiments on the matrix of orthogonal planning of the second order for four factors and processing of data experiments according with the methods of orthogonal planning the adequate regression model of the second order with variables in a code designation was received:

$$Y = b_0 + b_1x_1 + b_2x_2 + b_4x_4 + b_{12}x_1x_2 + b_{24}x_2x_4 + \\ + b_{34}x_3x_4 + b_{22}x_2^2 + b_{33}x_3^2, \quad (2)$$

where: $b_0 = 1{,}0517$; $b_1 = -0{,}076$; $b_2 = 0{,}0799$; $b_4 = -0{,}135$; $b_{12} = -0{,}0625$; $b_{24} = -0{,}0725$; $b_{34} = 0{,}0781$; $b_{22} = -0{,}086$; $b_{33} = -0{,}0885$.

3. Influence of each factor on the coefficient of variation an intervals between seeds in longitudinal direction was defined by an levels of other factors, equal $\pm 1{,}4142$ and 0; it was presented in the equations (3), tab. 2 and fig. 1. From them it is visible, that the response was depended from the factors $x_1(h)$, $x_4(v_\Lambda)$ straightlinely, but from factors $x_2(D)$, $x_3(v_0)$ — corvilinely; by that a response is diminishes by increase factors $x_1(h)$, $x_4(v_\Lambda)$ — the lines $y_{1.2}, y_{1.3}$, $y_{4.1} - y_{4.3}$; behind exclusion function $y_{1.1}$, which is increases by growing up the factor $x_1(h)$ ($x_2 = x_3 = x_4 = -1{,}4142$). Coefficient variation increases by growing factor $x_2(D)$ — the lines $y_{2.1}, y_{2.2}$; however by $x_1 = x_3 = x_4 = 1{,}4142$ function Y is diminishes with increase the diameter of seed

tube (line $y_{2.3}$). The increase of factor $x_3(v_0)$ was stipulated the decrease the response y (by $x_1 = x_2 = x_4 = -1{,}4142$; the line $y_{3.1}$) and increase y (by $x_1 = x_2 = x_4 = 1{,}4142$; the line $y_{3.3}$), but also the presence of a maximum $y_{max} = 1{,}1913$ (by $x_1 = x_2 = x_4 = 0$; the line $y_{3.2}$, the column 19, tab. 2).

4. The coordinates of special point factorial space were determined by quantization of the independent variables (tab.3); from it is visible, that minimum of the function response was placed in the line 5 ($\hat{y}$=0,2306); therefore by the coordinates of the special point S factorial space is take conditions of line 4 tab. 3:

$$y_S = 0{,}2306;\ x_{1S} = x_{2S} = x_{4S} = 1{,}4142;$$
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The two-dimensional sections of the function y was carried out on the factors x_2, x_3 with using of model (2).

The coordinates of the new centre $S(-1{,}4142;-1{,}4142)$; as coefficients $B_{22} = 0$, $B_{33} < 0$ ($B_{33} = -0{,}1745$), that the lines of an equal exit – the straights, but a surface of response is the stationary rise. The coordinates of lines equal exit (tab. 4) were defined from initial form (9), it was presented on the fig. 2; from it is evidently, that a response diminishes by the movement along axe X_3.

REFERENCES

1. **Basin V. and other. 1987.:** Machines for exact seeding of tilled crops: designing and calculation. – K: Technic. 151.
2. **Melnicov S. and other. 1979.:** Experiment planning in researches of agricultural processes. – M: Kolos, 200.
3. **Nalimov V., Chernova N. 1965.:** Statistical methods of planning of extreme experiments. – M: Nauka. 340.
4. **Ventcel E., Ovcharov L. 1973.:** Theory of probablies. — M.: Nauka. 336.
5. **Belodedov V., Nosko P., Fil P., Stavicky V. 2007.:** Parameter optimization using coefficient of variation of intervals for one-seed sowing apparatus with horizontal disc during maize seeding. – Lublin, "Teka". vol.7, p. 31-37.
6. **Belodedov V., Velichko N., Fil P., Breshev V., Mazneva M., 2008.:** "Simulation of influence of seeding conditions on closed to calculated quantity". – Lublin, "Teka", V. 10A, p. 11-17.
7. **Belodedov V., Nosko P., Fil P., Mazneva M., Boyko G. 2010.:** Selection of batchen with horizontal dick parameters while maize sowing. – Lublin, "Teka", V. XA, p. 33-40.
8. **Belodedov V., Nosko P., Fil P. 2010.:** Selection of optimal parameters dosator with horizontal dick jn the general criterion. – Lublin, "Teka", V. XC, p. 19-27.
9. **Zuryanov V.A. 1986.:** Sovershenstvovanie vusevayvchih apparatov (sveklovichnuh seyalok)/. Saharnaya svekla. № 3, s. 7-10.
10. **Zuryanov V.A. 1986.:** Universalnie vusevayushuh diski / Tehnika v selskom hozyaistve, № 3, s. 58-59.
11. **Komaristov V.E. 1961.:** O technom vuseve semyan kukuruzu, MESSX, № 2, s. 16-19.
12. **Basin V. S. 1973.:** Optimization ishodnuh parametrov vuseva semyn sveklu. – MESSX, № 4, s. 17-20.
13. **Budagov A. 1971.:** Tochnuy posev na vusokih skorostyah. – Krasnodarskoe kn. izd-vo, – 139 s.
14. **Budagov A. Petunin A.** Soshnik dlya tornoge razmesheniya semyan propasgnuh kultur, - MƏSSX, 1965, № 6, s. 4-6.
15. **Budagov A. 1969.:** Posev propashnuh kultur na vusokih skorostyah dvisheniya. Avtorepherat dis…doktora S. –h. nauk. – Odessa, 62 s.
16. **Buzenkov G. Ma S. 1976.:** Machinu dey posseva s.-h. kultur. – M: "Mashunostroenie", 279 s.
17. **Buzenkov G. I dr. 1976.:** Dinamika vozniknoveniya prosevov. – Traktoru I selhozmashunu, № 6, s. 16-18.
18. **Buzenkov G. I dr. 1979.:** Avtomatizachiya pasevnih agregatov – M:Rosselhozizdat, 88 s.
19. **Golozubov A. 1975.:** Issledovanie prochessa tochnogo vuseva semyen saharnou sveklu. – Dis…kand. tehn. nauk. – Harkov. 148 s.
20. **Zelenskiy U. 1987.:** Ispolzovanie punktirnuh seyalok dlya poseva ovoshnuh kultur. – Tehnika v s.-h., № 6, s. 13-14.

ПАРАМЕТРИЧЕСКАЯ ОПТИМИЗАЦИЯ ВЫСЕВА САХАРНОЙ СВЕКЛЫ ПО КОЭФФИЦИЕНТУ ВАРИАЦИИ ИНТЕРВАЛОВ

Виктор Белодедов, Павел Носко, Григорий Бойко, Павел Филь, Марина Мазнева

Аннотация. Представлены результаты многофакторного эксперимента, поставленного по матрице ортогонального планирования для четырех факторов: высоты и диаметра семяпровода, а также скорости вращения высевающего диска и движения ленты стенда. Результаты экспериментов обработаны в соответствии с методикой, характерной для ортогонального планирования, получена адекватная математическая модель процесса, по которой установлено влияние факторов и оптимальные условия высева.

Ключевые слова. Коэффициент вариации интервалов, влияние факторов, оптимизация.

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Calculation of magnetic systems of speed and gear teeth integrity sensors

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S u m m a r y. Magnetic system of speed and integrity of teeth sensors, which is a U-shaped magnetic core and magnetic circuit of circular section is optimized. A mathematical model of the dependence of the magnetic flux in the core induced by magnetized gear is presented. The results of numerical experiment are given. The conclusions and recommendations for optimizing the parameters of the SS magnetic systems are made

K e y w o r d s. Magnetic system, optimization, gear, mathematical model.

INTRODUCTION

Actuality of the study. Speed sensor (SS) are the most common elements of control systems.

Magnetic transducers of SS due to high sensitivity, the mechanical strength, the ability to operate in a contaminated environment, temperature stability have advantages over SS using another principle.

Improving the efficiency of magnetic SS is possible on the basis of theoretical studies of the magnetic system. The optimal parameters of the magnetic systems of SS are connected to the module gear, the frequency of which is controlled [1].

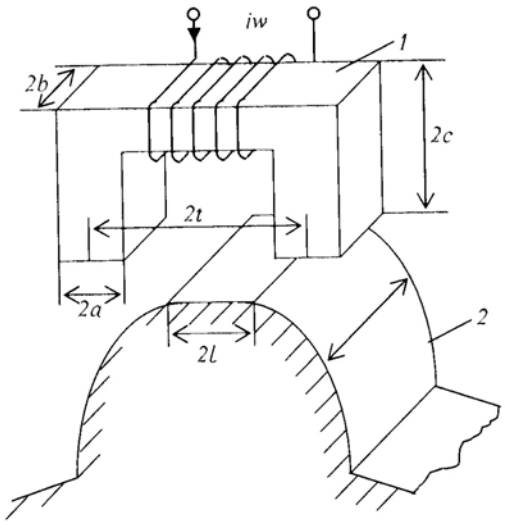
The basis of theoretical and mathematical model of optimization is the research of the magnetic field in the work area of SS. Responding to the irregular geometrical shape of the magnetic system of SS, which includes gear, there must be some idealization of form of ferromagnetic parts, which will provide analytical dependences for the basic value of the magnetic flux in the magnetic core of SS.

Feature of the magnetic system is that it consists of a magnetic transducer, the parameters of which are manageable and gear with given geometrical parameters

The purpose of article is to describe the method of calculation of the theoretical and parametric optimization of SS with U-shaped and cylindrical magnetic system

MATERIALS AND RESEARCH RESULTS

Magnetic system of SS, which is U-shaped magnetic core, that contains winding or magnetically sensitive element - Hall probe or flux gate is considered (fig. 1).



1 – magnetic core, 2 – gear tooth

Fig. 1. The magnetic system of SS

Effectiveness of SS with U-shaped and cylindrical magnetic system means the ratio

$$\varepsilon = \frac{\Phi_{max} - \Phi_{min}}{\Phi_{max} + \Phi_{min}}, \quad (1)$$

where: Φ_{max}, Φ_{min} is maximum and minimum values of the magnetic flux in the ferromagnetic core at its certain position relative to the tooth.

The criterion of optimization of the magnetic system is to obtain the maximum value $K_{эф} = K_{эф\,max}$.

To determine the main regularities of development of the information magnetic flux in the magnetic core of the sensor, the following idealized geometric model of the magnetic system is proposed (fig. 2).

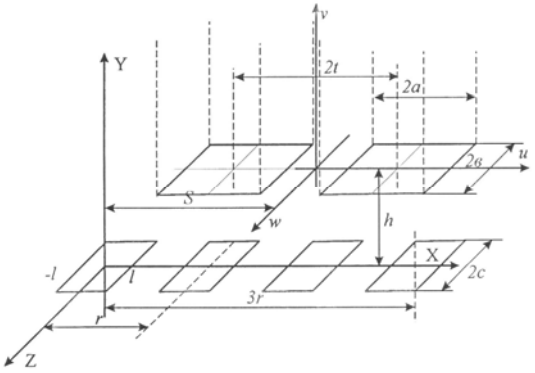


Fig. 2. The geometric model of the magnetic system of U-shaped sensor.

The basis of the calculation of the magnetic flux in the magnetic core is the K.M.Polivanov`s theorem of reciprocity, which is converted to the following form

$$\Phi = \frac{\mu_0}{iw} \int_{S_\Phi} \varphi_M \bar{M}_n dS_\Phi, \quad (2)$$

where: iw – ampere-turns of coil located at the core;

$\bar{M}_n$ – normal component of the magnetization on the surface of a ferromagnetic body;

S_Φ – surface area of a ferromagnetic body;

φ_M – scalar magnetic potential generated by core with winding placed on it with the number of turns w.

It is proposed to calculate the value φ_M by the formula

$$\varphi_M = \frac{1}{4\pi} \int_{S_n} \frac{\sigma}{r_{PQ}} dS_\Phi, \quad (3)$$

where: σ – density of a simple layer of fictitious magnetic charges at the poles of U-shaped core;

r_{PQ} – vector drawn from the source point P to the observation point Q.

In the first approximation we can assume that the normal component of the magnetization M_n is constant throughout the site with an area of the tooth *4ls*. This magnetization is close to the real, if gear magnetized with permanent magnet. We can assume that

$$M_n = (\mu - 1) H_{0n}, \quad (4)$$

where: H_{0n} – normal component of the magnetization field intensity;

μ – relative magnetic permeability of the ferromagnetic material.

Then (2) can be rewritten as

$$\Phi = \frac{\mu_0 (\mu - 1)}{iw} \int_{S_\Phi} \varphi_M H_{0n} dS, \quad (5)$$

where: H_{0n} – normal component of the magnetization field intensity on the surface of a ferromagnetic body.

It is assumed that the coil creates a current at the poles of the measuring transducer core constant density of magnetic charges: at one pole σ, on other $-\sigma$.

The potential created by a magnetic core with winding placed on it with the current, creates MDS - iw, is equal

$$\varphi_M = \varphi_{1M} + \varphi_{2M} = \frac{1}{4\pi} \int_{S_\Pi} \frac{\sigma dS}{R_1} - \frac{1}{4\pi} \int_{S_\Pi} \frac{\sigma dS}{R_2}, \quad (6)$$

where:

$R_1 = \sqrt{(x - t - u)^2 + h^2 + w^2}$; $R_2 = \sqrt{(x + t - u)^2 + h^2 + w^2}$;

values of t, u, w, x are clear from fig. 2.

Value $\sigma = \frac{iw}{2h}$, assuming that the magnetic voltage drop occurs in air gap of measurement transducer.

With (5) and (6)

$$\Phi = \frac{(\mu - 1) H_{0n} b \mu_0}{4\pi h} \sum_{i=-2}^{2} \int_{-c}^{c} \int_{l-ir}^{l+ir} \left(\int_{-b}^{b} ln \frac{x - t - a + S + \sqrt{(x - t - a + S)^2 + h^2 + (z - w)^2}}{x - t + a + S + \sqrt{(x - t + a + S)^2 + h^2 + (z - w)^2}} dw - \right.$$
$$\left. - \int_{-b}^{b} ln \frac{x + t - a + S +}{x + t + a + S +} \right. \quad (7)$$

$$\left.\frac{+\sqrt{(x+t-a+S)^2+h^2+(z-w)^2}}{+\sqrt{(x-t+a+S)^2+h^2+(z-w)^2}}dw\right)dxdz.$$

The aim of numerical calculations is to determine the dependence of the magnetic flux Φ on the parameters of the magnetic system of the measurement transducer. The values entering the formula (7), normalized by modulus of gear

$$a^*=\frac{a}{m},\ b^*=\frac{b}{m},\ c^*=\frac{c}{m},\ r^*=\frac{r}{m},\ t^*=\frac{t}{m},$$
$$S^*=\frac{S}{m},\ h^*=\frac{h}{m},\ M^*=\frac{M}{m}.$$

The minimum value of h is chosen so that the air gap between the plane of the poles of the magnetic system and the surface was not less than the value of the beats $h_{min}=\Delta h$.

In the numerical experiment, parameters a, t, h are changed (the asterisks are omitted). The value of S is chosen from the two values, one value corresponds to the maximum flow in the magnetic measuring transducer S_{max}, second - S_{min}. The magnetic flux in the magnetic system is directly proportional to the values of b and c, so that these values being calculated are not changed. The gap between the side walls of a U-shaped magnetic core is referred to as *g=2(t-a)*. The value of *r* is fixed. Tables 1 and 2 show the data of numerical experiment on the calculation efficiency ratio of the magnetic system of SS with rectangular section of magnetic circuit.

Table 1. The values of the efficiency coefficient of the SS magnetic system ε with h=0,1; m=8

Variants / Parameters	1		3	4	5
2*a*	1,6	1,6	1,6	1,6	1,6
2*t*	2	2,4	2,8	3,2	3,6
g	0,4	0,8	1,2	1,6	2,0
ε, short-cut calculation	0,4	0,52	0,68	0,56	0,41

The value of the length of a gear area is chosen equal *2l = 1*, the air gap between areas is also *2l*.

Numerical results shown in tables 1 and 2 show that there is a distinct maximum effectiveness ratio of the magnetic system of SS with the air gap between the poles of an approximately equal *2b*. When changing the air gap between the poles of the next higher efficiency ratio will fall more slowly than when changing gap size g down. By increasing the air gap h SS efficiency ratio decreases, but the values of the optimal parameters *2a, 2t, g* remain unchanged.

Table 2. The values of the efficiency coefficient of the SS magnetic system ε with h=0,2; m=8

Variants / Parameters	1	2	3	4	5
2*a*	1,6	1,6	1,6	1,6	1,6
2*t*	2	2,4	2,8	3,2	3,6
g	0,4	0,8	1,2	1,6	2,0
ε, short-cut calculation	0,16	0,22	0,34	0,29	0,26

In optimizing control parameters are 2a, 2t. Their values should ensure the maximum efficiency ratio, or the minimum value of the function G=1-ε. Minimization of function G is carried out by coordinatewise descent.

In the present case besides the parameters *2a* and *2t* the parameters S_{max} and S_{min} are taken into account for which the value of the flux in the core has a maximum and minimum values. In optimizing initially these parameters are searched from the values of the magnetic flux, and then the optimal values of *2a* and *2t* are searched. After determining the optimal values of *2a* and *2t* may be that the values S_{max} and S_{min} have changed. Then for the optimal parameters *2a* and *2t* once again S_{max} and S_{min} are defined and the process of coordinatewise descent is repeated again to find new optimal values of *2a* and *2t*.

The results of optimization of parameters of the SS magnetic system illustrated by the data given in table 3.

Table 3. Optimization of the parameters of the magnetic system

Parameters / Step number	S_{max}	S_{min}	*2a*	*2t*	ε
Initial settings	0	0,92	1,4	3,6	0,54
The value of the parameters k = 1	0,02	1,04	1,58	2,9	0,61
The value of the parameters k = 2	0,01	1,02	1,62	2,85	0,66
The value of the parameters k = 3	0,015	1,02	1,65	2,83	0,69

Calculations are made with *h=0,2*. From the data in Table 3 it is clear that after each refinement of values S_{max} and S_{min} an increase effectiveness ratio ε occurs, until it reaches its maximum value.

We consider a cylindrical magnetic system of SS containing magnetically sensitive element - the Hall probe (fig. 3).

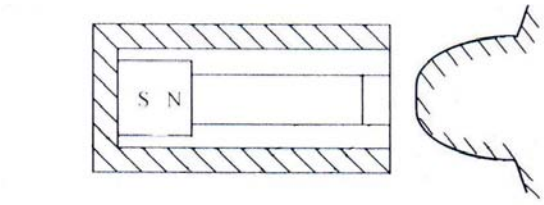


Fig. 3. SS simplified design with a cylindrical magnetic system.

Effectiveness of this type of speed sensor, means the ratio of (1), the same as for SS with U-shaped magnetic system

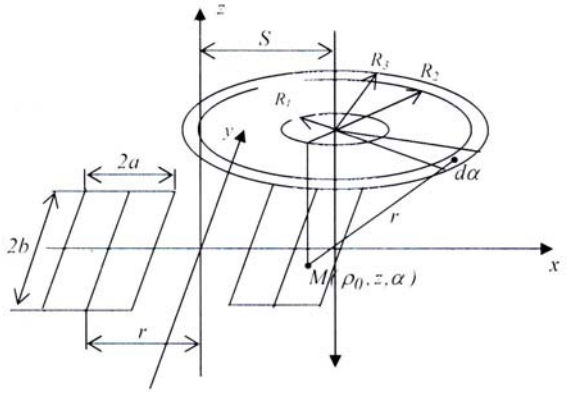


Fig.4. The geometric model of a magnetic system with a cylindrical core.

Let the inner core of the magnetic system has the magnetization M_{n0}, and the outer cylinder $-M_{n0}$, created by winding with a current iw, located on the inner core and the values of these values will be determined further. The potential created by terminal and internal disks can be calculated by the following formula:

$$\varphi = \frac{M_{n0}}{4\pi}\int_0^{2\pi}\int_0^{R_1}\frac{\rho d\alpha d\rho}{\sqrt{z^2+\rho_0^2+\rho^2+2\rho\rho_0\cos\alpha}} - \frac{M_{n0}}{4\pi}\int_0^{2\pi}\int_{R_2}^{R_3}\frac{\rho d\alpha d\rho}{\sqrt{z^2+\rho_0^2+\rho^2+2\rho\rho_0\cos\alpha}}. \quad (8)$$

The magnetic flux in the core of the magnetic circuit is calculated using the K.M.Polivanov`s reciprocity theorem, which is shown in equation (2).

It can be assumed that the normal component of the magnetization M_n is constant throughout area of the tooth. Using (5) and (8) we can write

$$\Phi = \frac{\mu_0(\mu-1)}{iw}\int_{-a}^{a}\int_{-b}^{b}H_n \cdot \left[\int_0^{2\pi}\int_0^{R_1}\frac{\rho d\alpha d\rho}{\sqrt{h^2+(x-S)^2+y^2+2\rho\sqrt{x^2+y^2\cos\alpha}}} - \int_0^{2\pi}\int_{R_2}^{R_3}\frac{\rho d\alpha d\rho}{\sqrt{h^2+(x-S)^2+y^2+2\rho\sqrt{x^2+y^2\cos\alpha}}}\right]. \quad (9)$$

Equation (9) is used in numerical experiments to determine the dependence of the efficiency coefficient of the magnetic system on the parameters R_1, R_2, R_3. The values entering the formula (9), normalized by value of the gear module

$$R_1^* = \frac{R_1}{m},\ R_2^* = \frac{R_2}{m},\ R_3^* = \frac{R_3}{m},\ S^* = \frac{S}{m},\ h^* = \frac{h}{m}.$$

Further asterisks of the letters that represent referred values, not put

In calculation the parameters $h,\ R_1,\ R_2,\ \Delta R = R_3 - R_2$. are changed. Value of the magnetic flux in the core of measuring transducer is determined at two points relative to movement of the magnetic system of SS and gear teeth: at point, where $\Phi = \Phi_{max}$ and at point, where $\Phi = \Phi_{min}$. The value of r is fixed. Platform length $2a = l$, the value of the air gap $h = 0,2$.

In tables 1, 2, 3, data of numerical experiment on the calculation of efficiency ratio of the SS magnetic system with a round section of magnetic circuit are given.

In optimizing controlled parameters are $R_1, \Delta R, R_3$; their optimal values should ensure the maximum efficiency ratio ε or the minimum value of the function $G=1-\varepsilon$. Minimization of function G is carried out by coordinatewise descent. Besides the parameters $R_1, \Delta R, R_3$, the parameters S_{max} and S_{min} are taken into account in which the flow value reaches its maximum and minimum values.

Table 4. The dependence of the efficiency of the value of R_3

Parameters \ Variants	1	2	3	4	5
R_3	1,2	1,3	1,4	1,5	1,6
R_1	0,74	0,74	0,74	0,74	0,74
ΔR	0,2	0,2	0,2	0,2	0,2
ε	0,38	0,4	0,38	0,36	0,28

Table 5. The dependence of the efficiency of the value of R_1

Parameters \ Variants	1	2	3	4	5
R_1	0,4	0,45	0,5	0,55	0,6
R_2	1,3	1,3	1,3	1,3	1,3
ΔR	0,2	0,2	0,2	0,2	0,2
ε	0,3	0,36	0,42	0,44	0,38

Optimization of SS with cylindrical magnetic system is the same as an optimization of SS with U-shaped magnet system.

Results of optimization of parameters of SS with cylindrical magnetic system are shown in table 6. The data in Table 6 indicate that all values converge to certain values that are optimal

Table 6. Optimization of the parameters of the magnetic system

Parameters / Step number	S_{max}	S_{min}	R_1	ΔR	R_3	ε
Initial settings	0	0,95	0,38	0,25	1,36	0,36
The value of the parameters $k = 1$	0,04	1,02	0,45	0,27	1,38	0,39
The value of the parameters $k = 2$	0,02	1,01	0,48	0,28	1,41	0,41
The value of the parameters $k = 3$	0,03	1,01	0,51	0,28	1,42	0,42
The value of the parameters $k = 4$	0,025	1,01	0,51	0,28	1,42	0,42

CONCLUSIONS

1. In optimizing parameters of SS with U-shaped and cylindrical magnetic system maximum and minimum points of the magnetic flux can shift, which requires an adjustment of their position followed by repeat of the optimization procedure

2. Optimal parameters of the magnetic system of SS with U-shaped magnetic core of rectangular sections are length of poles $2a = 1,62$ *m* and the distance between the poles of the core $2t = 2,85$ *m*.

3. Optimal parameters of the magnetic system of SS with a cylindrical magnetic core are round inner core radius is $R_1=0,51m$, thickness of the outer cylinder $\Delta R=0,28m$, the value of the radius of magnetic system $R_3=1,42m$.

REFERENCES

1. **Afanasiev Yu.V., 1989.:** Ferroprobes, Moscow, Energy, - 156 p.
2. **Afanasiev Yu.V., 1986.:** Fluxgate devices, Leningrad, Energoatomizdat, - 186 p.
3. **Boukreev V.V., 2004.:** By choosing the size of the measurement sensors ferromodulyatsionnyh inhomogeneous magnetic fields. Proceedings of Donetsk National Technical University. Series: "Electrical and Power Issue 79, Donetsk SHEE" DNTU "
4. **Buhl V.K. Ionak V.F. Dubenets A.L., 1972.:** Circular toothed magnetoelectric sensors // Instruments and Control Systems, - № 2. - p. 33-34.
5. **Chaban V.I. Semenov S.T., 1981.:** Refined mathematical model of the induction sensor angular speed, Theoretical Electrical Engineering: Collection, Lviv. No. 30, - S. 79-82.
6. **Domashevsky B.N., Kolikhanov V.K., Simonov N.B., 1983.:** Fluxgate flaw MFD-4K, Defectoscopy, - № 6, - p.43-47.
7. **Kolchin A.B., 1984.:** Sensor for diagnostics of machines, Moscow, Mechanical Engineering, -116p.
8. **Kolikhanov V.K., Gritsenko A.C., Domashevsky B.M., 1984.:** Installation for fluxgate of weld joints, Defectoscopy, - № 2. - P.31-35
9. **Kolikhanov V.K., Gritsenko A.C., Simonov N.B., 1986.:** On Improving of equipment for fluxgate-tight control panel, Defectoscopy, - № 7 - S. 90-91.
10. **Konyukhov N.E., 1987.:** Electromagnetic sensors of mechanical quantities, Moscow, Engineering. -255p.
11. **Kurbatov PA, Arinchin S.A., 1984.:** The numerical calculation of electromagnetic fields, Moscow, Energoatomizdat, -167 p.
12. **Lisitskaya L.N., Shumkov J.M., 1984.:** Transient electromagnetic field in the exciting coil - a plate under pulsed excitation, Theoretical Electrical Engineering, - № 37. - S. 125-134.
13. **Mikhlin S.G., Smolitskii H.L., 1965.:** Approximate methods for calculating differential and integral equations – Moscow, Science, - p. 55-69.
14. **Miroshnikov Vadim, Tatyana Pobeda, Sergey Kostin, 2010.:** Calculation of quantity characteristics of the field created by local magnetizing devises. TEKA Commission of Motorization and Power Industry in Agriculture, XC, p. 190-197.
15. **Miroshnikov Vadim, Oleivi Anver, 2010.:** Theoretical analysis of a circle current converter operation under control of hollow cylinders. TEKA Commission of Motorization and Power Industry in Agriculture, XB, p. 33-42.
16. **Nikitenko A.G., Grinchenko V.P., Bakhvalov Yu.A.** Calculation of magnetic fields and integral characteristics of electromagnets with unclosed magnetic circuit. - Electromechanics, № 10, 1977, p. 1067-1072.
17. **Romanenko A.B., 2003.:** Analysis and synthesis of magnetic systems, linear encoders Dissertation for the degree. Candidate. tech. of Sciences, Kiev, - 219 p.
18. **Yakovenko V.V., 1989.:** Magnetic sensors control systems based on ferromodulyatsionnyh elements: Abstract. Dis. Doctor. tech. Science. - Kharkov, – 34p.

19. **Yakovenko V.V., 1989.:** Magnetic sensors of mechanical quantities, Sensors and techniques to improve their accuracy: Study Guide - Kiev, Graduate School, - S. 57-109.
20. **Yoshino I., Ao K., Kato M., Mizutani S., 1987.:** MRE rotation sensor: high-accuracy, high-sensitivity magnetic sensor for automatic use "SAE Iechn. Pap. Jer." - №870470. - P.67-73.
21. **Zagidullin R.V., 2007.:** Calculation of the residual magnetization of the deformed steel plate, Ufa, Bashkir University Bulletin, – 14 p.

К РАСЧЕТУ МАГНИТНЫХ СИСТЕМ ДАТЧИКОВ ЧАСТОТЫ ВРАЩЕНИЯ И ЦЕЛОСТНОСТИ ЗУБЬЕВ ШЕСТЕРНИ.

Владимир Безкоровайный, Сейбу Бурейма, Дмитрий Сергиенко

Аннотация. Оптимизируется магнитная система датчиков частоты вращения и целостности зубьев, представляющая собой П-образный магнитопровод и магнитопровод круглого сечения. Представлена математическая модель зависимости магнитного потока в сердечнике, индуцированного намагниченным зубчатым колесом. Приведены результаты численного эксперимента. Сделаны выводы и даны рекомендации по оптимизации параметров магнитных систем ДЧВ.

Ключевые слова. Магнитная система, оптимизация, шестерня, математическая модель

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Experimental research of hydrotransporting concentrated residues at solid fuel burning

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Summary. The article presents data of experimental studies that determine the pressure losses and the effective coefficients of linear losses on friction and local resistance at transportation of ash concentrated wastes that show abilities of non-Newtonian fluid in the steady state of constant pipeline diameter, which has a straight portion and turns on 90^0 and 180^0.

Key words: non-Newtonian fluid, ash concentrated wastes, transportation, coefficients.

INTRODUCTION

Implementing energysaving technologies and improving energy efficiency of used systems and complexes is actual task in the world of economic uncertainty and rising cost of main energy sources.

About 30% of all electric energy is produced by power station in Ukraine, where disposal of solid residues is organized by hydraulic ash removal systems (HARS). One of the major shortcomings of such systems is low efficiency hydraulic transport due to big amount of liquid per unit of transported material (up to 50-80 m^3 of water per one ton of solid material). Expenses on restraining hydraulic ash removal are about 7,8 – 11,2 million per year and even more, depending power station intensity[Putilov 15].

One of the main directions of HARS efficiency development is increasing the content of transported material that leads to structure formation in condition of large number of fine-dispersed fractions. In this case ash (ash-cindery) hydraulic mixture obtains abilities of non-Newtonian liquids [Kapustin 8, Uriev 20].

The key hydraulic transport indexes changes occur not uniformly depending on transported material concentration that is necessary to consider at systems exploitation.

OBJECTS AND PROBLEMS

The research of increasing the concentration of solid component at ash-cindery wastes transporting was occurred by USIHydrocoal and USIHydrotehnics on the territory of Ukraine and UIS. However, the impact of solid material on the rheological properties was not taken into account [Dobkin 6, Svitlyi 19].

The aim of the article is experimental determination of head losses, coefficients of friction losses and local resistances at concentrated ash hydraulic mixture with abilities of non-Newtonian fluid flow.

Experimental determinations of pressure losses were made on bases of data of the piezometeris's display at different transporting speeds [Chernetskya-Beletskaya 4]. According to test results was constructed based friction losses and local resistance of the effective Reynolds number for direct plot, turn on by 90^0 (fig. 1) and 180^0 at concentrations of solid material 40, 50, 60%.

The analysis of the data showed that increasing of the movement resistance to the straight section and horizontal turn by 180^0 occurs throughout the study area and is close to linear.

But most interesting are the experimental dependences of resistance on vertical elbow 90^0,

which are characterized by increasing head losses at reducing average transportation speed from 0,8 to 0,5 m/s (accordingly $\mathrm{Re}_{e40} = 12000 - 26000$, $\mathrm{Re}_{e50} = 600 - 1400$, $\mathrm{Re}_{e60} = 90 - 200$).

The calculation of the linear losses coefficient λ_e for concentrated ash hydraulic mixture was made on the basis of experimental data results on determining hydraulic friction losses:

$$\lambda_e = \frac{2D \cdot \Delta p}{\rho_w \cdot L \cdot u^2}, \qquad (1)$$

where: D - diameter of pipeline, m;
ρ_w - density of slurry, kg/m^3;
L - length of pipeline, m;
Δp - pressure losses, Pa;
u - speed of slurry, m/s.

It was found that the effective coefficient of linear friction losses λ_e with increasing effective Reynolds number decreases (fig. 2.). However, this decrease is not linear and at confidence probability of 95% (confidence interval is no more than 0,0073) corresponds to approximating dependencies in the next form:

$$\lambda_e = \left(a_\lambda + b_\lambda / \ln \mathrm{Re}_e\right)^2, \qquad (2)$$

where: a_λ=0,0123C - 0,7124, b_λ = -0,1429C + 9,897 - coefficients dependent on the mass concentration of solid material in hydraulic mixture.

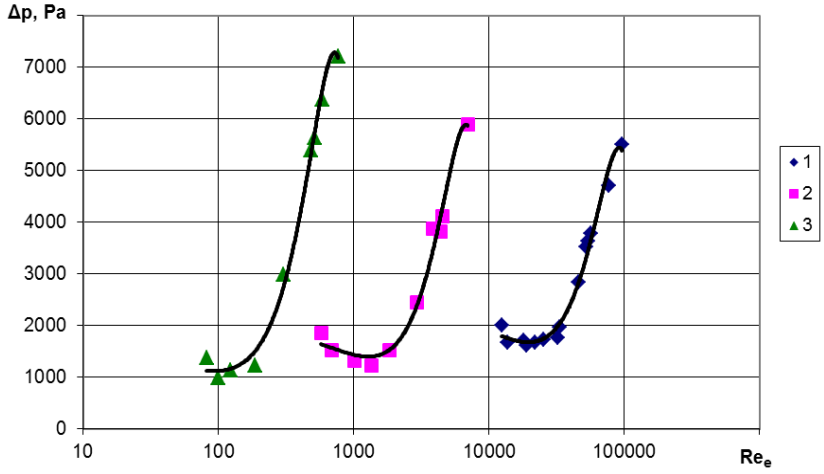

Fig. 1. Dependence of the resistance to turn of the pipeline by 90^0 on the effective Reynolds number 1, 2, 3 accordingly for concentrations of 40, 50, 60%

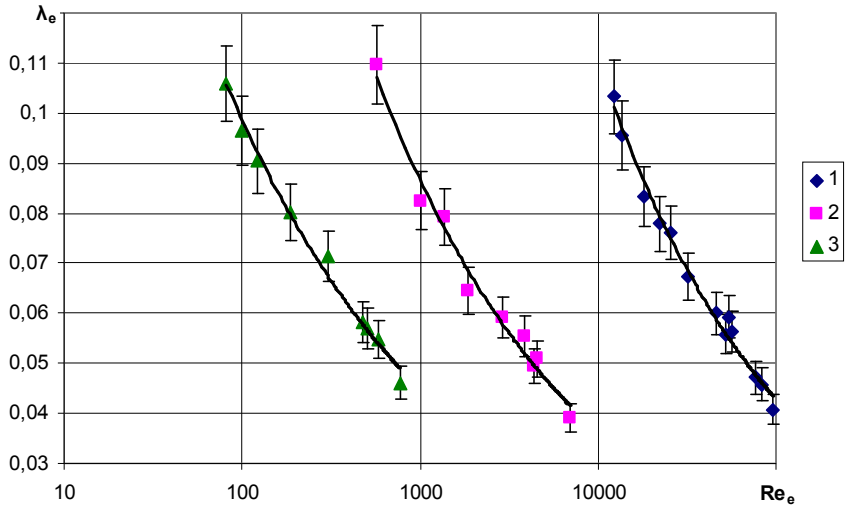

Fig. 2. Dependence of the effective coefficient of linear friction losses from effective Reynolds number 1, 2, 3 accordingly for the concentration of 40, 50, 60%

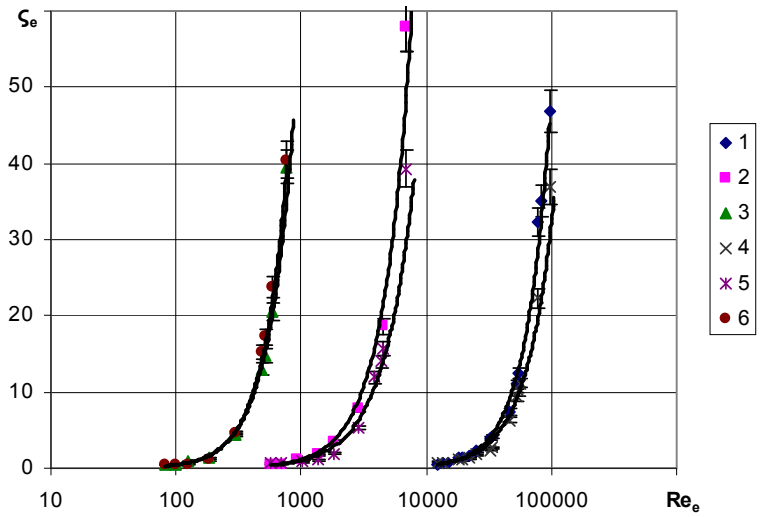

Fig. 3. Dependence of the effective coefficient of local resistance for pipeline's turn by 180^0 (1, 2, 3) and 90^0 (4, 5, 6) from the effective Reynolds number accordingly for the concentration of 40, 50, 60%

The effective coefficient of local resistances ζ_e at hydraulic mixture flow in molded parts was defined together with coefficient λ_e for linear pipeline section.

Dependencies for determination ζ_e from the effective Reynolds number for vertical turn by 90^0 are similar to the horizontal turn by 180^0 and are described in alike form of mathematical expressions. This means that the similar processes occur in them.

Obtained in the experiment data with confidence probability of 95% (confidence interval is not more than 0,057) to approximating stepwise dependence in the form

$$\zeta_e = m \cdot \mathrm{Re}_e^n \qquad (3)$$

where: $m_{180} = e^{-7,57-4,44C^3}$,

$$n_{180} = \frac{(C-48,5)^2}{320} + 1,89$$

- factors that depend on mass concentration of transported material for horizontal turn;

$$m_{90} = 2,99 \cdot 10^{-5} - 4,96 \cdot 10^{-7} C,$$

$$n_{90} = \frac{(C-51)^2}{245} + 1,74$$ - for vertical turn.

Changes of effective local resistance coefficients have strong stepwise characteristic and inflate at mass concentrations over 50%.

CONCLUSIONS

The experimental researches allow making the following conclusions:

- dependences of head losses changes from effective Reynolds number for straight section and turn areas by 180^0 are close to the linear because of local destruction at transportation speed increasing.

- head loss difference from effective Reynolds number for vertical elbow by 90^0 have extremes in speed range 0,5-0,8 m/s ($\mathrm{Re}_{e40} = 12000 - 26000$, $\mathrm{Re}_{e50} = 600 - 1400$, $\mathrm{Re}_{e60} = 90 - 200$), that is caused by the formation of immovable layer on the pipeline bottom.

- effective coefficient of friction losses, depending on the effective Reynolds number decreases non-linearly through the whole range of measurements for all concentrations of solid component, and effective local resistance coefficients for turn by 90^0 and 180^0 in the same conditions increase by step law, that shows the steady-state flow.

REFERENSES

1. **Bhasin A. K. Pommier L. W., Brien F. P. 1971.:** Some aspects of the kinematic behavior of solid particles in liquids. Sme-Aime annual meeting. - (preprint 71-b19).
2. **Carniani E., Donati E., Ercolani D., Gabrielli G., Ferroni E. 1993.:** Influence of mineral matter on cwf characteristics. Florida, USA. Clearwater.
3. **Chaltzev M., Vovk L. 2011.:** Analytical investigation into velocity change of the transported material in a pipeline bend. TEKA. Commission of motorisation and

power industry in agriculture. Lublin. vol. XB. - p. 20 - 29.
4. **Chernetskaya N., Kapustin D. 2010.:** Rebiality growth of hydrotransport system of thermoelectric power station. TEKA. Commission of motorization and power industry in agriculture. Lublin. vol. XC. - p. 27-31.
5. **Chernetska-Beletskaya N.B, Kushchenko A.V., Varakuta E.O., Shvornikova G.M., Kapustin D.O. 2011.:** Stand to research the characteristics of movement concentrated waste fuel energy. Lugansk. 1 (155). - p. 252-256.
6. **Dobkin E.L., Potapov I.A. 1985.:** Preparation and transportation of ash concentration slurry. Leningrad: USRIH. 180. - p. 26-32.
7. **Dzhvarsheyshvyly A.G. 1981.:** Pipe systems mining and transport enterprises. Moscow, Nedra.- 384 p.
8. **Kapustin D.O. 2012.:** Rheological study of concentrated withtin hydromixes. Lugansk. 3 (174). - p. 73-79.
9. **Loytsyanskyy L.G. 2003.:** Mechanics of fluid and gas. Moscow, Bustard. - 840 p.
10. **Molerus O. 1993.:** Principles of flow in dispers systems. London, Chapman and hall. - p. 273.
11. **Mooney M. 1951.:** Viscosity of a concentrated suspension of spherical particles. Journal of colloid science. vol. 6. - p. 162-170.
12. **Murko V.I. 1999.:** Scientific bases processes and obtain acquainted application water-coal suspensions: avtoref. dis. dr. techn. science: 05.17.07 "Chemical technology fuel and high energetic substances. Moscow, Uhu. – 48 p.
13. **Nazmeev U.G. 2002.:** System of ashslag deleting. Moscow, MEI. – 386 p.
14. **Pokrovskaya V.N. 1985.:** Pipelines in mining. Moscow, Nedra. - 192 p.
15. **Putilov V.Y., Lunkov A.M., Fatkullin R.M., Konovalov V.K., Torhunov S.F. 2009.:** Unit operating costs of coal ash and slag handling of thermal power plants in the example Kashirskaya. Mode of access to the journal.: http://ccp.e-apbe.ru/uploads/files/putilov-izderzhki.pdf.
16. **Sherman P. 1970.:** Industrial rheology. New York city: Academic press.
17. **Smoldyrev A.E. 1975.:** Hydraulic and pneumatic. Moscow, Metallurgy. - 384 p.
18. **Solt P.E. 2006.:** Bend location and pressure drop: an in-depth study. Powderandbulkengineering. 11. - P. 3- 6.
19. **Svitlyi U.G., Krut O.A. 2010.:** Hydro transport of solids. Donetsk: East print house, - 268 p.
20. **Uriev N.B. 1980.:** Highly concentrated dispersions. – Moscow, Chemistry. – 320 p.

ЭКСПЕРИМЕНТАЛЬНЫЕ ИССЛЕДОВАНИЯ ПАРАМЕТРОВ ГИДРОТРАНСПОРТИРОВАНИЯ ТВЕРДЫХ ОТХОДОВ ТЭС

Наталья Чернецкая-Белецкая, Александр Кущенко, Денис Капустин

Аннотация. В статье представлены материалы экспериментальных исследований по определению потерь давления и эффективных коэффициентов линейных потерь на трение и местные сопротивления при транспортировании концентрированных золовых отходов, которые проявляют свойства неньютоновской жидкости, в установившемся режиме по трубопроводу постоянного диаметра, который имеет прямолинейный участок и повороты на 900 и 1800.

Ключевые слова: неньютоновская жидкость, зола, концентрированная гидросмесь, транспортирование, коэффициенты.

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Information-administrative architectures conception and principles of their modeling

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Summary. The articles are devoted to information-administrative architecture and its monitoring conceptions. Approaches, methods and abstractions, allowing to carry out the IAA modeling and being the conceptual level of model with dynamic types definition is described. This allows designing and developing database for information-administrative architecture monitoring.
Key words: information-administrative architecture, monitoring, informational model, benchmarking.

INTRODUCTION

Choice of effective administrative technologies, structures and administrative systems are dictated by market laws. This choice is one of major strategic tasks of management subjects. World experience confirms: subjects, satisfying their demand industry of the administrative consulting, business-processes re-engineering and design of the corporate information systems, information management, busy at a search, creation and introduction of effective administrative systems, and this process in the last decades is multifaceted and fast.

The causal factors of this speed are different. The leading are economic - improving the efficiency, competitiveness, sustainability; technical and information management - development of software and hardware components, new information management technologies (MRP, MRPII, ERP); globalization - the growing influence of the relationships and interdependencies, and to a large extent , psychological - imitating the best or common patterns, suggestion, and the result is the essence of advertising. The essential role of the factors of imitation and suggestion makes fast, avalanche-like, by the type of chain reaction the nature of the distribution of these processes [Danich 2010].

The problem of creation of effective management systems is solved in the various scientific fields. This fields are: process-based approach in management (re-engineering and improvement of business processes) [Devenport 1990, Hummer 1990, Repin 2004], benchmarking [Biesada 1992, Camp 1989] and the architectural approach [Spewak 1993, Malhotra 1996, Hubert 2002].

Constraining factor introduction of new information and management structures (IMS) is the volumetric procedures of the object survey and architecture design, a low visibility of their results for the heads, making decisions on expansion of new architecture or essential change old serve. Changes' management at the enterprise usually needs complex research [Voronkov 2012]. Often, the top management of the firm has no enough knowledge and time to estimate the project. The subject, who was forced to make a difficult decision, usually seeks a precedent. This is a known psychological peculiarity difficult decisions with limited intellectual and time resources. Therefore, the standard solution of such problems is the search counterpart, in this case, IMS, successfully operating on a similar business or company.

The special sharpness to this problem was given by an economic crisis. Ineffective, badly concerted, overloaded by administrative staff organizational structures pulled at on a "economic bottom" many managing subjects. An exit from a

crisis is related in a great deal to the search of effective organizational structures.

This work focuses on the methods of decision of this problem. A purpose of work is exposition conception of monitoring of information-administrative architectures (IAA), definition of principles of modeling and analysis of architectures, making of practical recommendations on utilizing of monitoring results for a choice and perfection of organizational structures and administrative systems.

RESEARCH OBJECT

Information and administrative structures we proposed to call architecture [Danich 2007]. This phrase – information -administrative architecture - accurately reflects the diverse and, at the same time, the coherent nature of a single entity - the control system. There is great number of analogues to such notion, from architecture of buildings to processor architecture.

Information-administrative architecture (IAA) of enterprise is defined as a union of administrative and information structures that are interconnected and interdependent. Detailed selected, agreed in their characteristics, they get a synergistic effect and allow you to fully realize the production, personnel and financial potential of the company.

Information management architecture is the framework of the control system. Membership of the propagation of information management technologies, structures and systems to the class of fast, avalanche, is justified in [Danich 2010]. They are determined by the speed of the computer equipment and technology, rapid change of hardware and software platforms, the emergence and development of new management technologies and their dissemination in the environment of business entities under the laws of mass communication. Further concluded that the need for monitoring, ie tracking real information management structures, analysis and selection of the most preferred, synergistic, promising IUA. To achieve this, has the task of modeling, database of real structures and their use for typing, tracking the dynamics of real architecture's portraits, revealing preferred IAA. In fig. 1 shows the main elements of the IAA in their relationship.

It is important to understand that strictly formal definition of IAA is not exists and it is impossible because of the extreme complexity of the research object. Possible only apt description, the common "cliche" that allow clearly identify the class of objects for the purpose of theoretical research and practical application.

RESEARCH RESULTS

Define the concepts and terms used in this work, in particular the "organizational structure", "information-management structure."

The following definition of the structure of the organization is given in [Danich 2004]: "it is a fixed relationship that exists between departments and employees of the organization. This can be understood as an established pattern of interaction and coordination of technological and human elements."

The concept of structure implicitly or explicitly associated with a set of rules, regulations governing the activities of the organizations and its members.

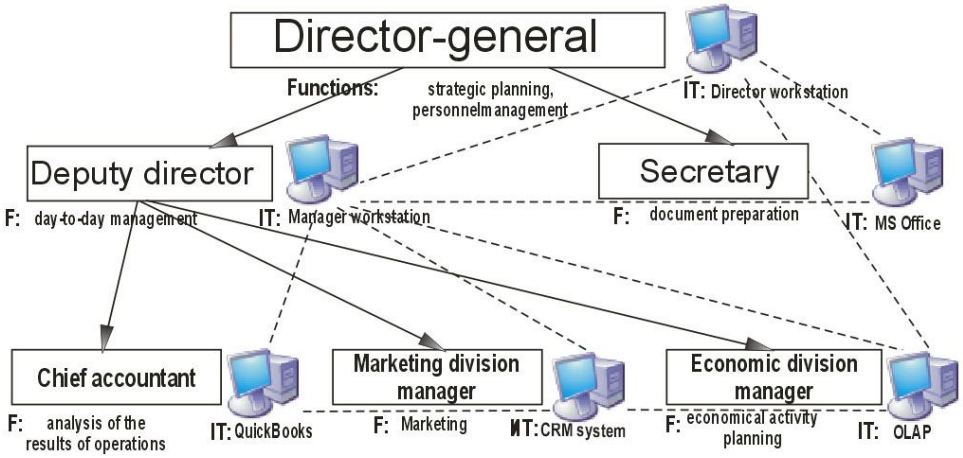

Fig. 1. Example of information-administrative architecture

In [Tolbert 2003] there are several definitions of organizational structures that emphasize balance and interaction of people. It also identifies three key functions of structures: the effective achievement of the objectives, the coordination of staff, and implementation of power (defined hierarchy, information flows). Characteristic features of these definitions are descriptive, weak formalization, blurred, descriptive, emphasizing the human factor. Weakly formalized, blurred are the result of the object complexity. These definitions explain the structure, but our goal - it formalized representation, analysis and reproduction on monitoring results. It is generally accepted definition descriptor complement structural members in the first place, graphic representation of the types of organizational structures - linear, functional, divisional, and others [Tolbert 2003, Vladimirova 1998]. The disadvantages of such submissions should include traditional mixing official and business unit structures (which creates problems in a constructive formalization), its lack of functional information, information-processing characteristics. Furthermore, the organizational structure should include a natural, in fact, based on the production and technological structure that determines the flow of resources, the relationship of components in the production process [ISO/TC 184/SC 5/WG 1]. If you add the organizational, legal and territorial structure, we can see that the organizational structure is a multilayered, multi-level composition requires adequate tools for the representation and manipulation.

The control system is part of the organizational structure, its necessary, system-organizing component, with its own constitution. Under the information-management organization we understand the structure of management of the organization, including termination and guide members in their relationship and interaction. In the context of monitoring natural to restrict the basic elements and relationships which determine the quality of the functioning of the organization.

Decisions about a choice or re-engineering of IAA are appropriate to the field of strategic management. A problem of estimation and prognosis of its (IAA) development dynamics is important here. The tasks of similar type must be decided in the context of structural-informational management [Danich 2004, Danich 2005]. This notion marks the complex of decisions, directed on perfection of executive system by an enterprise, foremost, administrative structure, realized under influence and in the close co-operating with development of the information system, providing management efficiency and organization reacting on the changes of external environment.

The global, strategic task of structural-informational management consists in guaranteeing of synergy of information and administrative structures, an increase of the information system contribution, information technologies in efficiency of administrative activity is its result. It is arrived at by a careful selection, concordance of information-administrative structure characteristics of enterprise and management by it on all stages of life cycle.

Quickly developing information technologies require from managers practical decisions on modernization and perfection of the information system, re-engineering of enterprises organizationally-administrative structures. Collection and accumulation of information about the real subjects of management, their administrative and information structures can become the rational and inexpensive variant tasks of structural-information management decision. Leaning against [Danich 2004], name such activity monitoring of information-administrative architectures.

Monitoring plugs in the questionnaire-inspection of management subjects, collection and accumulation of information in the public agency of statistics, specialized commercial, consulting firms or other structures, and then further research of information, showing up regularity and IAA development trends, distribution of the received results on commercial or on other basis.

The main directions of the monitoring should be considered as external and internal monitoring. The main task of internal monitoring is to determine the current state of their own IAA, consistency of its various components, its development trends and security. The main task of the external monitoring is definition of the current standard and preferred IAA, their tendencies. One of the attributes of the preferred architecture can be the use of modern scientific research results in management. For example, use at the enterprise quantum time management method [Walczak 2012] can serve as a reason for the priority consideration of the enterprise architecture during the search for preferred IAA. IAA monitoring suggests tracking the state of information-administrative architectures of enterprises of the city, the region, a macro to determine their tendencies, identifying preferred IAA and further distribution in order to improve

economic management as specific subjects and the overall economy. Based on the results of internal and external monitoring of preparing proposals for change and development of own IAA.

Main monitoring tools are legal and organizational scheme for the collection of data, information technology, providing registration, storage, processing, transfer of the resulting information.

Let us consider in more detail the parameters of state, coherence component trends IAA.

Under the state of IAA of enterprise or establishment we will understand the set of properties of its elements and architecture on the whole.

Selection of desirable IAA features is made by method of typification, the search for the best synergistic architectures that are successfully operating in similar businesses. To achieve this goal the problems of IAA modeling have to be solved, database of real architectures have to be created for using them to store the results of monitoring, surveillance dynamics, typification, determine the best IAA.

The most appropriate parametric typification allows us to classify members in ascending or descending order of a parameter (at least at the level of rank, for example, small, medium and large enterprise). In general, the parameter values can be ordered or partially ordered set. Parametric order typification allows extrapolating the results of research to the next point, which allows, on the one hand, foreseeing the development and on the other - to transfer IAA property from one object to another.

We note several features of organizational structures that determine the best choice of the shape of the image. First of all, it is a hierarchy. It is typical for all the components of the social system: the object of management, administrative and information system. Structure components are closely interlinked, and in many of its manifestations, they are identical, even authentic. The observed relationship means to choose the format for the organizational structure, which corresponds to the same extent in all three components.

IAA is a set of elements that perform or support the management, with the given system of relationships that characterizes the order, affiliation, dependence. The most iconic elements of IAA are divisions and posts. Each element has a specific function. Function performed by the person or department requires certain information technology delivered through software and hardware. Synergistic match between management, software and hardware components makes the technology effective.

Fundamental properties of IAA are the changeability and the multilayredness. Property of changeability means the possibility of permanent IAA reorganizations, of its structure, appearances of new element types, disappearances of old and modifications of existing. The multilayredness is a feature of architecture which consists of possibility of subsystems selection by the types of connections between elements or attributes of such elements.

Description of essence of IAA stipulates for its information model, i.e. aggregate of data structures, which are utilized for the IAA representation. We will stop for conceptions, constituent's basis of information-administrative architectures modeling.

There are two basic approaches to building information-administrative architectures models. The first is this: based on the analysis of the domain (business, law, etc.) in the real world, identifies entities and relations between them. These entities are directly displayed in the model in the form of classes, relations of type "common-private" in the form of inheritance, and the inclusion - by aggregation. The model of this kind is called a model with static type definition. Information-management architecture is changing very rapidly. This is the main obstacle to the use of models with a static definition of the types in the IAA databases, because the model itself in such conditions needs to be modified very often.

Therefore, a model of another kind was proposed: a model with dynamic types definition. It provides a means to describe the entities in the domain and to work with their instances. These descriptions can be added at runtime. This is achieved by unifying data storage mechanisms. With this approach, the user can create their own descriptions of subject area entities.

Let's pass directly to description of conceptual level of model with dynamic types definition. A model includes general description of enterprise, containing such information as the name of the enterprise, department subordination, type of ownership, legal form, industry and type of activity, quantity of manufacturing staff, size, efficiency, description of the modern information technologies use in the decision of management tasks, mission and strategy of the enterprise.

The structure of IAA appears as an aggregate of information layers, each of which describes IAA subsystem. The IAA layers can be divided into

main groups. It is layers, describing organizational and administrative structures of enterprise, describing the information system of enterprise, describing business-processes and documents circulation of enterprise. Common representation of IAA is formed from layers, the quantity of which depends on an enterprise, chosen detailed level and from plenitude of information about an object. A layer of IAA is the hierarchically ordered set of elements.

We will be stopped more detailed for that, how layers describe one or another IAA part. We will begin with a organizational and staff structure. It appears as a set of layers within the model framework. It is layers of linear and functional submissions and layer of organizational structure of enterprise. For layers, determining a submission, hierarchical order is natural, connections in these layers set relations between the chief and the subordinate. A linear submission is built «on the basis of vertical administrative hierarchy, being based on the strict submission of the lower unit to higher» [Milner 2003]. The division of administrative plenary powers and responsibility often takes a place «on the wide classes of tasks» [Milner 2003]. In this case it is possible to select a functional submission on the specified classes of tasks. For educational establishments it can be: functional submission on educational work, functional submission on an pedagogical work and other, for a production enterprise functional submission on questions of labor protection et cetera. Only aggregate of linear and functional submissions describes the organizational structure of enterprise to a full degree (for traditional organizational structures). Linear and functional submissions often contain the same elements, but in different relations. In the layer of organizational structure connections has other semantic, they determine a not submission, but inclusion in the structure of subdivisions. A layer determines the structure of subdivisions of all of enterprise on the whole.

As noted in [Vladimirova 1998] except for hierarchical organizational structures there are also matrix, project and flat patterns. Flat structures are hierarchical however, but for them the insignificant hierarchies depth and plenty of subordinates for one chief is characteristic. For flat structures a submission carries a little other nature, what for traditional, because many more plenary powers are delegated, a chief in a considerably lesser degree carries out control functions (lesser control depth), in a greater measure carries out the role of leader and tutor. But a submission is however, therefore flat structures appear directly within the model framework.

It is necessary to elaborate the possibilities of presenting project and matrix structures. In fig. 2 shows an example of a project structure. Here, the solid line represents the linear submission, dashed - the subordination of the project 1, dot dashed - the subordination of the project 2. Each submission alone is hierarchical, but all three of subordination imposed on the same post. The model allows the presence of the same elements in different hierarchies. Therefore, the project structure can be represented in the form of several hierarchies. Similarly presented and the matrix structure.

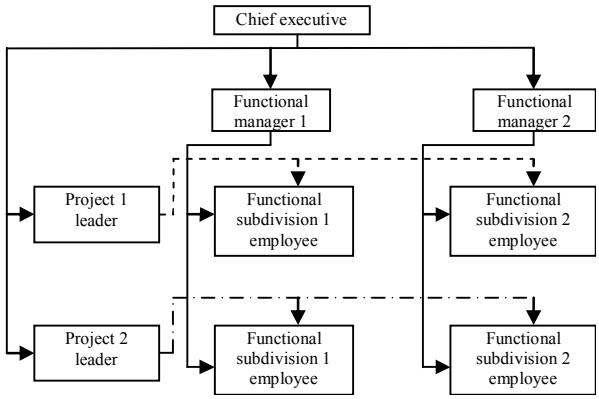

Fig. 2. Project organizational structure

The important constituent of the information system (IS) is hardware, in-use on an enterprise. Information about hardware can be represented through a layer the «Computer technique». In this layer there will be objects, describing a computer technique and groupings elements.

The business-process layer contains descriptions of business-process and subprocesses. Connections in this layer determine belonging of business-processes and subprocesses. There can be groupings elements in this layer. In particular root element usually can not describe business-process, but must be a grouping element. The documents circulation layer can contain the properly grouped set of objects, describing documents.

It was shown that all of the information about the architecture can be represented as a set of layers. For each layer is fixed semantic load, define what it means hierarchical order in this layer. For each layer is allocated a fixed set of entities, copies of which may be present. The model assumed that the semantic of relationships in the layer and a set of valid entities determines the layer type.

Every layer of IAA contains the objects of certain types. Within the examined model a type sets the structure of objects description, which

determines the list of attributes, values of which describe an object. Attributes have the name, type and sign of multiplicity. One of five types is assumed: integer, real, date and reference. References are typified. The sign of multiplicity determines whether an attribute can to have more than one value. For example, type "Computer" attribute of the "Software" can have several meanings, and in this case, the sign must be installed.

For the types of elements an inheritance is assumed. The derived type inherits its set of attributes from base. Addition of new attributes or overriding for existing is possible. An overriding takes a place by attribute definition in the derived type with the same name, as well as in base. Thus information about the type of attribute must differ. We will make an example of overriding. We will suppose in a type «Subdivision» an attribute is set «Chief» - reference to «Position». For a type there is «Department», derived type from «Subdivision», overriding is possible for the specified attribute, changing its type on reference to the object of type«Manager of a department». Such overriding will allow narrowing the set of objects from which a choice is made during setting of attributes values, and the same to lighten the constructing of concrete IAA.

Aggregation of objects is not foreseen directly. But a necessary effect can be attained through the use of references. At first an object must be added to some layer, and then it is possible to set reference to it. So a layer is the only possible container for objects, presenting the elements of IAA. It was noted that an object can simultaneously be in some layers.

It is recommended to create a new type for every IAA entity, even if on some stage of design it is possible to treat base. In many cases is possible not to enter types: «Accountant», «Chief of sales department», et cetera, to take advantage of base type «Position». But new types creating is desirable by three reasons. First, even if types are in the relations of inheritance, they use the different sets of the shared values. In the second place, more extensive types system allows to specify references more precisely. Thirdly, the IAA model can develop and go into a detail. For description of some IAA elements can be required additional attributes. It is desirable to be in a position to enter them independently. If in the architecture model of enterprise both a accounts department and shop, and marketing department, is described the objects of type «Subdivision», there will not be possibility to add additional attributes only for shops.

Objects of the some type of attribute that save values that describe the characteristics of the element IAA as a whole. The Information about the structure of that element is represented by means of other objects that are subsidiaries for the source or under other layers. In other layers of the objects that describe the structure of the elements are not arbitrary and are usually grouped hierarchically in the form of a subtree. Often different IAA elements have a similar structure. In creating a IAA model needs to be able to reuse similar items. It can do this using the template elements.

The item template is a description of the IUA, which contains as its general characteristics and structure. Templates can be composed of several layers.

For example you want to construct a model of the enterprise - trading networks. The first step is to determine the template of the department. It will contain information on its linear and functional subordination, of computers and organizational structure. Some layers can be relatively simple. A layer of the organizational structure will contain only one object describing department within the department as there are no other units. The rest of the layers will be more complicated. After the template units "Shop" is constructed. For each layer defined template is the root object. Next, the structure of the model is detailed in the store including using a template section. With the template user can create multilayered representation of some part of the IUA. For each layer, the position of insertion of objects describing the unit being set up on the template has to be specified. Even similarities IAA are rarely completely identical. Therefore, after the use of a template is usually necessary to modify the resulting representation to reflect the specifics of the elements of the IAA. Once the template of shop is set up you can start constructing representations of enterprise architecture, which is built with already-defined templates.

After the template use almost always is a few to change turning out presentation of IAA element, it presentation in future is unconnected with an initial template. That at making alteration in a template, they in any way do not affect IAA elements, constructed by this template before. It is consequently necessary to define it fully before the use of its template (work out in detail in necessary degree). At such use of templates the modeling of concrete IAA is carried out a method from below

upwards. But a method from above – downward is more comfortable to carry out the IAA modeling. At the memberwise constructing of IAA representation without the use of templates a modeling is carried out exactly a method from above – downward. For support of this method of IAA design with the use of templates possibility to create a template, based on the fragment of the already constructed IAA, is foreseen. At such creation of template an element which together with children will form the proper template layer gets out in every layer of existent representation. After it information of template modify, deleting or changing information which behaves to the concrete enterprise or part. Such modification is less labour-intensive then constructing of template structure from a beginning.

In the research process realization of the above expounded conceptual model was with the use of two object-oriented DBMS: Jasmine and Versant [Danich 2006, Danich 2007]. In Jasmine the object-oriented model must be described twice: in ODQL language for DBMS and in language of client application. For Versant the classes declaration of client application serve as of database schema.

In this work, looked through the problems of the monitoring arrangements, the results of monitoring carried out in enterprises Luhansk region in the period from 2000 to 2008 was obtained and to organized.

IAA monitoring companies in the region showed that the IS and IT has become an integral part of enterprise management systems. They provide a solution to problems of accounting, information technology management activities of individual departments.

CONCLUSIONS

The article describes the concept of information-administrative architecture. The approaches, methods and abstraction, allowing for the modeling of the IAA is a conceptual level model with a dynamic type definition. System (database), which provides a toolkit that supports these methods, will be IAA modeling environment. That is what will allow the database to store the information about IAA different classes of enterprises, which allow you to define and distribute the most effective and preferred information-administrative architectures.

The most important area for further research in the field of IAA monitoring is the development of a specialized query language to databases of information management architectures, as well as classification of the types of hierarchies and overall architecture types, highlight the best of them.

REFERENCES

1. **Danich V.N., 2010.:** Modelling of avalanche-like socioeconomic processes, TEKA. Commission of motorization and power industryin in agriculture. - Lublin University of Technology, Volodymyr Dal East-Ukrainian National University of Lugansk. Volume XA. – Lublin. – P. 78 – 90
2. Industrial automation systems — Requirements for enterprise-reference architectures and methodologies. ISO/TC 184/SC 5/WG 1.
3. **Tolbert P. S, Hall R., 2001.:** Organizations: Structures, Processes and Outcomes (10th Edition). - Pearson Education. ISBN: 0132448408.
4. **Vladimirova I., 1998.:** The organizational structure of management companies, Management in Russia and abroad. - M.: Business and Services. - № 5.
5. **Voronkov D., 2012.:** Methodology of research of potential changes at the enterprise: the transformation concept, evaluation and synergism, TEKA. Commission of motorization and power industryin in agriculture. - Lublin University of Technology, Volodymyr Dal East-Ukrainian National University of Lugansk, v. 10D, p. 305-312.
6. **Danich V., Demin M.K., 2007.:** The conceptual level model of information management architectures with dynamic type definition, Bulletin of V. Dahl ENU, Lugansk: Ed. ENU, № 4. -p. 30-42.
7. **Danich V., Demin M., 2007.:** Synthesis of object models of information-administrative architectures, Projects management and the development of production: ST. Science. etc. Lugansk: View of V. Dahl ENU, № 4 (24). - p. 114-121.
8. **Danich V., Demin, M., Chernyshev G.., 2006.:** Object-oriented database of information-administrative architectures among Jasmine, Bulletin of V. Dahl ENU, Luhansk: Ed. V. Dahl ENU, № 2 (96). - With. 42 – 47.
9. **Danich V., 2004.:** Simulation of rapid socio-economic processes: Monograph. - Kiev: Pub. V. Dahl ENU. -304 p.
10. **Danich V., Tanchenko S., Khrestina I., 2005.:** Structural and information management in the strategic management of the company, Strategy of economic development of Ukraine. - K.: Pub. Kyiv National Economic University, № 16. P.64-71.
11. **Milner B., 2003.:** The theory of organizations. - Moscow: INFRA-M. – 558 p.
12. **Repin V., Elipherov V., 2004.:** Process-based approach in management. Bussines-Process Modelling. – Moscow: RIA “Standards and quality”. – 408p.
13. **Devenport T.H., Short J.E., 1990.:** The Industrial Engeneering: Information Technology and Business Precess Redesign. Sloan Management Review.
14. **Hammer M., 1990.:** Reengineering Work: Don't Automate, Obliterate. Harvard Business Review. – July--August 1990.

15. **Biesada A. , 1992.:** Strategic benchmarking // Financial World, September 29, P 30.
16. **Camp R., 1989.:** Benchmarking: The Search for Industry, Best Practices that Lead to Superior Performance. ASQC Quality Press.
17. **Hubert R., 2002.:** Convergent Architecture. pub:Wiley.
18. **Malhotra Y., 1996.:** Enterprise Architecture: An Overview [Electronic resource] – Access order: www.brint.com, free. – Title from screen.
19. **Spewak, Hill, 1993.:** Enterprise Architecture Planning: Developing a Blueprint for Data, Applications and Technology. Pub: Wiley.
20. **Walczak R., 2012.:** Quantitative time management methods in project management, TEKA. Commission of motorization and power industryin in agriculture. - Lublin University of Technology, Volodymyr Dal East-Ukrainian National University of Lugansk, Vol. 12, No. 1, p. 301–306.

КОНЦЕПЦИЯ ИНФОРМАЦИОННО-УПРАВЛЕНЧЕСКИХ АРХИТЕКТУР И ПРИНЦИПЫ ИХ МОДЕЛИРОВАНИЯ

Виталий Данич, Максим Дёмин

Аннотация. Статья посвящена концепциям информационно-управленческих архитектрур и их мониторинга. Описаны подходы, методы и абстракции, позволяющие осуществлять моделирование архитектуры, являющиеся концептуальным уровнем модели с динамическим определением типов, что позволяет проектировать и реализовывать базы данных для мониторинга информационно-управленческих архитектур
Ключевые слова: информационно-управленческая архитектура, мониторинг, информационная модель, бенчмаркинг.

TEKA. COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE – 2012, Vol. 12, No.4, 31-35

Models of the dynamics of the information-management architectures of the coal industry enterprises

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S u m m a r y . The article presents results of the development of models of the dynamics of the informatively-administrative architectures of the enterprises of the coal industry. Models are in the form of the finite-state machine and the iteration scheme. Elementary transformations are the basis of models. Models of dynamics allow will build a model of forecast of development of the IAA.

K e y w o r d s : the informatively-administrative architecture, an elementary transformations, the finite-state machine, the finite-difference equations, factors of influence.

INTRODUCTION

Informatively-administrative architecture (IAA) of the enterprise is defined as a set of management and information structures, which are in cooperation [Danich, Dyomin 2012]. Management of development of IAA is reasonable and constructive in the presence of the models of dynamics. Model of the dynamics of IAA of the enterprise is a means of achieving an optimum balance between the elements that comprise the architecture, under certain circumstances of the development of the enterprise and the economic situation.

Analysis of the publications

The concept of IУA and mathematically-information formalism their ideas were proposed in the [Androsov, Danich 2008; Danich 2004; Danich, Androsov, Dyomin, Tanchenko 2009; Danich, Shevchenko 2011], classes of elementary transformations have been identified in [Danich, Shevchenko 2012].

OBJECTS AND PROBLEMS

High-quality management of the modern enterprise is impossible without the forecast of its development [Akimenko, Danich 2006; Danich 2004; Danich, Drobyshevs'kaja, Tanchenko 2004; Danich, Tanchenko, Hrestina 2005]. Identification of the previous state of the object and fixed factors and regularities of changes gives the opportunity to build a model of the dynamics, to form a forecast of the future state and properties of the object, identify the trends of its development [Danich, Demin, Chernyshev 2006; Danich, Demin, Klepakova 2007]. Models of the dynamics of the informatively-administrative architectures is the basis for the preparation of forecasts of development of the enterprise.

The process of development IУA enterprise has, as a rule, the discrete nature. Adding or removing elements, links architecture, their changes are not continuously, and through certain steps of time. The monitoring of these changes is also discretely, but, as a rule, through longer periods of time. According to the results of monitoring shall be compiled the statistical series of observations of the «portraits» IAA of the enterprise on the certain moments of time []. Portrait includes set of elements of IAA, relations between them and certain rules of their functioning. Such totality call the state of IAA. Therefore, “the portrait of IAA” and “the state of IAA” are synonymous in the framework of this study.

The aggregate of the registered and located in order of time states of IAA is the time series of,

or the same a number of statistical of dynamics IAA (statistical dynamics of IAA). If we define a S_{t_k} – state of IAA in a moment of time t_k, where the index k (k=1,2,…) indicates the sequence of conditions for the growth of time, the ordered set $ST = \{S_{t_0}, S_{t_1}, S_{t_2}, ...\}$ shows temporal dynamics of IAA of the according to the monitoring. Note that the sequence $t_0, t_1, t_2, ...$ is not necessarily uniform, i.e. $t_{k+1} - t_k$ may not be constant.

But, the concept of the dynamics of the system contains more profound meaning than the presence of a number of statistical data, ordered by time. First of all, the concept of the dynamics of system linked to the definition of factors and mechanisms of influence, which determine the change in the system or in the external environment under the influence of the system [Forrester 1961, Lychkina 2009, Sterman 2000, Warren 2008, Morecroft 2007]. The construction of models of the dependence of changes in IAA enterprises under the influence of certain factors, i.e. models of the dynamics of IAA and is the main aim of this work.

Changes in IAA enterprises have essentially discrete character, therefore formalisms, with the help of which served model of the dynamics of IAA, must be discrete. Such formalisms, or formal models, can be the iteration scheme, finite or infinite state machines (probabilistic or deterministic).

In this work, a models of the dynamics of IAA enterprises are considered in the form of iteration scheme and the finite probabilistic machines (probabilistic or deterministic).

At first describe the model in the form of state machine.

Let's remind, that a finite deterministic state machine is the totality of (cortege) of the five elements: $\langle X, S, Y, \lambda, \varphi \rangle$ where X – the set of input signals (input alphabet), S – the set of states of the state machine, Y – multiple outputs (output alphabet), λ – the function of transition, which displays the Cartesian product of $(X \times S)$ in a set of $\boldsymbol{S}$, φ – the exit function, which displays the Cartesian product of $(X \times S)$ in a set of $\boldsymbol{Y}$ [Hopcroft, Motwani, Ullman 2007, Pentus, Pentus 2006]. Sets of $\boldsymbol{X}$, $\boldsymbol{S}$, Y are finite. The state machine is called infinite, if at least one of these sets is the infinite.

The state machine is called probabilistic when the transition depends on the random variables ξ, what are determined by the specific laws of distribution of [Buharaev 1985, Danich 2004]. Such laws of distribution can be specified (taking into account the discreteness of the machine) function $\boldsymbol{p}(\boldsymbol{w}, \boldsymbol{s}, \boldsymbol{x})$, which gives the probability of transition from state $\boldsymbol{s}$ to state $\boldsymbol{w}$ when the input signal $\boldsymbol{x}$ [Danich 2004]. Pay attention to the multiplicity of random variables ξ. For each combination of $(\boldsymbol{x}, \boldsymbol{s})$ corresponds to a random value $\boldsymbol{\xi_{s,x}}$ (or ξ_{ij}, if the state and the input signals renumbered). Function $p(w, s, x)$ (or $p_{ij}(w)$) as the time and sets the law of value distribution $\xi_{s,x}$.

A model in the form of a finite-state machine is based on a constructive a finite number of possible states of architecture, that is their small numbers, and on the knowledge of the (certainty) of these states. Such a situation takes place for the small enterprises or enterprises with a highly conservative architecture, which is rarely changed and these changes (and hence, the following states) are known.

The transition from one state IУA to another occurs, as a rule, as a result of the adoption of a management decision, but what kind of decision will be made - it is unknown in advance. It is initiated and is determined by the strategic plans of management, certain events and situations of economic and institutional issues: rising or falling of demand for production of the enterprise, the sustainability situation or the crisis situation in the economy, a change of the law. Future uncertainty transitions naturally considered an accident, and to associate with it a certain probability of transition from state to state [Zubanov 2001]. The probability of transition is determined by the current state, the input signal (and dependent on him the decision) and is written as a function of the probability distribution.

The finite-state machine (FSM) can be described in the form of a table or matrix transitions:

Table 1. The finite-state machine

X_j / S_i	X_1	X_2	…	X_m
S_1	$\boldsymbol{w_{1,1}}$	$\boldsymbol{w_{1,2}}$	…	$\boldsymbol{w_{1,m}}$
S_2	$\boldsymbol{w_{2,1}}$	$\boldsymbol{w_{2,2}}$	…	$\boldsymbol{w_{2,m}}$
…	…	…	…	…
S_n	$\boldsymbol{w_{n,1}}$	$\boldsymbol{w_{n,2}}$	…	$\boldsymbol{w_{n,m}}$

In the table are marked with: X_j – input signal, S_i – state of IAA, $\boldsymbol{w_{i,j}}$ – random state from the set $\boldsymbol{S}$, $\boldsymbol{w_{i,j}} \in \{S_1, S_2, ..., S_n\}$, or a random event, whose meaning lies in the choice of a certain state from a set $\boldsymbol{S}$.

The set of states of the enterprise $S=\{S_1, S_2,..., S_m\}$ is finite and known beforehand. Random state $\boldsymbol{w_{i,j}}$ responsible random variable $\xi(\boldsymbol{w_{i,j}})$, or $\xi_{i,j}$, that is equal to the index of the state from the set $\boldsymbol{S}$. Function $\boldsymbol{p_{ij}(w)}$, what determines the probability of transition from the state of $\boldsymbol{S_i}$ to the state of $\boldsymbol{w_{i,j}}$ in the presence of the input signal $\boldsymbol{X_j}$, the law specifies the distribution of the random variable $\xi_{i,j}$.

The set of input signals is finite: $X=\{X_1, X_2, ..., X_n\}$, and also known beforehand.

The input signals are the phenomena and events , external and internal, which lead to changes. These phenomena and events are the factors change. To the above-mentioned, you can add industry factors: development of a new coal seam or decrease in the number of the coal seams, the introduction of a new lava. It should be noted and the reason of informational-technological nature - introduction of new information technologies, software, operating systems, etc. An avalanche-like development of new information technologies [Danich 2010] encourages accelerating the change informatively-administrative architectures of enterprises.

The factors of influence on the development of the information management architectures there are events, phenomena and processes, which take place, are taking place both within the enterprise, and also in the environment.

The action of a factor causes the first analytical reaction of individuals preparing and taking decisions. So, the beginning of such analysis can be considered a receipt of the input signal. The fact of the implementation of certain events without analytical reactions of decision-makers, in our opinion, can not be considered as receipts of the signal.

Note that moments of times t_k may be attach prior to the events, that is, the flow of events can determine the moments of time t_k, and not vice versa.

In the context of this work we are interested in the events of social and economic life, which can have impact on the structure of the enterprise, its informatively-administrative architecture.

Etymology the concept of «factor», its modern interpretation investigated in [Shvedchikov 2011], as well as allocated the special features of the factors influencing the development of the enterprise and are given their classification. In [Belozercev 2005] investigated the factors of external environment and offered their classification taking into consideration the industry peculiarities of functioning of the coal-mining enterprises. The list of the factors, determining the acceptance of the administrative decisions regarding the development of the coal companies defined in the [Piskunova 2002]. But, in general, the factors affecting the structure, the development of IAA enterprises of the coal industry, have been insufficiently studied.

It is necessary to define such factors, in respect of which revealed the presence of cause-and-inheritance of the connection between the effects of these factors and changes IAA of the enterprise. That is, such a connection supported by the facts.

But there may be such events and phenomena, which we do not know, or do not consider important the existence of a relationship. Their inclusion in a set of factors $EV=\{ev_1, ev_2,...\}$ depends on the point of view of the researcher. Set can be replenished, therefore, is open. Let us pay attention to the fact of influence may be a certain process, as a phenomenon.

Classification of factors of influence, the identification of the properties, features will contribute to building a more precise models of forecasting of the development of IAA.

The basis of classification may be different, special attention deserves the time of the influence and type of activities of the objects of the subject area.

Taking into account at time of the impact of we can distinguish the following types of events and processes:

1) at-one-moment - factors such effect which goes in an instant;
2) temporary - the influence of such factors lasts for a period of;
3) permanent - factors affect constantly.

This allocation let us explain by examples.

In 2003 closed joint-stock company «Lugansk coal company» has become the investor of GP «Anthracite». To the present time in the object of investment has been invested more than 800 million hryvnas. To implement the terms of the investor was changed the structure of the GP - introduced a new department - the department of the investor, was held the redistribution of authority and responsibility. The emergence of investor became a one-off factor, the response in respect of him led to a change in the structure of IAA and change the distribution of responsibilities, powers and responsibilities of the managers. On the other hand, the annual investment in the development of the enterprise is a permanent factor, which influences the adoption of

managerial decisions from top-managers to lower-level managers.

The permanent factor of influence are also indicators of the passage of mountain developments, depending on which the purchase of materials and equipment and to solve other important management tasks.

To temporary factors of influence includes the development of a new horizon of mine. The influence of this factor varies from several months to one and a half-two years.

General changes in the architecture, as a rule, is a set (ordered, partially ordered or random) of simple of transformation, which can be reduced to elementary (easiest). The concept of elementary transformations IAA enterprises, considered in [Danich, Shevchenko 2012], allows you to simplify the model, and extending them to the model of an infinite state machines or iterative schemes.

The analysis of changes gave the opportunity to spend their decomposition and highlight elementary transformations. Set of elementary transformations constructively finite and contains a relatively small number of elements: $E=(E_1, E_2,..., E_m)$. Elementary transformations are made in respect of the current state of architecture, transforming it into position next. Accordingly, the model of an infinite probabilistic state machine will have the form:

Table 2. The model of an infinite probabilistic state machine

S \ X	X_{t_i}
S_{t_i}	$S_{t_{i+1}} = F\left(S_{t_i}, e_{t_i}\left(S_{t_i}, X_{t_i}\right)\right)$

In the table are marked with S_{t_i}, X_{t_i} - the current state and the current input signal, $S_{t_{i+1}}$ - the next state, $S_{t_{i+1}} = F\left(S_{t_i}, e_{t_i}\left(S_{t_i}, X_{t_i}\right)\right)$ - the function of transformation of the current state in the next state, $e_{t_i}\left(S_{t_i}, X_{t_i}\right)$ - random elementary transformation, $e_{t_i}\left(S_{t_i}, X_{t_i}\right) \in \{E_1, E_2, ..., E_m\}$, $p\left(\xi_{t_i}, S_{t_i}, X_{t_i}\right)$ - the law of distribution of the probability using of elementary transformations $\boldsymbol{e_{t_i}}$ to obtain the next state.

We will consider that the random elementary transformation $e_{t_i}\left(S_{t_i}, X_{t_i}\right)$ is stationary (not directly depends on t_i). Therefore, for a description of the conversion functions will use the form $S_{t_{i+1}} = F\left(S_{t_i}, e\left(S_{t_i}, X_{t_i}\right)\right)$, where $p\left(\xi, S_{t_i}, X_{t_i}\right)$ - is the law of the distribution of the random variable $\boldsymbol{\xi}$, which corresponds to random events $e\left(S_{t_i}, X_{t_i}\right)$. Of course $\boldsymbol{\xi}$, as that $\boldsymbol{e}$ depends on S_{t_i}, X_{t_i}.

Writing of an infinite state machine in the form of a matrix does not differ fundamentally from the iteration scheme. An iterative scheme, we define a function $S_{t_{i+1}} = F\left(S_{t_i}, e_{t_i}\left(S_{t_i}, X_{t_i}\right)\right)$ without brackets of matrix.

The potential infinity of the set S or X provides infinity of state machine.

The function F in most cases is the inclusion of link or of a new element in the current set of elements or set of links of IAA.

Building a model of the dynamics of architecture provides for the definition of the set of elementary transformations E, sets of factors - the input signal X, the distribution $p\left(\xi, S_{t_i}, X_{t_i}\right)$ of the random variable $\boldsymbol{\xi}$, which corresponds to random events $e\left(S_{t_i}, X_{t_i}\right)$. The solution of such tasks can be performed on the basis of the results of monitoring in the framework of the identification problem is the estimation of the parameters of the model. These parameters are, first of all, the parameters of the distribution of the random variable $\boldsymbol{\xi}$.

CONCLUSIONS

Identified and are classified factors of influence on the development of the coal industry enterprises. The formalized description of factors. The definition of the state machine through elementary changes of state, and not through the states of enterprises, allows you to simplify the construction of models of the dynamics of IУA and then use them for development forecast.

Model of the dynamics ensures the timely conversion IУA under certain circumstances of development of enterprise or changes of the economic situation, which gives certain advantages: high competitiveness, increasing the controllability of the enterprise divisions.

REFERENCES

1. **Akimenko O.S., Danich V.N., 2006.:** Informatively-administrative architecture establishments of the social sphere. Vestnik VNU im. V. Dalja, Izd. VNU im. V. Dalja, Lugansk, №2 (96), pp. 13 – 18.
2. **Androsov V.I., Danich V.N., 2008**.: Creation of models of security of informatively- administrative architectures enterprises by means of Windows 2003 server. Vestnik VNU im. V. Dalja, Izd. VNU im. V. Dalja, Lugansk, №9 (127), V. 2, pp. 6 – 13.

3. **Belozercev R.V., 2005.:** Assessment of the impact of environmental factors on the functioning of the coal-mining enterprises. Izd-vo DonNTU, Naukovi praci DonNTU, serija: ekonomichna, vypusk 100-1, pp. 198-207.
4. **Buharaev R.G., 1985.:** Fundamentals of the theory of probabilistic automata. Nauka, Moscow, 288 p.
5. **Danich V.N., Drobyshevs'kaja A.E., Tanchenko S.M., 2004.:** Monitoring of informatively-administrative architectures in the system of structural-information management. Izd. VNU, Lugansk, №11 (81), pp. 78 – 83.
6. **Danich V.N., Tanchenko S.M., Hrestina I., 2005.:** Structural-information management in the strategic management of the enterprise. The strategy of economic development of Ukraine, Vydavn. Kyi'vs'kogo nacional'nogo ekonomichnogo universytetu, Kyi'v, № 16, pp. 64-71.
7. **Danich V.N., Demin M.K., Chernyshev G.E., 2006.**: Object-oriented database informatively- administrative architectures in the environment of Jasmine. Vestnik VNU im. V. Dalja, Izd. VNU im. V. Dalja, Lugansk, №2 (96), pp. 42 – 47.
8. **Danich V.N., Demin M.K., Klepakova N.V., 2007.:** Dynamics of development of the informatively-administrative architectures of the enterprises of the trade. Vestnik VNU im. V. Dalja, Izd. VNU im. V. Dalja, Lugansk, №11 (117), V. 2, pp. 240 – 247.
9. **Danich V., Dyomin M., 2012.:** Informatively-administrative architectures conseption and principles of their modeling. TEKA Commission of Motorization and Power Industry in Agriculture, Lublin, V. XA, p. .
10. **Danich V.M., Shevchenko S.M., 2011.:** Theoretical-multiple models of informatively-administrative architectures. Volodymyr Dahl East-Ukrainian National University, Lugansk, 304 p.
11. **Danich V.M., Shevchenko S.M., 2012.:** Classes of elementary transformation in the dynamics of the informatively- administrative architectures. Actual questions of theory and practice of management: II International scientific and practical conference of young scientists and students, 16-18 March. Lugansk, pp. 368-370.
12. **Danich V.N., 2004.:** Modelling of avalanche-like socioeconomic processes. Monograph. Izd-vo VNU im. V. Dalya, Lugansk, 304 p.
13. **Danich V.N., 2010.:** Modelling of avalanche-like socioeconomic processes // TEKA. Commission of motorization and power industryin in agriculture, Lublin University of Technology, Volodymyr Dal East-Ukrainian National University of Lugansk, Volume XA, 368 p.
14. **Danich V.N., Androsov V.I., Dyomin M.K., Tanchenko S.M., 2009.:** The concept of monitoring informatively-administrative architectures and its use in the management of the enterprise. VD "INGEK", Kharkov, pp. 390-410.
15. **Forrester Jay, 1961.:** Industrial dynamics. MA: Pegasus Communications, Waltham, 464 pp.
16. **Hopcroft John, Motwani Rajeev, Ullman Jeffrey, 2007.**: Introduction to Automata Theory, Languages, and Computation. Addison Wesley, New Jersey, 521p.
17. **Lychkina N.N., 2009.:** Retrospective and perspective of the system dynamics. The analysis of dynamics of development. Biznes-informatika, Moscow, No 3, pp. 55-67.
18. **Morecroft John, 2007.:** Strategic Modelling and Business Dynamics A Feedback Systems Approach, John Wiley&Sons Ltd., 464 p.
19. **Pentus A.E., Pentus M.R., 2006.:** The mathematical theory of formal languages. Internet-universitet informacionnyh tehnologij; BINOM. Laboratorija znanij, Moscow, 247 p.
20. **Piskunova N.V., 2002.:** Mechanism of formation of a complex of managerial decisions on the development of coal-mining enterprises of Ukraine. Izd-vo DNU, Dnipropetrovs'k, vypusk 135, pp. 92-100.
21. **Shvedchikov O.A., 2011.:** Factors of the external environment influencing on the sustainable development of the industrial enterprise. Chasopys ekonomichnyh reform, №3, pp. 111-114.
22. **Sterman John, 2000.:** Business Dynamics – Systems Thinking and Modeling for a Complex World. McGraw-Hill Higher Education, 982 p.
23. **Warren Kim, 2008.:** Strategic Management Dynamics. London Business School, John Wiley& Sons Ltd. , London, 720 p.
24. **Zubanov N.V., 2001.:** Analysis of sustainability with respect to the goal set by as one of the approaches to the description of the functioning of the organization in the conditions of uncertainty. Samara, 116 p.

МОДЕЛИ ДИНАМИКИ ИНФОРМАЦИОННО-УПРАВЛЕНЧЕСКИХ АРХИТЕКТУР ПРЕДПРИЯТИЙ УГОЛЬНОЙ ОТРАСЛИ

Виталий Данич, Светлана Шевченко

Аннотация. В статье представлены методы разработки моделей динамики информационно-управленческих архитектур (на примере предприятий угольной отрасли). Модели представлены конечными и бесконечными вероятностными автоматами, а также итерационными схемами. Основой моделей являются элементарные преобразования. Модели, описанные в статье, позволяют построить модели прогноза развития ИУА.

Ключевые слова: информационно-управленческая архитектура, елементарные преобразования, конечный вероятностный автомат, итерационная схема, факторы влияния.

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Results of researches by the numeral methods of vertical influences on the way of carriages of industrial transport at the railroad ties SB 3-0

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S u m m a r y . Determined the impact of special power and special cars on the road transport industry with concrete sleepers type SB 3-0. The dependences of the dynamics of changes in the coefficients depending on the type of rolling stock and the life path

K e y w o r d s : special and specialized rolling stock, rail track in curves, interaction of rolling stock and track.

INTRODUCTION

One of the main problems in determining the possibility of inserting the road industrial transport perspective constructions, such as concrete sleepers type SB 3-0, is to find ways and means to accurately determine the impact of the special force and special wagons industrial transport this design rail base.

These methods and tools must provide not only qualitative but also quantitative information about the processes that are adequate to the real processes in the way. Requires that information was the form of graphs depicting during dynamic processes in time. Amount of input in research and technical information that describes almost all details of the design track and rolling stock must be large enough for studies of the effect on the dynamic processes of interaction of rolling stock and track a large number of parameters and their combinations and traffic conditions.

This method is, in my opinion, the method of mathematical modeling of spatial dynamical system "crew-path" [1-4] and its implementation with the use of modern software systems. Algorithm and program mathematical models actually adequate natural physical processes taking place in the way of actual structures and rolling stock, which is confirmed by a series of experimental studies [5, 6, 7].

Study of the effects of special and specialized wagons on the road by numerical methods using a software implementation of the mathematical model allows to obtain accurate results with the original data set. Meanwhile, in the experiments on the way to establish accurate baseline data for each experience is almost impossible. Execution time studies numerical methods, fast initial data, costs, material and financial resources, mathematical modeling method is much superior to natural experiments.

To identify the characteristics of special effects on the path of rolling stock and industrial transport with sleepers SB 3-0 multiple calculations were performed using the computer program of the mathematical model of the spatial dynamical system "crew- rail track " [1-4].

As calculated crews were taken some of the most common types of special and specialized wagons of metals and mining companies in Ukraine.

Also adopted the most massive main transport wagon - a tetraaxial wagons on trolleys type CRI-HZ-0, which was considered as the reference load for comparative qualitative analysis of the results. The calculations use the model 12-1000, as the most commonly used for external and internal transportation of metallurgical and mining enterprises.

Technical specifications of the above wagons, which were taken into account, and based on the analysis of information contained in [8-10]. For each crew accounted 25 parameters.

Velocity of the crew asked for special wagons from 2.5 to 7.5 km / h, in some cases - up to 10 km / h, for specialized wagons and gondola car model 12-1000 - from 5 to 40, rarely - up to 80 km / h , corresponding speed limit for such rolling on industrial transport.

The direct part of the way with rails type P65. Features rails - moments of inertia, section modulus, cross-sectional area are consistent rail wear in service. [11]

Spatial stiffness and damping coefficient given equivalent rail supports are taken depending on the age of the way the results of research presented in [12].

Because of the vertical impact forces on the path y different types of special and specialized wagons can differ by more than two times, and the force constant change moving crews, for comparative analysis is more convenient to use and informative than their absolute values, and the coefficients of the dynamics and amplitude coefficients. Performance ratio is the ratio of the maximum vertical dynamic forces generated by the movement of the static wheel (or axial) loads:

$$K_y = \frac{P_{\max din}}{P_{st}}$$

Since moving crew vertical forces vary not only large, but also in the smaller side of the static values, the magnitude of these changes can be assessed values of the amplitude ratio:

$$K_a = \frac{P_{\max din}}{P_{\min din}}$$

It should be noted that the use of the design scheme of rail as a beam on a continuous elastic foundation in dynamic computations of the crew and the path in the vertical plane, the motion of the crew on the direct level ground with the established rate of rate of change and amplitude coefficient equal to one. Meanwhile, in the real vertical forces are continually changing and these coefficients differ from unity is essential.

In fig. 1 shows the resulting calculations graphic changes of the vertical forces acting on the wheels on the rails when driving different cars on the road at a speed of 10 km / h. As the x-axis covered wagon used by the distance y-axis - the impact force (N). In these calculations, the value of spatial rigidities rail supports were assumed constant.

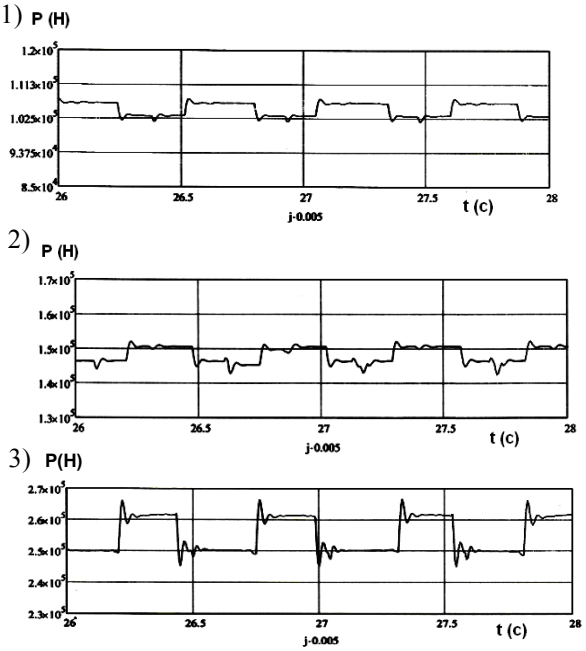

Fig. 1. Graphs of dynamic vertical forces during the motion of cars: 1 - open-top car model 12-1000, speed - 10 km / h; 2 - Boxcar BC-85; 7 - hot metal transfer car capacity of 140 tons, the speed - 5 km/h

The graphs show that the dynamic vertical forces affect both performance moving crews, their speed and stiffness rail supports. And the nature of the changes of the force varies considerably at different variants of calculations.

In fig. 6 – 2 are obtained from the analysis of the results of calculations plots of the rate of change and amplitude ratios of speeds of the wagons that are the most typical types of rolling stock for an industrial railway. The velocities of motion adopted in the aisles actually implemented. The figure shows plots of the both the new construction, and after ten years of operation. Diagram of sleepers in the calculations is assumed to be 1840 pcs. / Km.

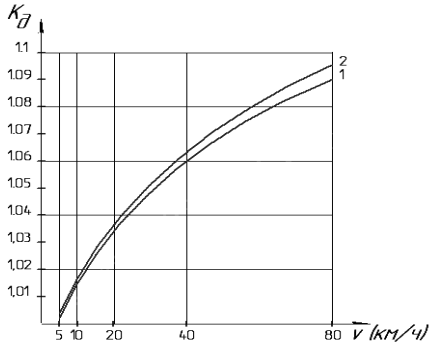

Fig. 2. Graph of rate of change of velocity of the gondola car model 12-1000
1 - time of service $t_{ts} = 0$; 2 - time of service $t_{ts} = 10$ years

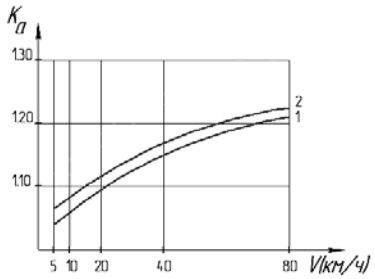

Fig. 3. Graph of amplitude coefficients of speed gondola car model 12-1000: 1 - time of service t_{ts} = 0; 2 - time of service t_{ts} = 10 years

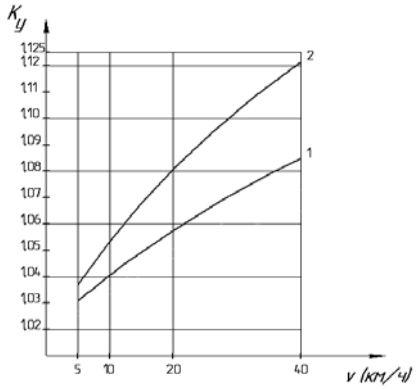

Fig. 4. Graph of rate of change of velocity of the dumpcar VS-85: 1 - time of service t_{ts} = 0; 2 - time of service t_{ts} = 10 years

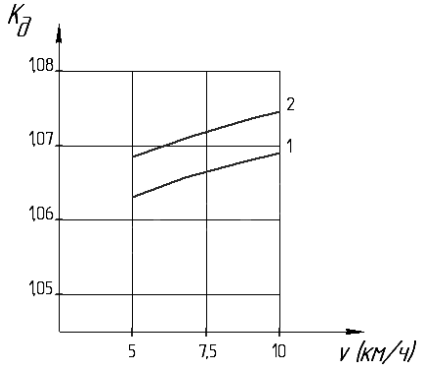

Fig. 5. Graph of rate of change of velocity of hot metal transfer car capacity of 140 tons: 1 - time of service t_{ts} = 0; 2 - time of service t_{ts} = 10 years

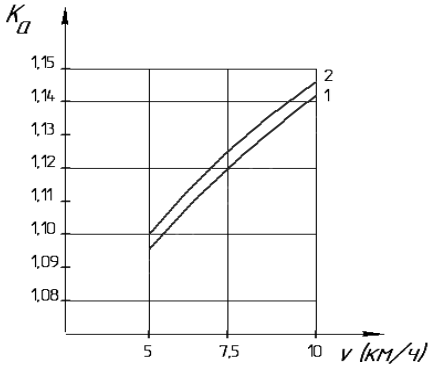

Fig. 6. Graph of amplitude coefficients of speed of hot metal transfer car capacity of 140 tons: 1 - time of service t_{ts} = 0; 2 - time of service t_{ts} = 10 years

For all the types of wagons depending on rate of change and amplitude ratios of velocities are exponential functions, and the exponent of the argument is less than one, though, focusing on the general terms of the dynamics of the process, one would expect different values. Apparently this affects not only the speed of the cars, but also the ratio of spring stiffness kit cars and the way the parameters of dissipation in these subsystems, and other factors.

At the same speeds, such as 5 km / h, for gondola performance ratio is in the range 1,006 ÷ 1,009; dumpcar VS-85- 1,032 ÷ 1,057; hot metal transfer car capacity of 140 tons - 1,059 ÷ 1,075. At the same time, at a speed of 10 km / h value of the amplitude ratio was 1.06 - 1.15 for gondolas 1.01 - 1.02 for dumpcar VS-85, 1.128 - 1.147 hot metal transfer car capacity of 140 tons

Thus, the effect of axial load and stiffness of spring group on a straight stretch of track that does not have the irregularities on the analyzed parameters is clearly seen.

Introduction to calculations unequal elasticity rail supports the use of the Monte Carlo has a very significant impact on the rate of change. So, at a speed of 10 km / h, changing the unequal elasticity supports from 0 to 0.2 (Fig. 7) causes an increase in rate of change from 1.02 to 1.055 when moving gondola cars, dumpcars for the BC-85, these changes amount to 1,065 ÷ 1,125, hot metal transfer car capacity of 140 tons - 1,085 ÷ 1,173.

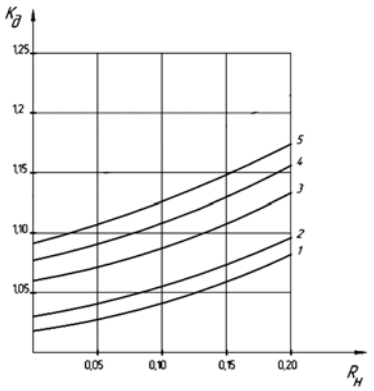

Fig. 7. Graph of the coefficients of the dynamics of the crew ratio unequal elasticity rail supports, the speed of 10 km/h: 1 - open-top car model 12-1000; 2 - dumpcar 6 BC-60; 3 - dumpcar BC-85; 4 - 70 tons of pig iron platform; 5 - 140 t hot metal transfer car

When implemented on the paths of industrial rail train speed main influence on the vertical dynamic forces have short isolated surface roughness of up to 6 m in Fig. 8 and 9 are graphs of changes and rate of change of the amplitude

coefficients of the movement of certain types of cars, taken to the calculations, the vertical isolated irregularities length of 2 and 4. In these calculations, as supports taken concrete sleepers, the life of the way - 10 years. To establish the effect is uneven impact on the dynamics of the rolling stock on the road, the rigidity of supports are the same.

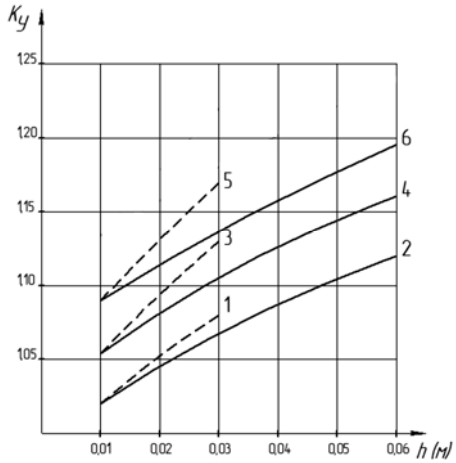

Fig. 8. Graph of rate of change of the vertical depth of the rough on concrete sleepers, the speed of 10 km/h: 1, 3 and 5, 7 - 2 m length of irregularities; 2, 4, 6, 8 - roughness length of 4 m; 1, 2 - open-top car model 12-1000; 3, 4 - dumpcar BC-85; 5, 6 - hot metal transfer car 140 t

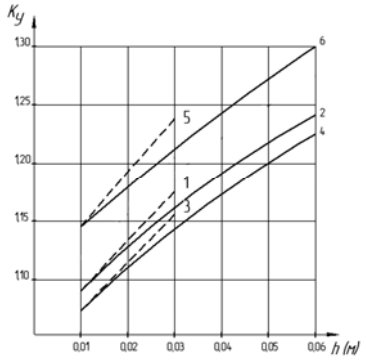

Fig. 9. Graph of amplitude coefficients of the dynamics of the depth of the vertical road bumps on concrete sleepers, the speed of 10 km / h: 1, 3, 5, 7 - 2 m length of irregularities; 2, 4, 6, 8 - roughness length of 4 m; 1, 2 - open-top car model 12-1000; 3, 4 - dumpcar BC-85; 5, 6 - hot metal transfer car 140 t

At a speed of 10 km / h on a straight section of road with a vertical isolated roughness length of 2 or 4 m gondola performance ratio, depending on the depth of roughness reaches 1.075 - 1.123, the amplitude coefficient - to 1.230, for dumpca, BC-85, these values are 1.16 and 1.22, for hot metal transfer car 1.195 and 1.30. In this case, if the calculation is introduced unequal elasticity rail supports, the coefficients of the dynamics when driving on the road with vertical irregularities increased by 12-20%, the amplitude coefficients - by 8-17%.

CONCLUSIONS

Thus, the use of a design scheme way as beams on elastic supports in the mathematical model of a dynamic system "crew- rail track" allowed to establish estimates that on a straight section of road with a maximum value of unequal elasticity supports dynamic vertical forces acting on the wheel on the rail for the gondola car 12-1000 can be up to 118 kN (40 km / h), for dumpcar BC-85 - 174 kN (40 km / h), hot metal transfer car lifting capacity of 140 tonnes - 296 kN (a speed of 10 km / h). Over time of driving these wagons with the same speed on the road with a vertical, isolated roughness values of the vertical force increased to 126 kN for the gondola, 187 kN for dumpcar, BC-85, 319 kN for hot metal transfer car capacity of 140 tons.

REFERENCES

1. **Darenskiy A.N., 2010.:** Calculation of rail as a beam on elastic supports under moving load / A.N. Darenskiy, N.V. Buhayets, V.G. Vitolberg // GIET, abstracts. - 2010. № 14. – P.171.
2. **Darenskiy A.N., 2010.:** Methodological bases of choice design scheme of dynamic systems "crew- rail track" for an industrial transport / A.N. Darenskiy // IMSRT, 2010. - № 2.-P. 32-36.
3. **Darenskiy A.N., 2010.:** Design model dynamic systems "crew- rail track" for an industrial railway. Terms and assumptions of the mathematical model of the system / A. Darenskiy, V.G. Vitolberg // DonNUERT. Scientific Papers - 2010. - № 21.-P. 219-230.
4. **Darenskiy A.N., 2010.:** Terms contacting wheels and rails in the horizontal plane. Strength and kinematic relationships crew and track [Text] / A. Darenskiy / / Coll. Science. works UkrSART - - № 113.-P. 171-177.
5. **Golubenko A., Malohatko A., Klyuev S., Klyuev A., 2011.:** The application review on the rolling stock of devices for turn of wheel pairs in the horizontal plane // TEKA - № XI A – P. 5 – 11.
6. **Golubenko A., Kostyukevich A., Tsyganovskiy I., Nozhenko V.** The influence of a rail lateral bending on the stress – strain state of a wheel – rail contact // TEKA - № XI A – P. 78 – 84.
7. **Darenskiy A.N., 2009.:** Results of experimental work on the determination of resistance forces concrete sleepers movements / A.N. Darenskiy, V.G. Vitolberg, N.V. Bugaets // DonNUERT. collection of scientific papers. - 2009. - № 17.-P. 157-171.

8. Wagons. Design theory and calculation: Textbook / Ed. L.A. Shadura - Moscow: Transport, 1943 - 439 p.
9. The wagons of the USSR [Directory 7/16/68].-M.: RIIinformheavyindustry, 1969. - 176.
10. The wagons of the USSR [Directory 8/18/74].-M.: RIIinformheavyindustry, 1975. - 198 p.
11. Terms of payment railroad for strength and stability / E.I. Danilenko, V.V. Rybkin. - K.: Transport of Ukraine - 2006.-168 p.
12. **Darenskiy A.N., 2010.:** The results of determination of the spatial elastic resistance railroad to deformation conditions for industrial transport // IMSRT. - № 6. - P. 24-31.

РЕЗУЛЬТАТЫ ИССЛЕДОВАНИЙ ЧИСЛЕННЫМИ МЕТОДАМИ ВЕРТИКАЛЬНЫХ ВОЗДЕЙСТВИЙ НА ПУТЬ ВАГОНОВ ПРОМЫШЛЕННОГО ТРАНСПОРТА ПРИ ШПАЛАХ СБ 3-0

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Аннотация. Определены силовые воздействия специальных и специализированных вагонов промышленного транспорта на пути с железобетонными шпалами типа СБ 3-0. Получены зависимости изменения коэффициентов динамики в зависимости от типа подвижного состава и срока службы пути.

Ключевые слова: специальный и специализированный подвижной состав, рельсовый путь в кривых, взаимодействие подвижного состава и пути.

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The study of physical and mechanical properties of fabrics for production of special clothes

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S u m m a r y. Detailed below is an experimental study of physical-mechanical and protective properties of special fabrics exposed to the effects of organic solvents.
K e y w o r d s: physical-mechanical properties , organic solvents, special clothes for mechanics on car repairs.

INTRODUCTION

The protective functions of special clothes depend substantially on the material selected for their production. Nowadays the advanced technologies allow manufacturing clothes of improved safety, which provide protection from the effect of aggressive media. The analysis of standards applied to special clothes showed that there is no clear classification of protective clothes on their purpose of function. This results in a very ambiguous specification of standard values of clothes. We have to distinguish certain blocks to combine products of fabrics that can provide protection for occupational groups including the same or similar hazardous factors according to the possibility of causing damage.

OBJECTS AND PROBLEMS

For actual labour conditions at car service stations and motor transport companies it is typical to have not just one but several acting hazardous and harmful production factors: mechanical damages, oil products, high and low temperatures, electric current, dust, toxic substances, acids, alkalis, organic solvents, static electricity and common production dirtying. Hence it became necessary to study special materials of domestic manufacture used in production of a special suit for protection of people working with organic solvents taking into account the antistatic properties as well.Determination of the effect of organic solvents on the change of physical-mechanical and protective values of special materials.

Materials and results of study**.** Special textile materials of domestic batch manufacture and their physical-mechanical, protective, hygienic and antistatic properties were examined in laboratory environment in relation to the resistance to organic solvents. The examination covered fabrics with different fibre composition and various types of impregnation:

- Art. 81415A (oil-lubricant-waterproof, composition: polyester 67%, cotton 33%)
- Art. 18422 AXM (oil-lubricant-waterproof, composition: polyester 67%, cotton 33%)
- Art. 81415 *(lubricant-waterproof,* composition: polyester 67%, cotton 33%*);*
- Art. 81412 *(lubricant-waterproof,* composition: polyester 67%, cotton 33%*);*

The following organic solvents were taken as aggressive medium: acetone and benzine. The basic criteria for assessment of physical-mechanical, protective, hygienic and antistatic properties of materials were surface density[GOST 3811-72], thickness [GOST 12023-93], breaking load [GOST 3813-72], elongation at rupture [GOST 3813-72], rip load [GOST 3813-72], organic solvents and oil products resistance [DSTU GOST 12.220:2004], air permeability [GOST 12088-77].The tests were carried out in

consideration of the European Standard [DSTU EN 1149-1:2003 "Electrostatic properties. Specific surface resistance (testing methods and requirements)" applicable in Ukraine]. The examination was conducted with use of the following equipment: analytical balance VLA-200M, thickness gauge TP 25-II, tension testing machine PT-250-M, air permeability meter VPTM-2, surface electric resistance meter IESTP-1. The properties of examined materials are given in table 1.

Table 1. Physical-mechanical, protective, hygienic and antistatic properties of textile materials

Parameters	Fabric articles Art.			
	81415A	18422AXM	81415	81412
Surface density of fabric, g/m^2	212	225	210	216
Thickness, mm	0,31	0,40	0,30	0,30
Breaking load, N				
warp	1058,0	707,0	965,3	1061,3
weft	670	436	614	604,3
Elongation at rupture, %				
warp	24,5	13,5	20,7	18,5
weft	18,1	13,8	23,0	22,7
Rip load, N				
warp	49,7	30,1	40,2	67,3
weft	42,8	29,4	37,2	49,8
Air permeability, dm^3/m^{2}s	50,17	43,50	57,0	56,5
Water absorbency, %	0,08	0,12	0,09	0,08
Surface electric resistance, ohm	$0{,}13\cdot10^5$	$1{,}66\cdot10^4$	$1{,}66\cdot10^{12}$	$4{,}62\cdot10^{11}$

According to the analysis, all the fabrics have approximately the same thickness and surface density but different strength properties [Chubarova Z.S.,1988]. Rather low water absorbency values can be explained first that these fabrics mainly contain polyester hydrophobic fibres in their composition and second that they are appropriately impregnated. Protective properties of textile materials when contacting organic solvents can be determined by their chemical resistance. The change of the breaking load value of fabrics after their treatment with aggressive substances during certain time is mostly used as chemical resistance criterion. Values of strength were selected as criterion of chemical resistance because they belong to basic parameters used for assessing the degree of connection between the elements of material structure. Reduction or increase of these values after the impact of aggressive substances can indicate the change of this structure. Tables 2, 3, 4 and 5 represent results of the examination how the physical-mechanical and antistatic values of materials changed after being treated with organic solvents.

Table 2. Change of physical-mechanical and antistatic values of the material Art. 81415 A after organic solvents treatment

Parameters	Output data	After treatment	
		acetone	benzine
Breaking load, N			
warp	1058,0	1007,8	1149,0
weft	670,0	591,3	662,0
Elongation at rupture, %			
warp	18,2	19,0	19,2
weft	22,5	22,2	21,9
Aggressive substance impact resistance, %			
warp		95,3	108,8
weft		91,3	98,8
Surface electric resistance, ohm	$0{,}13\cdot10^5$	$0{,}35\cdot10^5$	$0{,}13\cdot10^5$

Table 3. Change of physical-mechanical and antistatic values of the material Art. 18422AXM after organic solvents treatment

Parameters	Output data	acetone	benzine
Breaking load, N			
warp	707,0	625,6	640,0
weft	436,0	390,4	422,0
Elongation at rupture, %			
warp	13,5	11,2	12,2
weft	13,8	14,3	13,0
Aggressive substance impact resistance, %			
warp		88,5	90,5
weft		89,5	96,8
Surface electric resistance, ohm	$1{,}66\cdot10^4$	$0{,}35\cdot10^5$	$1{,}66\cdot10^4$

Table 4. Change of physical-mechanical and antistatic values of the material Art. 81415 after organic solvents treatment

Parameters	Output data	acetone	benzine
Breaking load, N			
warp	965,3	857,5	1006,1
weft	614,0	656,6	656,6
Elongation at rupture, %			
warp	20,7	19,3	21,7
weft	23,0	24,0	24,7
Aggressive substance impact resistance, %			
warp		88,8	102,7
weft		106,9	107,5
Surface electric resistance, ohm	$1{,}66\cdot10^{12}$	$1{,}66\cdot10^{12}$	$1{,}29\cdot10^{12}$

Table 5. Change of physical-mechanical and antistatic values of the material Art. 81412 after organic solvents treatment

Parameters	Output data	acetone	benzine
Breaking load, N			
warp	1061,3	1002,9	1140,9
weft	604,3	568,4	574,9
Elongation at rupture, %			
warp	18,5	18,7	20,0
weft	22,7	22,7	21,3
Aggressive substance impact resistance, %			
warp		94,5	107,3
weft		94,1	95,1
Surface electric resistance, ohm	$4{,}62\cdot10^{11}$	$3{,}33\cdot10^{11}$	$3{,}05\cdot10^{11}$

CONCLUSIONS

According to the testing results, the following conclusion can be made up. The fabric article 81415A has the highest values of breaking loads after treatment with organic solvents and the highest resistance to the impact of aggressive substance. The fabric article 18422 AXM has the lowest values accordingly. The fabric article 81415A, according to the examination results, has the surface electric resistance in compliance with requirements of DSTU EN 1149-1 as well.

REFERENCES

1. **Brezhnev A.A., Izmerov N.F., 1985.:** The encyclopaedia of labour safety and hygiene, volume 1. – M.: Profizdat. – p. 696.
2. **Stekolshchikov M.N., 1986.:** Hydrocarbon solvents.– M.: Khimiya. – p.120.
3. **Maksimov B.K., Obukh A.A.,1978.:** Static electricity in industry and means of protection. – M.: Energiya.– p.80.
4. DSTU 3974 – 2000., 2000.: The system of products development and production startup. Rules of conducting research and design works. General provisions – K.: Derzhstandart Ukrainy. –p. 34.
5. GOST 15001-88.,1988.: Products of production and technical purpose – M.: Standards press.– p.8.
6. DSTU EN 340 – 2001.,2001.: Special protective clothes. General requirements – K.: Derzhstandart Ukrainy. – p.7.
7. GOST 11209-85., 1985.: Cotton and mixed protective fabric for special clothes. Requirements specifications – M.: Standards press. – p.14 .
8. DSTU EN 1149-1:2003.,2003.: Electrostatic properties. Specific surface resistance (methods of testing and requirements) – K.: Derzhstandart Ukrainy.– p.8.
9. **Chubarova Z.S., 1988.:** Methods of quality assessment of special clothes – M.: Legprombytizdat. – p.161.
10. GOST 3811-72.,1972.: Textile materials. Textile fabrics, nonwoven fabrics and piece-articles. Methods for determination of linear dimensions, linear and surface density. – M.: Standards press. – p.10.
11. GOST 12023-93. Textile materials. Fabrics. Methods of thickness determination. – M.: Standards press, 1993. – p.9.
12. GOST 3813-72.,1972.: Fabrics and piece-articles. Methods of determining rip properties in tension. – M.: Standards press. – p.10.
13. DSTU GOST 12.220-2004.,2004.: Personal protection means. Method of determining strength of materials and seams to the impact of aggressive media. – K.: State Customer Standard of Ukraine. – p.18.
14. GOST 12088-77.,1977.: Textile materials and products of them. Method of determining air permeability. – M.: Standards press. – p.10.
15. GOST 3816-88.,1988.: Textile fabrics. Methods of determining water-absorbing and waterproof properties. – M.: Standards press. – p.13.
16. GOST 19616-74.,1974.: Woven and knitted fabrics. Method of determining the specific surface electric resistance. – M.: Standards press. – p.4.
17. **Kolesnikov P.A.,1971.:** Basic principles of designing heat-shielding clothes. - M.: Light industry.- p.111.
18. **Buzov B., Pozhidaev N., Modestova T., Pavlov A., Flerova L., 1972.:** Laboratory practices on the course of "Study of sewing production" / – M.: Light industry. – p.383.
19. **Deyneka I., Mychko A., 2008.:** Methodical foundations for the investigations of protective materials against aggressive reagents // Scientific Herald, Mukachev, Technological Institute. – No 5 – p. 39 – 45.
20. **Volodymyr Gavrysh, Marina Morneva. 2010.:** Development of high resource plasma spraying equipment and prospects of its usage in food industry // TEKA Kom. Mot. i Energ. Roln. – OL PAN, 10A, 139–144.
21. **Vladimir Gavrysh, Marina Morneva. 2010.:** Lathe turning with plasma heating of hard-to-treat materials // TEKA Kom. Mot. i Energ. Roln. – OL PAN, 10C, 63–69.

ИССЛЕДОВАНИЕ ФИЗИКО-МЕХАНИЧЕСКИХ СВОЙСТВ МАТЕРИАЛОВ ДЛЯ ИЗГОТОВЛЕНИЯ СПЕЦИАЛЬНОЙ ОДЕЖДЫ

Елена Демяненко, Нина Михайлова

Аннотация. В статье представлены экспериментальные исследования физико-механических и защитных свойств специальных материалов отечественного производства, используемых при изготовлении спецодежды для защиты слесарей по ремонту автомобилей, работающих с органическими растворителями с учетом антистатических свойств.

Ключевые слова: физико-механические свойства, органические растворители, спецодежда для слесарей по ремонту автомобилей.

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The development of the model of regional system of control and provision of education quality

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S u m m a r y. A university was examined as an object of informatization, its problem areas of activity were defined, the model of the regional system of control and assurance education quality, which includes systems of monitoring, analyzing and forecasting the statistical data obtained from all the educational institutions in the region, is proposed in this paper.

K e y w o r d s: university, the automation of the university management, the module of statistical data collection, analysis, monitoring, forecasting.

INTRODUCTION

Further socio-economic and political changes in society, the strengthening of the statehood, the entry of Ukraine into the international civilized society are impossible without the modernization the higher education system aimed at training specialists according to the level of international requirements [Shevchenko 2010]. One of the conditions of Ukraine entering into European and world educational space is the introduction into the Ukraine higher educational system of the main ideas of the European credit transfer and accumulating system (ECTS), which operates at the institutional, regional, national and European levels and is a key requirement of the Bologna Declaration of 1999. [Van der Vende 2000].

An important aspect of the modernization of education in Ukraine is reforming the control system of quality of education of future professionals. the quality control allows to match the actual level of education of graduates with current regulatory requirements of academic and vocational training and European standards of education [Kornienko 2009].

At present, the use of computer and information technologies in various spheres of our life is becoming more popular. The field of education is not an exception. The automation of the university management is still one of the important areas of informatization of higher education. Moreover, the need to solve this problem, the requirements for information system providing its solution, enhanced due to the introduction of strategic planning and the creation of a quality management system at the university [Ribcev, Dodonova 2010].

The creation of a modern automated information-analytical system of management of a large university is an extremely complex task requiring considerable material and intellectual resources. Significant attention and resources are given by the university community to the solution of this problem [19].

OBJECTS AND PROBLEMS

University as an object of informatization is a complex organizational institution, which has several features distinguishing it from organizations of other types.

1. A university is a large hierarchical structure with remote offices and branches with a constantly changing staff and students (on average 30% of the students and staff are changed over one year).

2. University is an organization that has a wide range of activities (education, research, provision of a variety of paid services, etc.).

3. University is an innovative structure in which innovations occur quite frequently and may lead to changes in business processes, organizational structure, departments' functions, document circulation, etc.

4. University is a public educational institution, which should be able to share information with the outside world.

5. University is a democratic structure with many centers of influence and quite complex mechanism of development of management decisions [Krjukov 2007].

The activities of the modern university are a multi-character. There are several problem areas of university activity: administrative management and management accounting, finance, management of educational process, document management, information resources management, educational process itself, research work, etc. (fig. 1).

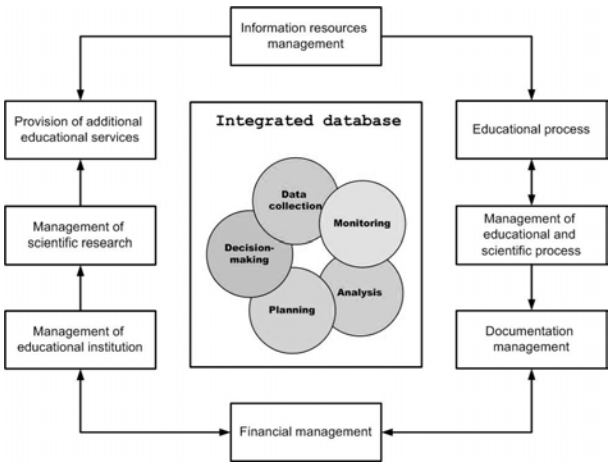

Fig. 1. Problem areas of the activity of the higher educational institution

The actual process of management of educational institutions shall consist of four inter-related classes of problems:

1) planning is a formalized formulation of efforts directions of all personnel to achieve the common goals of educational institutions;

2) organization is the creation of a structure for optimal performance of work and solution of problems of educational institutions;

3) motivation is the provision of the staff of the structural subdivisions of educational institutions with technical means and moral encouragement;

4) control is the establishment of standards and rules, definition the results achieved and correction of actions.

Geographically, the majority of universities have distributed in a certain region structure which can be connected through a single system [Zharikov 2010]. Likewise, it is advisable to connect all educational institutions in the region for the improvement of management efficiency, timely receipt of necessary statistical data. Now such information management system is needed which would cover not only all areas of education, but also the spheres of economy and national economy [Dyadychev 2011].

To implement the tasks described above it is necessary to create a quality system of monitoring, analyzing and statistic data forecasting (SMAF). SMAF should combine the following structures: higher education institutions of the region, a center of employment of the region, the Department of Education of the region and the Ministry of Science and Education, Youth and Sports of Ukraine (fig. 2).

For the organization of the first block of SMAF in each high school it is necessary to organize the server that stores all statistical data of the university, in total it is the data of educational and managing activities of the dean's offices, selection committee, student accounting of contractual and budget forms of training, as well as the personnel department. If the university does not have the system of automation of university management, automated control system is installed on the server, this system contains the following modules:

1. Module of automation of educational and managing activities of dean's offices.

2. Module of selection committee work.

3. Module of work of the student accounting of the budget form of training.

4. Module of work of the student accounting of the contract form of training.

5. Module of work of the personnel department.

6. Module of the collection of statistical data on all existing modules.

If university has a system of automation of university management, then only the module of the collection of statistical data on the university is installed on the server. SMAF has three main blocks (fig. 2):

a) The first block is the collection of statistical data on the university;

b) The second block is the collection of statistical data on all universities of the region;

c) The third block consists of modules of work with the data of the second block.

The scheme of the work of the first block is shown in fig.3.

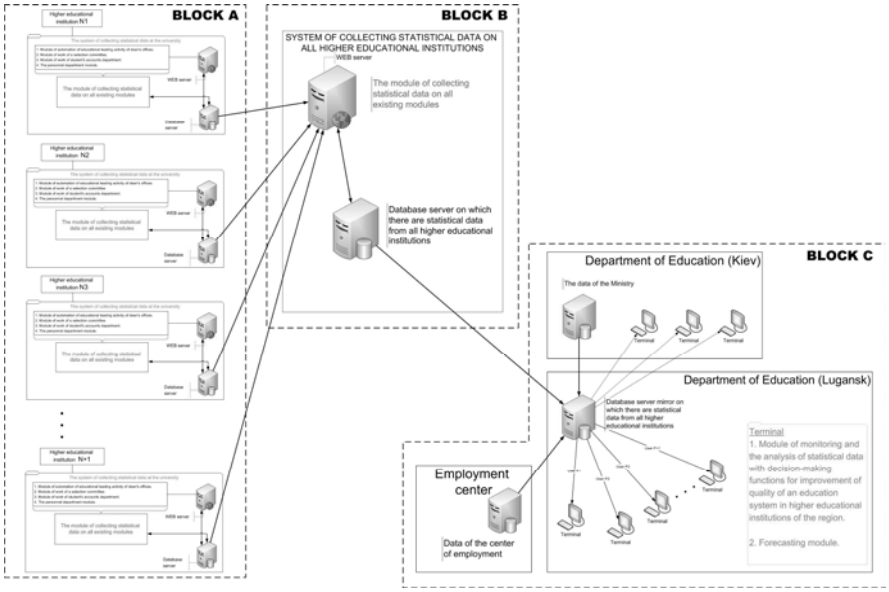

Fig. 2. The model of system of monitoring, analyzing and forecasting of statistical data of higher educational institutions of the region

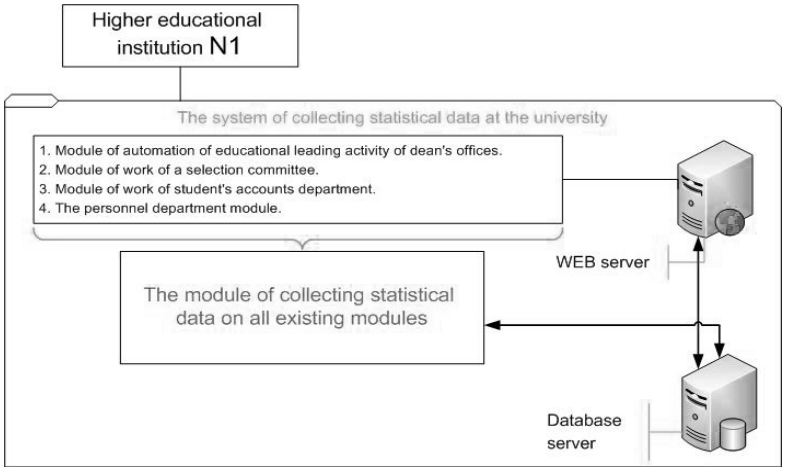

Fig. 3. Collecting of statistical data on university

To implementation of the second block of SMAF (fig. 4) it is necessary to organize in the region a server with the module of the collection of statistical data on all universities of all the existing modules of statistical data collection. The data will be copied to the main server at a certain time, so as not to disrupt the work of the units working directly with the stored data.

For the organization of the third block of SMAF (fig. 5) it is necessary to organize the server at the education department of the regional center (for example, in our case, it is t the city of Luhansk), mirroring storage of the second unit will be hosted on a server, which makes the system independent of the possible problems connecting to a remote server and provides the fastest operation of terminals in the department.

Also, the module of monitoring and statistical data analysis with the functions of decision making to improve the quality of education in higher educational institutions of the region is installed on the server. The data from the employment center of the region and the Ministry of Education of Ukraine are required for the functioning of the forecasting module.

The algorithm of the SMAF work is the following:

1. Statistical data are collected from of modules of the automation systems of the university on the server in a certain databases, data to the database can be exported also via XML format [Valeriy Dyadychev, Andriy Kolesnikov 2008].

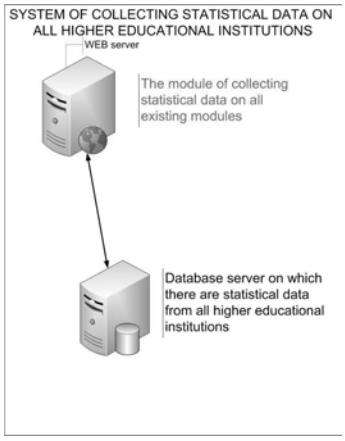

Fig. 4. The block of statistical data collection of all universities of the region

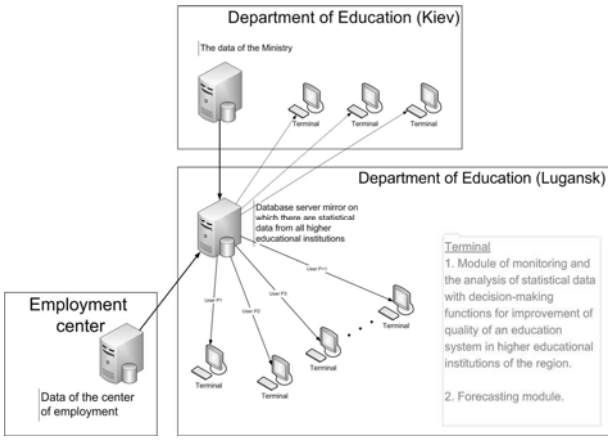

Fig. 5. The block of modules of work with the block B data

2. Further the data in the night time or at the request of the university are copied or updated on the main server, after the completion of copying and data integrity checking the information is cloned on the server of the department of education of the region.

3. From the regional employment center the data on the necessary specialists and on specialists which are in excess in the region comes on the server of the education department of the region.

4. From the the Ministry of Education the data on the plan of entrants reception, on specialists which the country needs and so on come on the server of the education department of the region.

5. The employees of the education department of the region according to available data can conduct monitoring, fulfill analysis and forecasting, make the necessary corrective actions, as well as have the ability to solve problems with excess and shortage of specialists in certain branches of the region.

CONSLUSIONS

In summary it should be noted that the model of a regional system of control and guaranteeing of education quality was developed in this article. It includes the following main components: data collection system of the university, data collection system of all universities in the region, the module of monitoring and analysis of statistical data, module of prediction. Using the automated control system the management of higher education institutions can promptly obtain any information they need, has the ability to measure and analyze the basic processes of the quality management system, to monitor the learning process and on the basis of the received data's evaluates the quality of services and, in case of discrepancy the criteria of the quality of higher education, makes timely corrective action. Creation of such regional system is supposed to involve not only education but also the Ministry of Education, the regional department of education, employment center, all of this allows to improve the effectiveness and efficiency of work, to support high quality educational services stably, to increase the satisfaction of students alumni's and employers.

REFERENCES

1. **Bykov V.Ju., Gapon V.V., Pleskach M.L., 2005.:** Rozvytok struktury komp'juternyh system opracjuvannja statystychnoi' zvitnosti dlja zabezpechennja upravlinnja osvitoju // Komp'juter u shkoli ta sim"i'. –№3. – p. 3–6.
2. DSTU-P IWA 2:2007 «Nastanovy shhodo zastosuvannja ISO 9001:2000 u sferi osvity».
3. **Dyadychev V.V., 2011.:** Modeljuvannja vprovadzhennja innovacijnyh tehnologij u regional'nu systemu osvity: Monografija / Dyadychev V.V., Kryshtal' N.I., Koljesnikov A.V., Ribcev I.V., – Lugans'k: vyd-vo SNU im. V. Dalya, – 250 p.
4. **Valeriy Dyadychev, Andriy Kolesnikov, Stanisław Sosnowski, 2008.:** Methods of databases optimization with the purpose of their productivity improvement/ TEKA. Commission of motorization and power industry in agriculture. – Lublin, Poland. –Vol. VIIIA. – p. 47-51.
5. **Eduard Zharikov, 2010.:** Topical questions of implementation of information services in a network of university/ TEKA. Commission of motorization and power industry in agriculture. – Lublin, Poland. – Vol. XA. – p. 331-337.
6. **Kornienko L.G., 2009.:** Modul'no-rejtingovaja sistema kontrolja uspevaemosti kak sredstvo monitoringa kachestva obuchenija studentov/ L.G. Kornienko, O.T. Mar'jushkina // Problemy inzhenerno-pedagogichnoi' osvity. Vyp. 24-25. – Kh.: UIPA, – p.247-258.

7. **Krjukov V.V., Shahgel'djan K.I., 2007.:** Korporativnaja informacionnaja sreda vuza: metodologija, modeli, reshenija: Monografija. – Vladivostok: Dal'nauka, – 308 p.
8. **Lucenko E.V., Korzhakov V.E., 2007.:** Refleksyvnaja avtomatyzyrovannaja systema upravlenyja kachestvom podgotovky specyalystov // Vestnyk Adygejskogo gosudarstvennogo unyversyteta. Seryja 4: Estestvenno-matematycheskye y tehnycheskye nauky. – № 4. – p. 28-36.
9. **Lucenko E.V., Lojko V.I., Korzhakov V.E., 2007.:** «ASU VUZom kak samoorganizujuwaja sistema» // Nauchnyj zhurnal KubGAU, №30(6).
10. **Malysheva E.Ju., Bobrovskij S.M., 2006.:** Informacionnoe obespechenie sistemy upravlenija kachestvom vuza // Izv. Samar. Nauch. Centra Rossijskoj akademii nauk. Special'nyj vyp.: «Tehnologija upravlenija organizaciej. Kachestvo produkcii i uslug». – p. 145-149.
11. **Muzhyk A.I., 2008.:** Metodologichni polozhennja pobudovy integrovanoi' avtomatyzovanoi' systemy upravlinnja zakladamy osvity // Visnyk NAU – №4 – p. 121-125.
12. **Ribcev I.V., Dodonova V.V., 2010.:** Programnyj modul' «IT-VUZ. DEKANAT» jak element systemy monitoryngu navchal'nogo procesu u vyshhomu navchal'nomu zakladi // Visnyk SNU im. V.Dalja – №9 (151), ch.2 – p. 92-96.
13. **Safonova V., 2011.:** Vdoskonalennja metodologichnyh pidhodiv do ocinky jakosti osvity jak zagal'noderzhavnogo priorytetu // Ekonomist. – №1. – p. 54-59.
14. **Savenko A.Ju., Palamarchuk A.O., 2011.:** Avtomatyzovana informacijna systema upravlinnja vyshhym navchal'nym zakladom // Teoretychni i praktychni aspekty ekonomiky ta intelektual'noi' vlasnosti – p. 94-96.
15. **Shevchenko V.M., 2010.:** Mehanizmy realizacii' derzhavnoi' polityky u sferi vyshhoi' osvity v umovah innovacijnogo rozvytku Ukrai'ny: [Elektronnyj resurs] / V.M. Shevchenko // Derzhavne upravlinnja: udoskonalennja ta rozvytok. – № 5. – Rezhym dostupu do zhurnalu: http:// www.dy.nayka.com/ua.
16. Udoskonalennja zmistu j tehnologij ocinjuvannja jakosti pidgotovky majbutnih fahivciv vidpovidno do vymog Jevropejs'koi' asociacii' jakosti osvity: Materialy regional'nogo naukovo-praktychnogo seminaru / Za red. G.V. Tereshhuka. – Ternopil': Vyd-vo TNPU im. V.Gnatjuka, 2007. – 160 p.
17. Upravlenie vysshim uchebnym zavedeniem: Uchebnik / Pod red. S.D.Reznika i V.M.Filippova. – M.: Infra-M, 2010.
18. **Van der Vende M.K., 2000.:** Bolonskaja deklaracija: rasshirenie dostupnosti i povyshenie konkurentosposobnosti vysshego obrazovanija v Evrope // Vissha osvita v Єvropi. – № 3. – Tom XXV.
19. www.vsu.ru «Integrirovannaja informacionno-analiticheskaja sistema upravlenija uchebnym processom».
20. **Zhuravs'kyj B.C., Zgurovs'kyj M.Z., 2003.:** Bolons'kyj proces: golovni pryncypy vhodzhennja v Jevropejs'kyj prostir vyshhoi' osvity. – K.: IVC «Vydavnyctvo «Politehnika», – 200 p.

РАЗРАБОТКА МОДЕЛИ РЕГИОНАЛЬНОЙ СИСТЕМЫ КОНТРОЛЯ И ОБЕСПЕЧЕНИЯ КАЧЕСТВА ОБРАЗОВАНИЯ

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Виктория Додонова

Аннотация. В статье в качестве объекта информатизации рассмотрен университет, определены его проблемные области деятельности, предложена модель региональной системы контроля и обеспечения качества образования, которая включает в себя системы мониторинга, анализа и прогнозирования статистических данных, полученных со всех учебных заведений региона.
Ключевые слова: университет, автоматизация управления университетом, модуль сбора статистических данных, анализ, мониторинг, прогнозирование.

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Passive safety features of parts produced by rapid prototyping technologies

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S u m m a r y. The article presents a new tool for modeling parts produced by rapid prototyping (RP) technologies that has great potential for building structures with programmable properties, especially for items related to the energy dissipation during deformation. Using a wide variety of building materials and controllable part growing is the most important benefit for industry implementation of RP technology. Mass deployment is also hampered by the high price of equipment and materials for the technology.
K e y w o r d s: Rapid prototyping, passive safety, stress-strain diagram,

INTRODUCTION

Rapid prototyping (RP) is an advanced manufacturing technology commercialized since the middle of 80s. At present, RP technology is widely used in engineering for conceptual and functional models. There are many commercial RP systems available on the market today such as stereolithography (SLA) [Jacobs P.F., 1995], selective laser sintering (SLS) [Abe F., Osakada K., Shiomi M., 2001], fused deposition modelling (FDM) [Too M.H., Leong K.F., Chua C.K., Du Z.H., Yang S.F., Cheah C.M. and S.L. Ho, 2002], laminated object manufacturing (LOM) [Fazil O., Sonmez H., Thomas Hahn, 1998], three dimensional printing (3D printing) [Sachs E., Cima M., Cornie J., 1990] and etc [Luqi R., Steigerwald G., Hughes V., Berzin A., 1991, Herranz A., Moreno-Navarro J., 2003, Gil A., Kowalski P., Wańczyk K., 2011, Pysz S., Karwiski A., Czekaj E., 2009]. The main principle all of them is that machine is building the part by adding layers of new material to the previous one. This building goes under full computer control based on the 3 dimensional computer model of the part.

OBJECTS AND PROBLEMS

Processes description. All RP systems have a limit on type and properties of materials that can be used. Usually it is a wide range of polymers or even low temperature melting metals. It is possible to select some common properties for parts that will be built due to the common principals of building (layer by layer). In this work were described RP processes, that use the heat energy to melt the material, to bind two layers together (FDM, SLS).

FDM uses special head that is feed by the thermoplastic filament, then the head is melting thermoplastic and moving in X-Y plane to form the proper layer configuration on the table (fig. 1). After the layer is completed, the table lower in Z direction to the height of one layer (Z step) and machine begins the next layer according the 3D computer model.

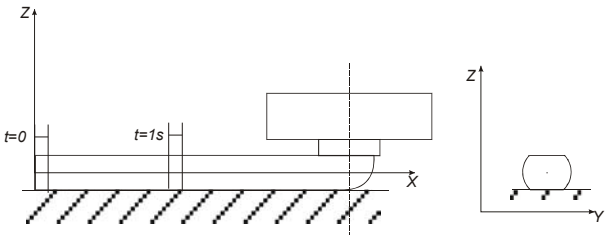

Fig. 1. FDM process scheme

SLS uses the layer of powder on the table that is melted by laser beam to form one layer configuration. On the next step the machine puts

the next layer of powder on the table and process repeats till the height of powder will reach the actual part height.

Properties analysis. Even when the properties of original material are well known it is impossible to use it for future construction calculation (for example FEA). Parts will be anisotropic and material properties will depend on a lot of parameters [Rodrigues J.F., Thomas J.P. and Renaud J.E., 2001], such as the form of the construction (design), orientation of the part, original material properties, filling and regimes of the manufacturing.

Tests show the great difference in properties of parts made by casting (monolithic) and by RP from the same material [Ahn S.H., Montero M., Odell, 2002]. The ability to predict final properties, during the design and preparation stage allows to find an optimal way of manufacturing. Among the most significant data for future FEA stay the tensile strength and preliminary stresses in the part. Both depend on the strength of bonding two neighbor layers or paths. To predict this bonding the model of the process was built.

In the beginning of the process, the first path of melt material lays down on the foam foundation (fig. 2). This material comes out the FDM tip with diameter D, with the temperature near the liquid state ($T_0 = T_{liq}$). After distortion, material begins to cool, it brings the volume decreasing and creates temperature compress stress and shrinkage.

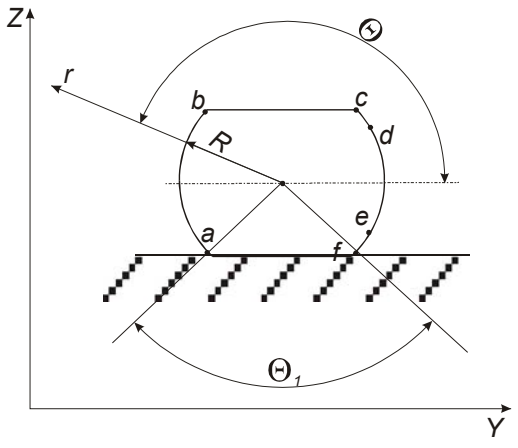

Fig. 2. Distorted material intersection (1 level)

During cooling, material gives out the heat energy to the air (*a-b-c-d-e-f surface*), to the foundation (*f-a surface*). Edge element $X=0$ gives out the energy to the air, edge element on the other side $X=X_i$ contacts with the new, just distorted intersection.

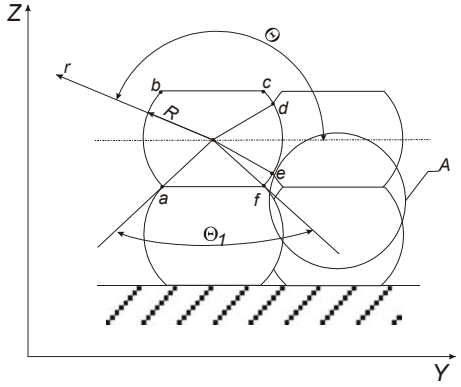

Fig. 3. Model of the process

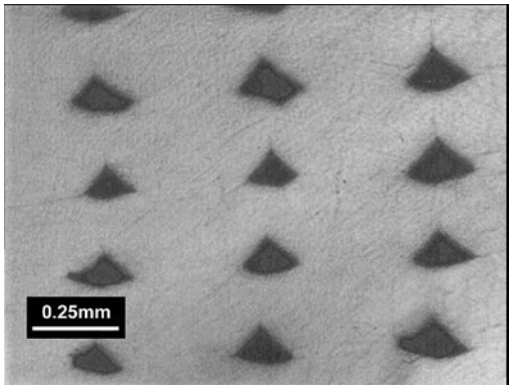

Fig. 4. Real part intersection

For the second (next) layer building (fig. 3), the surface *e-a* contacts with the previous slice. During this contact, the heat energy is melting the previous level (fig. 5). The depth of this melting d_{liq} is the main parameter, that defines the strength of layer binding. We can define three different material states: the liquid ($T>=T_{liq}$), with the depth d_{liq}; the transitional (d_t - d_{liq}); and the hard one ($T<T_{liq}$).

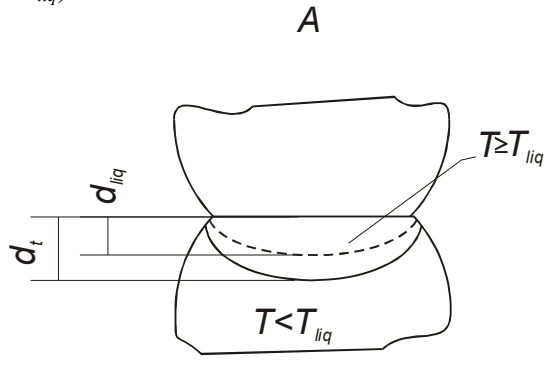

Fig. 5. Depth of material melting (penetration)

In side direction (Y) material will contact with the neighbour curve, on the surface d-e, and it will define the strength of side binding.

The value of bonding depends on the dliq and the length of contact (*d-e*). Sector (*d-e*) is in

direct dependence on overlapping of curves and on other generates parameters (width, gap, etc.).

Temperature field in the materia

$$\frac{\partial^2 T}{\partial r^2}+\frac{1}{r}\frac{\partial T}{\partial r}+\frac{1}{r^2}\frac{\partial^2 T}{\partial \Theta^2}+\frac{\partial^2 T}{\partial Y^2}=\frac{1}{a}\frac{\partial T}{\partial t}, \quad (1)$$

where: r,Θ,Y – cylindrical coordinate; a – coefficient of temperature conduction $\left(a=\lambda/c\right)$; λ – coefficient of heat conduction; c – specific thermal capacity; t – time.

Initial conditions for this problem are the following

$$\text{when } t=0, T(r,\Theta,Y,t)=T^0_{\Pi\Pi}. \quad (2)$$

Boundary conditions are the following:

- there is convectional heat exchange on the area $a-b-c-d$ (fig.3)

when

$$r=R\cdot f(\Theta), \Theta'_a\le\Theta\le\Theta'_d, \frac{\partial T}{\partial r}+\frac{\alpha_1}{\lambda}\left(T-T'_0\right)=0, \quad (3)$$

where: α_1 – coefficient of heat release; T'_0 – build envelope temperature (environment temperature);

– on the area $a-c$ and $d-e$ material contacts with foundation or with the cool material

$$\lambda\left(\frac{\partial T}{\partial r}\right)_{r=+R}=\lambda_{\Pi}\left(\frac{\partial T_{\Pi}}{\partial r}\right)_{r=-R}, \Theta''_d\le\Theta\le\Theta''_e, or, \Theta''_c\le\Theta\le\Theta''_a, \quad (4)$$

where: λ_{Π} – coefficient of heat conductivity of foundation (or cool material); T_{Π} – foundation (old material) temperature;

– on the left side

$$\text{when } X=0,, \frac{\partial T}{\partial X}+\frac{\alpha_2}{\lambda}\left(T-T''_0\right)=0, \quad (5)$$

where: α_2 – coefficient of heat release of this side;

– on the right side for contact with new material

$$Y=l,, \lambda\left(\frac{\partial T}{\partial Y}\right)_{Y=+l}=\lambda\left(\frac{\partial T^0_{\Pi\Pi}}{\partial Y}\right)_{Y=-l}. \quad (6)$$

It is convenient to seek the solution of problem (1)-(6) in form:

$$T(r,\Theta,Y,t)=\sum_{n=0}^{N}\Phi_n(r)a_n\cos n\Theta\cdot\exp(-k_0 t)Y^n, \quad (7)$$

where: $\Phi_n(r)$ – the function of only r argument ; a_n,k – undefined coefficients.

It is possible to reach a solution of this equation, based on Bessel function of first and second kinds.

This decision defines the temperature distribution in the part. This allows to create simulation of cooling process. Temperature inequality causes the non-linear deformation of form. Using the apparatus of thermo elasticity, it is possible to predict the elementary volume deformation

$$\varepsilon_x=\frac{1}{E}\left[\sigma_x-\gamma(\sigma_y+\sigma_z)\right]+\alpha T;$$
$$\varepsilon_y=\frac{1}{E}\left[\sigma_y-\gamma(\sigma_x+\sigma_z)\right]+\alpha T;$$
$$\varepsilon_z=\frac{1}{E}\left[\sigma_z-\gamma(\sigma_x+\sigma_y)\right]+\alpha T; \quad (8)$$
$$\gamma_{xy}=\frac{\tau_{xy}}{G};$$
$$\gamma_{yz}=\frac{\tau_{yz}}{G};$$
$$\gamma_{xz}=\frac{\tau_{xz}}{G},$$

where: ε_{ij} - deformation of elementary volume, %; σ - stress, MPa; γ,α - coefficients; γ_{ij} - shearing; E - elastic (Young's) modulus, MPa; G – shear modulus, MPa; T – temperature field $T(x,y,z,t)$, obtained before. It is necessary to point that this model will work properly for amorphous materials and not good for crystalline due to the great specific volume variation during the solidification [Gibson I. Shi,D, 1997]. But especially this reason limits the application of such materials in RP.

To receive stress and shearing, it is convenient to use the potential energy of deformation. Final deformation (shrinkage) of the part will be resulted as a sum of elementary volume deformations

$$u_x=\int\varepsilon_x dx+C_1; \quad (9)$$
$$u_y=\int\varepsilon_y dy+C_2;$$
$$u_z=\int\varepsilon_z dz+C_3,$$

where: C_1, C_2, C_3 – are defined by the boundary conditions.

From one side, the temperature field gives the opportunity to find the depth of penetration of one layer to another. It will depends on the boundary of $T=T_{liq}$ (temperature of liquid state). From other side, slicing process (RP preparation stage) arranges almost all necessary data for

analysing the part as a sum of elementary volumes. These two details allow to predict the tensile strength in different directions.

The analyse of compression behaviour of specimen produced by FDM technology is possible with the help of FEA (fig. 6). The strength of filaments bonding was calculated according to the value of d_{liq} and the length of contact (*d-e*) (fig. 5).

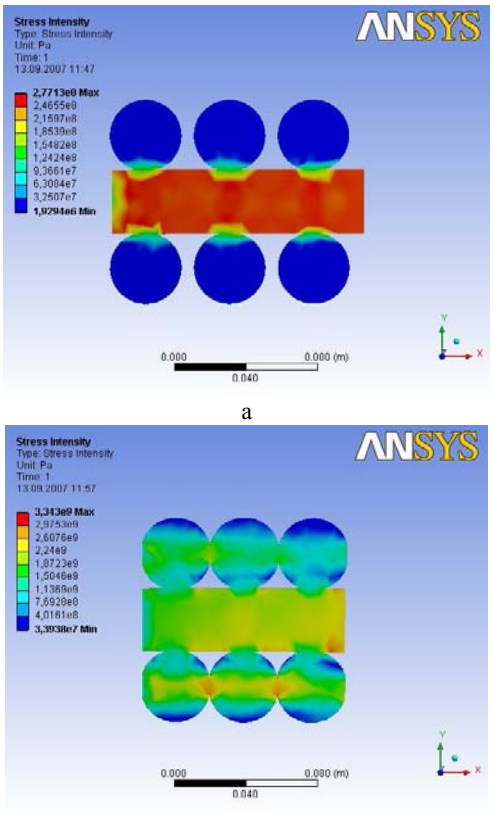

Fig. 6. Deformation of FDM structures: a – initial state, b – final state

Two different mechanisms work during compression that produces bilinear stress-strain diagram in elastic mode. First slope (fig. 7) is caused by elastic behaviour of interlayer links (fig. 6a). The same slope continues till neighbour filaments meet each other and start theirs compression (fig. 6b). In the point of theirs meeting will be the breakpoint of stress-strain diagram, because two different mechanisms produce the force of deformation.

Honeycomb structure of RP parts (fig. 4) gives a unique opportunity to create constructions with controllable passive safety characteristics. The energy of deformation can be easily calculated with the help of stress-strain diagram of specimen compression.

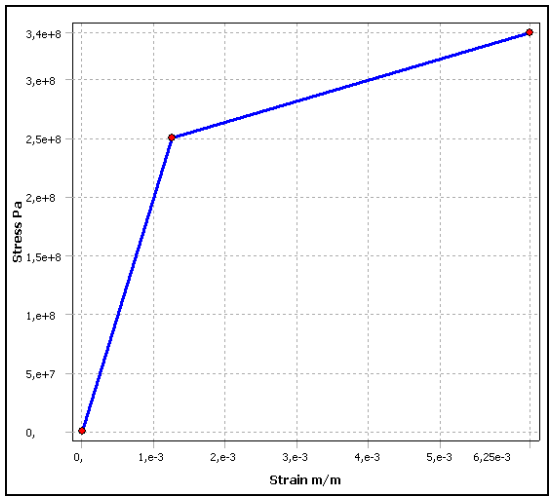

Fig. 7. Stress-strain diagram of RP specimen during compression test

CONCLUSIONS

RP technology is pretty new instrument of parts building and has a great potential for building constructions with programmable properties, especially for a lot of applications connected with energy dissipation during deformation. Ability to control all bindings in the part individually gives an opportunity to create very flexible programs of deformation, even programs that will be very close to optimal ones. Interlayer links determine the first slope of stress-strain diagram and can be changed by regimes of part building. The second slope connects with material characteristics and can be changed only for the part at all. Building material is the most critical factor that breaks the development of RP technology in industrial area. The second factor that breaks mass implementation is the high price for equipment and material for real rapid manufacturing applications.

REFERENCES

1. **Jacobs P.F., 1995.:** Stereolithography and other RP&M technologies. Deadborn, MI: Society of Manufacturing Engineers. - 451 p.
2. **Abe F., Osakada K., Shiomi M., 2001.:** The manufacturing of hard tools from metallic powders by selective laser melting, J. Mater. Process. Technol. – V. 111., № 1 – 3. – Pp. 210.
3. **Too M.H., Leong K.F., Chua C.K., Du Z.H., Yang S.F., Cheah C.M. and S.L. Ho, 2002.:** Investigation of 3D Non-Random Porous Structures by Fused Deposition Modelling // Int. J. Adv. Manuf. Technol. - Volume 19, Issue 3. – Pp. 217 – 223.
4. **Fazil O., Sonmez, H., Thomas Hahn, 1998.:** Thermomechanical analysis of the laminated object manufacturing (LOM) process, Rapid Prototyping Journal. - Vol. 4. Iss. 1. - Pp. 26 – 36.

5. **Sachs E., Cima M., Cornie J., 1990.:** Three-Dimensional Printing: Rapid Tooling and Prototypes Directly from a CAD Model, CIRP Annals - Manufacturing Technology. – Vol. 39, Iss. 1. – Pp. 201 – 204.
6. **Luqi R., Steigerwald G., Hughes V., Berzin A., 1991.:** CAPS as a Requirements Engineering Tool. Proc. Conference on TRI-Ada, San Jose, CA, pp. 75 – 83.
7. **Herranz A, Moreno-Navarro J., 2003.:** Rapid Prototyping and Incremental Evolution Using SLAM, Proc. 14th IEEE International Workshop on Rapid Systems Prototyping, San Diego, pp. 201 - 209.
8. **Gil A., Kowalski P., Wańczyk K., 2011.:** Reducing Energy Consumption During Manufacture Of Semi-Finished Components Of The Planetary Gear Through The Use Of Castings Made By Rapid Prototyping, TEKA Kom. Mot. i Energ. Roln. - Vol. XIC. Pp. 53 – 63.
9. **Pysz S., Karwiski A., Czekaj E., 2009.:** An analysis and comparision of properties of Al-Si alloyautomotivecastings made by rapid prototyping and standard lot producton. TEKA Kom. Mot. i Energ. Roln., Vol. IX, Pp. 251 - 258.
10. http://www.axure.com/products.aspx
11. **Rodrigues J.F., Thomas J.P. and Renaud J.E., 2001.:** Mechanical behaviour of acrylonitrile butadiene styrene (ABS) fused deposition materials. Experimental investigation, Rapid Prototyping Journal. Vol.7 No.3. Pp.148 - 158.
12. **Ahn S.H. Montero M., Odell, 2002.:** D.Anisotropic material properties of fused deposition modeling ABS, Rapid Prototyping Journal. Vol. 8 No. 4. Pp. 248 – 257.
13. **Gibson I. Shi D., 1997.:** Material properties and fabrication parameters in selective laser sintering process, Rapid Prototyping Journal. Vol. 3, No. 4. Pp. 129 - 136.
14. **Dai K. X-X. Li L.L., Shaw, 2004.:** Comparisons between thermal modeling and experiments: effects of substrate preheating, Rapid Prototyping Journal. Vol. 10, № 1. Pp. 24 – 34.
15. **Sung-Hoon Ahn, Caroline S. Lee, Woobyok Jeong, 2004.:** Development of translucent FDM parts by post-processing, Rapid Prototyping Journal. Vol. 10, № 4. Pp. 218 – 224.
16. **John Kietzman, Byong-Ho Park, Friedrich Prinz, 2001.:** Part strength improvement in polymer shape deposition manufacturing, Rapid Prototyping Journal. Vol. 7, № 3. Pp. 130 – 137.
17. **Hong Wenbin, Lee Yong Tsui, Gong Haiqing, 2005.:** A study of the staircase effect induced by material shrinkage in rapid prototyping, Rapid Prototyping Journal. Vol. 11, № 2. – Pp. 82 – 89.
18. **Frances D Bryant, Guanghua Sui, Ming C Leu, 2003.:** A study on effects of process parameters in rapid freeze prototyping, Rapid Prototyping Journal. Vol. 9, № 1. Pp. 19 – 23.

СВОЙСТВА ПАССИВНОЙ БЕЗОПАСНОСТИ ДЕТАЛЕЙ, ИЗГОТОВЛЕННЫХ ТЕХНОЛОГИЯМИ БЫСТРОГО ПРОТОТИПИРОВАНИЯ

Андрей Фалалеев, Елена Ноженко

Аннотация. В статье рассмотрен новый инструмент для моделирования деталей, произведенных с использованием технологий быстрого прототипирования, которые имеют большой потенциал для создания конструкций с программируемыми свойствами, особенно для элементов, связанных с диссипацией энергии при деформации. Возможность использования большого разнообразия материалов и управляемой схемы выращивания деталей является наибольшим преимуществом данной технологии, в то время как массовому внедрению технологий в промышленность препятствует высокая цена на оборудование и материалы.

Ключевые слова: RP технология, пассивная безопасность, диаграмма деформация

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Mathematical model of choice of the switcher's optimal operating mode which work on the system of two units on the basis of fuel rate diminishing criterion

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S u m m a r y . In article questions of work optimisation an installation diesel engine-generating are considered. Criterion function of diesel locomotives total expenses by is defined; the equation for calculation of the fuel expense by shunting diesel locomotives which work on system of two units is worked out.
K e y w o r d s . Criterion function, system of two units, fuel expense, shunting diesel locomotive, energy expenses.

INTRODACTION

Experience of the switcher's use, which works by system of two unit's shows that efficiency of their work, can be substantially increased by optimization of the diesel-generator setting operating mode and perfection of control system of locomotive. The choice of optimal operating mode must be based on principles of the complete use of locomotive power and diminishing of expenditure of energy during exploitation [Pappok, Semenido 1962, Stepanov, Dychkov 1968]. For determination of the switcher's optimal operating modes which work on the system of two units it is necessary to analyze the expenses of diesel fuel at implementation of different mobile operations on the whole for a change.

ANALYSIS OF RESEARCHES AND PUBLICATION

Analyzing existent methodologies of determination of fuel rate diesel locomotives we determined that all of it has a substantial defect – it does not take into account operating mode and influence of operating factors on the expense of fuel rate diesel locomotives which work on the system of two units [CT-2421 2000, CT-249 2001, CT-0059 2003].

AIM OF THE ARTICLE

The aim of this paper is determination of the efficiency function of total charges during work of switchers which work on the system of two units for a shift and it limitation and composition the mathematical model for the calculation of fuel rate diesel locomotives which work on the system of two units for a change taking into account time of work on the different modes and change of the modes at implementation of switcher's operations.

EXPOSITION OF BASIC MATERIAL

We executed preliminary estimate of statistical information about the efficiency level of the use of diesel-generator installations of switchers which work on the system of two units [Chernjak, Sazonov, Guschin, Doroshenko, Gatchenko 2006, Gatchenko V.O. 2011] that allows to build the model of rational choice operating mode taking into account actually producible work on the basis of fuel rate diminishing criterion.

As a basis of the model efficiency function we put the total operation cost minimization [Sumtsov, Bragin, Klimenko 2012].

For determination of operating costs of switcher which work on the system of two units during the shift we proposed next function:

$$E = f(B_T, B_{x.x.}, B_{zap}, C_{d.p.}) \to \min, \qquad (1)$$

where: B_T - expenditure of fuel in the mode of traction;

$B_{x.x.}$ - expenditure of fuel in the mode of idling;

B_{zap} - expenditure of fuel rate on the start of diesel;

$C_{d.p.}$ - cost of diesel fuel.

Thus total expenditure of fuel consists of diesel expenditure of fuel in the mode of traction, idling and expenditure on engine start [Kossov, Azarenko, Komaritsky 2007, Osipov, Mironov, Revich 1979].

Fuel engine start in the mode of traction, idling, on the expenditure start:

$$B_T = G_T \cdot \tau_T = \sum_{i=1}^{n} \tau_{pozi} \cdot P_i \cdot g_{ei} \cdot 10^{-3}, \qquad (2)$$

where: G_T - fuel expenditure in the mode of traction, kg;

τ_{pozi} - time of the diesel-generator setting work on position *i* of machinist controller;

P_i - power of diesel on position *i* of machinist controller, kW;

g_{ei} - specific fuel rate on position *i* of machinist controller, g/ kW h.

$$B_{x.x.} = g_{x.x.} \cdot \tau_{x.x.} \qquad (3)$$

where: $g_{x.x.}$ - fuel expenditure in the mode of idling, kg/h;

$\tau_{x.x.}$ - work time in the mode of idling, h.

$$B_{zap} = g^{zap} \cdot n, \qquad (4)$$

g^{zap} - fuel expenditure on the engine start, kg;

n - amount of starts is for a shift.

Then target function:

$$E = \left(\sum G_T \cdot \tau_T + \sum g_{x.x.} \cdot t_{x.x.} + g^{zap} \cdot n\right) \times C_{d.p.} \to \min$$

Limitation:

$$\begin{cases} T_{n.c.} \in -40 \div 40^0 C; \\ T_{o.v.} \in 40 \div 45^0 C; \\ Q \in 0 \div 3000 t. \end{cases}$$

$T_{n.c.}$ - ambient temperature, ^oC;

$T_{o.v.}$ - temperature of diesel cooling water, ^oC;

Q - weight of train, t.

By variables components of target function are operational time in the different modes and amount of starts for a shift [Gatchenko 2011].

For determination of operational time in the different modes graph of the states of the system of diesel-locomotive switcher was built, which work on the system of two units and the worked out model for determination of probability of locomotives stay in the different states of the system which is realized in the software product of MATHCAD [Falendish, Ustenko, Gatchenko, Volodarets 2011].

Defining on the developed model probability $P(X_i)$ of being of diesel engines in the different states of count it is possible to calculate the fuel rate in the different modes of diesel-locomotive switcher operations which work on the system of two units for a shift [Gorbunov, Kostyukevich, Kravchenko 2010, Gorbunov, Kostyukevich, Kravchenko, Kovtanets 2010.].

The time of the certain state of the system $\tau(X_i)$

$$\tau(X_i) = P(X_i) \cdot t_{zm}, \qquad (5)$$

$P(X_i)$ - probability of presence in the certain state of the system;

t_{zm} - time of shiftwork.

Total expenditure on operation of diesel-locomotive which works on the system of two units is a function from time of presence in the different states of the system [Kalabuhin, Beletsky 2009, Kalabuhin, Beletsky 2010]:

$$f(\tau(X_i)) = \left[\left(g_{x.x.} \cdot \left(\tau(X_{2,4}) + 2\tau(X_3)\right)\right)\right] +$$
$$+ \left[\tau(X_{5,7}) \cdot \sum_{i=1}^{k} P_i \cdot g_{ei} \cdot P(X_{pozi}^{5,7}) \cdot (1 + k_Q) + g_{x.x} \cdot \theta_j (1 - k_Q)\right] +$$
$$+ \left[2\tau(X_9) \cdot \sum_{i=1}^{k} P_i \cdot g_{ei} \cdot P(X_{pozi}^{9})\right] +$$
$$+ \left[\tau(X_{6,8}) \cdot \sum_{i=1}^{k} \frac{P_i \cdot g_{ei} \cdot P(X_{pozi}^{6,8}) \cdot (1 + k_{PT}) \cdot (1 + k_Q) +}{g_{x.x.} \cdot \tau(X_{6,8}) \cdot (1 - k_{PT}) \cdot (1 - k_Q)}\right] + g^{zap} \cdot n$$

In addition in target function we entered three coefficients $\theta_{j`}$, k_{PT}, k_Q.

Coefficient $\theta_{j`}$ considers switching of operating mode depending on an ambient temperature:

- $j = 1$ *if* $t^0 C \le 0$;
- $j = 2$ *if* $t^0 C > 0$.

Accordingly: $\theta_1 = 1,\ \theta_2 = 2$.

Coefficient k_{PT} considers switching of operating mode depending on temperature diesel cooling water:

- $k_{PT} = 0\ if\ t^0C \le 40\ or\ 40 \le t^0C < 45,\ \uparrow t^0C$;
- $k_{PT} = 1\ if\ t^0C > 40\ or\ 45 \ge t^0C > 40,\ \downarrow t^0C$.

Coefficient k_Q considers switching of operating mode depending on weight of train:

- $k_Q = 0\ if\ Q < 3000\ t$;
- $k_Q = 1\ if\ Q \ge 3000\ t$.

By means of developed mathematical model it is expedient to determine the optimal operating modes of switcher's diesel-locomotive which work on the system of two units, on the criterion of fuel expenditure diminishing.

CONCLUSIONS

1. A certain target function of total expenditure during work of switcher which works on the system of two units for a shift.

2. The restriction of target function on an ambient temperature, to temperature diesel cooling water, to weight of train are imposed

3. On the basis of model for determination of probabilities of presence of diesel locomotives in the different states of the system worked out, an equation for the calculation of expense of fuel by diesel-locomotive switcher which work on the system of two units for a change taking into account time of operation on the different modes and change of the modes at implementation of mobile operations were developed.

4. The calculations of fuel expenses on this model perspective direction of increase of degree of the use of diesel-generator options of mobile diesel engines which work on the system of two units will allow to ground.

REFERENCES

1. **Basov G.G., Bykadorov V.P., Mishchenko K.P., Naysh N.M., 2006.:** Lugansk locomotive 1956 - 2006: Directory, Lugansk, JSC "HC "Luganskteplovoz", 518 p.
2. **Beletsky Y.V., Naish N.M., Kalabuhin Y.E., 2010.:** Monitoring systems of fuel profitability. Lugansk, East-Ukrainian National University named after V. Dahl, No. № 1 (143), pp. 26-30.
3. **Chernetskaya N.B., Beletsky Y.V., Varakuta E.A., 2010.:** Complex approach to versatile use of cargo locomotives on Ukrainian railways. Science and education: International scientific conference, February, 12-22th, Colombo, pp. 40-43.
4. **Chernjak U.V., Sazonov V.O., Guschin A.M., Doroshenko V.I., Gatchenko V.O., 2006.:** Reserves of diesel fuel economy by екфшт and shunting diesel locomotives are not settled. Coll. scient. proceedings, Kharkov, UkrDAZT, Vol. 72, pp. 17-21.
5. **Falendish A.P., Gatchenko V.O., 2011.:** Modelling of the fuel expense by shunting diesel locomotives which work on system of two units on the basis of mathematical model. Coll. of proceedings, DIRT, Dnetsk, No. 26, pp. 95-101.
6. **Falendish A.P., Gatchenko V.O., Sumtsov A.L., 2012.:** Choice of optimisation ways of shunting diesel locomotives work which work on system of two units. Lugansk, East-Ukrainian National University named after V. Dahl, No. № 5 (176), pp. 91-96.
7. **Falendish A.P., Ustenko O.V., Gatchenko V.O., Volodarets N.V., 2011.:** Definition model of system conditions of shunting diesel locomotives work on system of two units. Coll. scient. proceedings, Kharkov, UkrDAZT, Vol. 123, pp. 17-24.
8. **Gatchenko V.O., 2011.:** Estimation of influence of operational factors on operating mode and the expense of fuel of shunting diesel locomotives which work on system of two units. Coll. of proceedings, DIRT, Dnetsk, No. 25, pp. 145-150.
9. **Gorbunov N., Kostyukevich A., Kravchenko K., 2010.:** Efficiency function for evaluation of the locomotive traction and adhesion qualities, TEKA Commission of Motorization and Power Industry in Agriculture V. X, Poland 2010. – pp. 80 - 86.
10. **Gorbunov N., Kostyukevich A., Kravchenko K., Kovtanets M., 2010.:** Influence of operatonal factors on redistribution of wheel pairs vertical loads upon rails, TEKA Commission of Motorization and Power Industry in Agriculture XIA. Poland 2011. – pp. 92-99.
11. **Kalabuhin Y.E., Beletsky Y.V., 2009.:** The basic criteria of versatile use of a rolling stock of Ukrainian railways. Bulletin of Ukrainian Engineering academy, Vol. 3-4, pp. 189-192.
12. **Kalabuhin Y.E., Beletsky Y.V., 2010.:** The analysis of possibilities of multi-purpose use of locomotives on Ukrainian railways. Bulletin of BelSUT: science and transport, Vol. 1(20), pp. 19-21.
13. **Kossov Y.Y., Azarenko V.A., Komaritsky M.M., 2007.:** To a question about choice of power characteristics of a perspective independent traction rolling stock. Transport of the Russian Federation. No. 10, pp. 20-21.
14. Methodical instructions of diesel fuel expenses calculation in locomotives shunting work,: 2000, CT-2421.
15. Methodical recommendations about rationing of specific expenses of fuel and energy,:2001, CT-249.
16. **Osipov S.N., Mironov K.A., Revich V.I., 1979.:** Basics of locomotive traction. Moskow, Transport, 440 p.
17. **Pappok K.K., Semenido E.G. 1962.:** Motor, rocket and missile fuel, Moskow, Gostoptekhizdat, pp. 741.

18. **Stepanov E.M., Dychkov B.G., 1968.:** Ionization in the flame and the electric field, Moskow, Metallurgy, 312 p.
19. **Sumtsov A.L., Bragin N.I., Klimenko O., 2012.:** The analysis of service systems of the modernised shunting diesel locomotives. Lugansk, East-Ukrainian National University named after V. Dahl, No. № 3 (147), pp. 185-188.
20. The instruction on technical rationing of electric energy expenses and fuel locomotives on draught of trains,: 2003, CT-0059.

МОДЕЛЬ ВЫБОРА ОПТИМАЛЬНЫХ РЕЖИМОВ РАБОТЫ МАНЕВРОВЫХ ТЕПЛОВОЗОВ, КОТОРЫЕ РАБОТАЮТ ПО СИСТЕМЕ ДВУХ ЕДИНИЦ НА ОСНОВЕ КРИТЕРИЯ СНИЖЕНИЯ РАСХОДА ТОПЛИВА

Анатолий Фалендыш, Виктория Гатченко, Юрий Белецкий

А н н о т а ц и я . В статье рассмотрены вопросы оптимизации работы дизель-генераторной установки. Определена целевая функция суммарных затрат топлива тепловозами, составлено уравнение для расчета расхода топлива маневровыми тепловозами, которые работают по системе двух единиц.
К л ю ч е в ы е с л о в а . Целевая функция, система двух единиц, расход топлива, маневровый тепловоз, затраты энергии.

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Diesel-locomotive switcher's modernisation by hybrid transmission of power

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Summary. The questions of diesel locomotive's modernization with a hybrid transmission and workings out of model of definition necessary for power consumption of the energy store and power-plant power which are established on it are considered in the article.
Keywords. switcher, hybrid transmission, model, power consumption, energy store, power-plant.

INTRODACTION

Power of diesel locomotives during exploitation changes in wide limits. It goes out from many observations that a loading of locomotives power-plant depends on the polygon of exploitation and never exceeds a value 0,5 [Kossov, Azarenko, Komaritsky 2007, Kossov, Azarenko, Kornev, Komarnitskiy 2008]. It means that middle service rating of locomotives power-plant average is not more than half from her capacity.

If we set the energy store of sufficient capacity on a locomotive, then the set power of power-plant can be reduced in two times and anymore without harm for implementation of hauling work [CT-2421 2000, CT-249 2001, CT-0059 2003].

Storage batteries, condensers of high capacity, can be used in quality of possible energy stores, gyroscopic vehicles [Gulia 1980]. The power intensity of store on a locomotive is limited to gravimetric, by volume and cost descriptions.

Therefore determination of minimum power intensity of store, which is needed for implementation of certain type of locomotives work, is expedient.

RESEARCH OBJECT

Development of technical decisions in relation to modernization of mobile diesel engine by the hybrid transmission of power and determination for it of necessary power-hungriness of store of energy and power of power-plant.

BASIC MATERIAL

Application of energy store in the locomotive hauling network - is one of ways of the cost of fuel cutting on traction in the whole world [Falendish, Volodarets 2010, Golubenko, Mogila, Nozhenko 2007]. It is most actual for a locomotive power which works in the pulse-mode, for example: motor carriage rolling stocks, shunting engines.

In a table 1 comparative description over of hybrid and storage-battery locomotives is brought.

Practice proves that middle power of diesel-locomotive switcher's diesels folds 10-15% from nominal power of diesel. Therefore the use of energy store exactly for diesel-locomotive switcher is most appropriate. For realization of this project it is necessary to decide next questions:

- ground of modernisation method is by transfer it in the system of hybrid diesel locomotive;
- ground of necessary power of the diesel-generator setting;
- development of the diesel-generator setting of small capacity direct current;

Table 1. Comparative description of hybrid and storage-battery locomotives

Parameter	Series of locomotive					
	CKD (Prague) TA436.05 (718)	Railpower GG20B GreenGoat	Railpower GG10K GreenKid	GE Evolution Hybrid locomotive	LAM-01	CHME3
Type of energy store (ES)	storage battery of NiCd NKS300	lead-acid storage battery		storage battery of NaNiCL2	storage battery of NiCd	-
Power of ES max., kW	400			1300 (1460)		
Economy, %	to 24	20-70	to 55	15		-
Energy, kW·h	172,8	720	360	1000		
Energy, mega Joile	622	2592	1296	3600		
Tension, V	576	600	300			
Capacity, A·h	300	1200	1200			
Mass of ES, t	11,5					-
Year of making	1986	2002	2004	2007	2003	1960
Axial formula	Bo' - Bo'	Bo - Bo	Bo - Bo	Co - Co	1o-1-1o+ 1o-1-1o	3_O-3_O
Operating mass, t	64	127	112,5	207	96±3%	123
Content of fuel, l	1280			9000	-	6000
Type of electricity transmission	alternating- direct current			alternating - alternating current	direct current	
N_{max} of disel+ storage batteries, kW	600	1400	700		-	-
Ne, kW	189	200	90	3280	129	993
F_{max}, kN	161			534	160	362
F_{∞}, kN	104			427	30	225
v_{max}, kilometre/h	65	96,5	48,3	120	80	95

- ground of necessary capacity of energy store;
- ground of type energy stores;
- development of electric charts of power transmission from the energy store to the railway motor.

It is foreseen that after modernization of switcher and conversion of it in the hybrid diesel locomotive, expense of diesel fuel can diminish to 50% and emission in the atmosphere of harmful substances will go down on 80 - 90%.

Quantitative description of object technical perfection degree is determined of it technical level and presents a component of technical estimation at the general estimation of transport vehicles quality.

Expecting the coefficients of K technical level for the considered switchers in relation to the diesel locomotive CHME 3, will get their next values:

$$K_{(TA\ 436.05\ (718))}=0,68,\ K_{(LAMAS\text{-}01)}=0,52,\ K_{(GG10K\ GreenKid)}=1,02,\ K_{(GG20B\ GreenGoat)}=1,32.$$

Coming from aforesaid, it is possible to draw conclusion that creation of hybrid locomotive on the base of switcher CHME 3 is an expedient decision.

For planning of hybrid diesel locomotive it is necessary to be determined with the parameters of the diesel-generator setting and energy stores. A locomotive will work on a next chart: work on the middle loading will be provided by the engine of low power, during work on idling and subzero loading the engine of will fill up the supply of energy in a store and carry out work of diesel engine, and on the high loading of diesel engine will come true due to energy of store and due to the engine of low power.

Existent models of calculation of locomotive parameters of [Kamaev 1981, Ivanov 1974, Birukov, Savoskin, Burchak 1992] does not foresee hybrid traction, that is why in this kind used can not be and require their revision. The model of determination of technical and economic indices was worked out to the diesel engine with a hybrid transmission [Falendish, Volodarets 2010], but there is a necessity for determination of it optimal parameters.

For the decision of this question the programming algorithm of power intensity calculation of energy store and switcher's power with a hybrid transmission was made, which is represented on fig. 1.

For the analysis of BISP input data are: power-plant power of Nf, which was determined during a journey each 2 minutes $\Delta\tau$. As a result get: value of the fixed data amount n, duration of work to the diesel engine τcm, and also dependence of Nf(τ).

During the choice of engine power by a input data are: vector i from BISP data, steps amount Nsteep of engine power change which settles accounts, and on the basis of it vector j. Thus we calculated: coefficient of power change bj, middle power from BISP data Ncp, power Npr, which is accepted at quality base for calculations, engine power which settles accounts, Nustj.

For the calculation of energy store power intensity use next data: initial power of calculation E_o [Gorbunov, Kostyukevich, Kravchenko, Kovtanets 2010]. Thus the necessary power intensity of energy store E_{nej} settles accounts minimum depending on select engine power, and also the power intensity of energy store E_i is determined, j on every stage of treason of necessary power to the diesel engine, and dependence of objective power $E(\tau)$ from time of work τ.

For determination of dependence *Ene(Neng)* of necessary power intensity of energy store and power of diesel locomotive engine by a input data is a vector of $Neng_j$ of values of power installation and vector Ene_j of values of store minimum power intensity, necessary for providing initial work of locomotive.

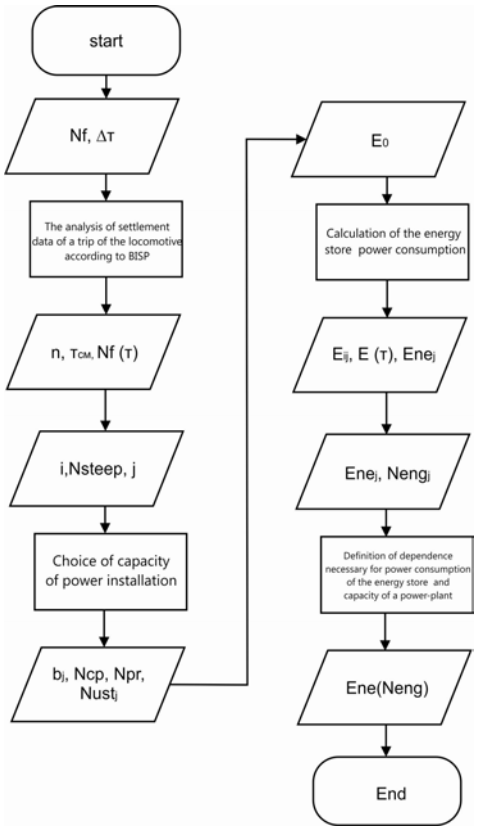

Fig. 1. Programming algorithm of power intensity calculation of energy store and switcher's with a hybrid transmission

On the basis of the offered algorithm the program of necessary power intensity calculation of energy store and power installation was worked out to the diesel locomotive with a hybrid transmission by means of program package MATHCAD [Mogila, Nozhenko 2007].

Using this program for design switcher with a hybrid transmission, it is possible to choose rational correlations it power installation and energy store [Gatchenko 2011, Gorbunov, Kostyukevich, Kravchenko 2010.].

We consider it application on an example to the diesel locomotive CHME 3.

From data of BISP for the diesel locomotive CHME 3 №2191 dependence of locomotive operating power Nf_i is built on time of it work τ_{and}. This dependence is represented on fig. 2.

It is farther necessary to choose power of locomotive power installation and depending on it expect power intensity of energy store for every *i* step of change of locomotive operating power. Graphicly it is represented as dependence of power intensity E_i of energy store on time of locomotive work τ_{and}.

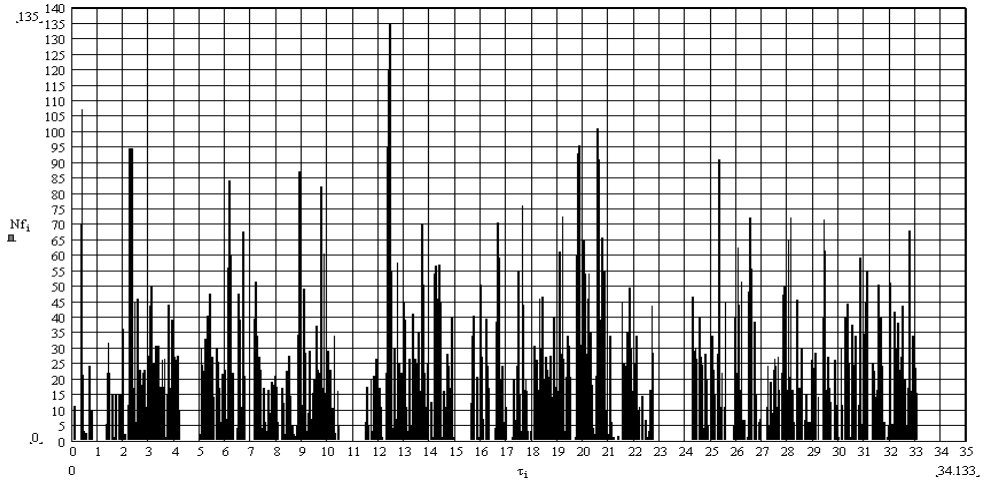

Fig. 2. Dependence of operating power to the diesel locomotive CHME 3 from time of it work from BISP data

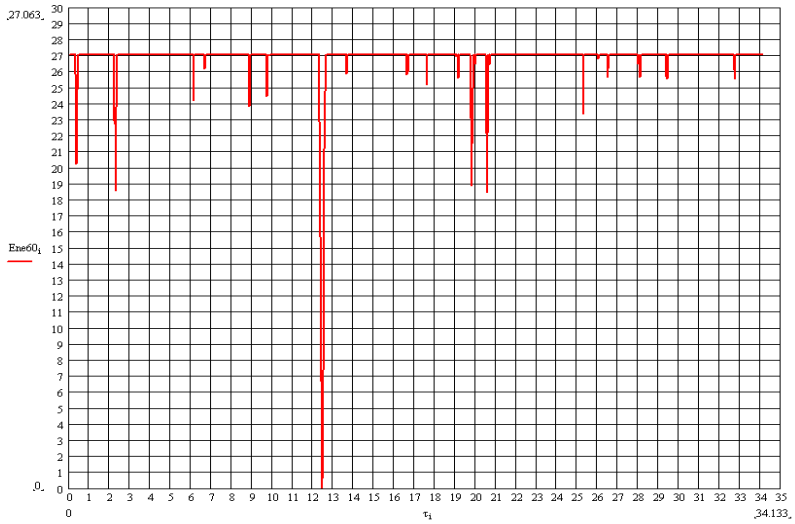

Fig. 3. is Dependence of power intensity of energy store on time of locomotive work $\tau_{and.}$ for power installation power 60 kW

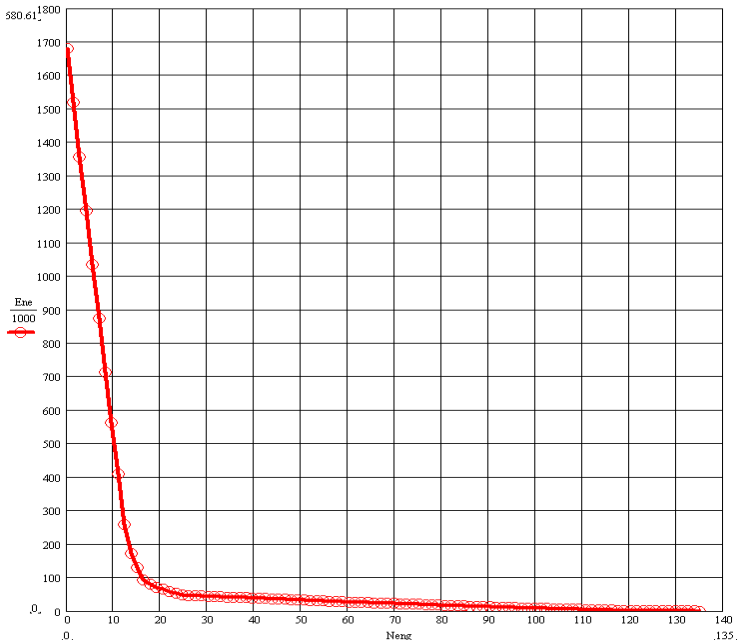

Fig 4. Dependence of power intensity of energy store *Ene* on power of select power-plant *Neng* for basic work reference

On fig. 3 for the examined operating mode of diesel locomotive CHME 3 considered dependence E_i (τ_i) is brought at select power *Neng* of power installation 60 kW [Falendish, Volodarets, Bragin, Zaytsev 2010].

It goes out from resulted to figure, that for an engine with power 60 kW it is necessary to choose the energy store with minimum power intensity 27 M Joil.

And on the last stage for to the projected diesel locomotive taking into account the change of it operating power dependence of power intensity of energy store *Ene* is built on power of select power-plant *Neng* [Falendish, Bragin 2011]. Dependence *Ene (Neng)* for the considered regime of work of diesel locomotive CHME 3 is represented on fig. 4.

Electing the type of store, it is needed also to take into account it mass-size indexes [Sumtsov, Bragin, Klimenko 2012]. Therefore there is a necessity for the calculation of maximum power intensity of energy store which is limited to free space of diesel locomotive. For this purpose it is necessary to know it specific weight and capacity [Chernjak, Sazonov, Guschin, Doroshenko, Gatchenko 2006].

In a table 2 specific indexes over of various energy stores are brought.

Table 2. Specific indexes of energy stores

Type of store	Specific mass, kg/kJoil	Specific volume, l/kJoil
Condenser of public corporation «Ekond»	0,37	0,19
Electrochemical condenser of «Esma»	0,068	0,0465
Flywheel	0,0042	0,0009
Nickel-cadmium battery	0,021	0,012
lithium-ion battery	0,0003	0,001

On the basis of these indexes, and also on condition of limitation of free space to the diesel engine of CHME 3, the maximum power-intensity of various stores of energy was expected. Results over of calculation are brought in a table 3.

Table 3. Results of calculation of maximum power intensity of various energy stores for diesel locomotive CHME3

Type of store	Power intensity on the type of limitation, MJoil	
	On mass	On volume
Type of store	54	211
Condenser of public corporation «Ekond»	294	860
Electrochemical condenser of «Esma»	4761	44444
Flywheel	952	3333
Nickel-cadmium battery	66667	40000

From comparison of calculations which over are brought in a table 3 and on fig. 4, it goes out that for the locomotive CHME 3 it is possible to choose any of the cited above stores on condition of their mass-size parameters.

CONCLUSIONS

1. The analysis of existent locomotives which have hybrid traction is conducted, and calculated its expected technical level were fulfilled.
2. Analyses of existent diesel-locomotive switcher's work were conducted.
3. Some of technical decisions is offered in relation to modernization of diesel-locomotive switcher by the hybrid transmission of power.
4. Calculation model of necessary power intensity of energy store and power installation power of switcher with a hybrid transmission procedured, algorithm and program of calculation were developed
5. The uses of various energy stores are reasonable on condition of their mass-size parameters was ground.

REFERENCES

1. **Birukov I.V., Savoskin A.N., Burchak G.P., 1992.:** Mechanical part of a traction rolling stock. Textbook for students, Moscow, Transport, 440 p.
2. **Chernjak U.V., Sazonov V.O., Guschin A.M., Doroshenko V.I., Gatchenko V.O., 2006.:** Reserves of diesel fuel economy by shunting diesel locomotives are not settled. Coll. scient. proceedings, Kharkov, UkrDAZT, Vol. 72, pp. 17-21.
3. **Falendish A.P., Bragin N.I., 2011.:** Information settlement system of an estimation of a technological level of diesel trains. Lugansk, East-Ukrainian National University named after V. Dahl, No. № 3 (147), pp. 185-188.
4. **Falendish A.P., Volodarets N.V., 2010.:** Technological level estimation switcher locomotives with hybrid transfer. Lugansk, East-Ukrainian National University named after V.Dahl, No. №5(147), pp. 134-141.
5. **Falendish A.P., Volodarets N.V., 2010.:** Working out of calculation model of performance characteristics of a shunting diesel locomotive with use of hybrid draught. Coll. of proceedings, DIRT, Dnetsk, No. 23, pp. 156-162.
6. **Falendish A.P., Volodarets N.V., Bragin N.I., Zaytsev A.V., 2010.:** International scientific and practical conference of young scientists and students «Innovation technologies on a railway transport», 23-25 September. Krasny Liman, pp. 108-109.
7. **Gatchenko V.O., 2011.:** Estimation of influence of

operational factors on operating mode and the expense of fuel of shunting diesel locomotives which work on system of two units. Coll. of proceedings, DIRT, Dnetsk, No. 25, pp. 145-150.

8. **Golubenko A., Mogila V., Nozhenko H., 2007.:** Energy of diesel locomotive's electrodynamic braking for increase of efficiency of diesel locomotive engines, Coll. of scientific labours, Zilina. Issue 69, pp. 163 - 170.
9. **Gorbunov N., Kostyukevich A., Kravchenko K., 2010.:** Efficiency function for evaluation of the locomotive traction and adhesion qualities, TEKA Commission of Motorization and Power Industry in Agriculture V. X, Poland 2010. – pp. 80 - 86.
10. **Gorbunov N., Kostyukevich A., Kravchenko K., Kovtanets M., 2010.:** Influence of operatonal factors on redistribution of wheel pairs vertical loads upon rails, TEKA Commission of Motorization and Power Industry in Agriculture XIA. Poland 2011. – pp. 92-99.
11. **Gulia N.V., 1980.:** Energy stores. Science, Moscow, pp. 137-138.
12. **Ivanov V.N., 1974.:** Design and dynamics of diesel locomotives. Moscow, Transport, 336 p.
13. **Kamaev A.A., 1981.:** Design, calculation and designing of locomotives. Textbook for students, Moscow, Mechanical engineering, 351 p.
14. **Kossov Y.Y., Azarenko V.A., Komaritsky M.M., 2007.:** To a question about choice of power characteristics of a perspective independent traction rolling stock. Transport of the Russian Federation. No. 10, pp. 20-21.
15. Methodical instructions of diesel fuel expenses calculation in locomotives shunting work,: 2000, CT-2421.
16. Methodical recommendations about rationing of specific expenses of fuel and energy,:2001, CT-249.
17. **Mogila V.I., Nozhenko Y.S., 2007.:** Using wasted energy used for braking of the locomotive efficiency diesel engines, Collected scient. proceedings, Kharkov, UkrDAZT, Vol. 82, pp. 153-157.
18. **Sumtsov A.L., Bragin N.I., Klimenko O., 2012.:** The analysis of service systems of the modernised shunting diesel locomotives. Lugansk, East-Ukrainian National University named after V. Dahl, No. № 3 (147), pp. 185-188.
19. The instruction on technical rationing of electric energy expenses and fuel locomotives on draught of trains,: 2003, CT-0059.
20. **Kossov Y.Y., Azarenko V.A., Kornev A.N., Komarnitskiy M.M., 2008.:** Influence the efficiency of energy storage in the fuel efficiency of the locomotive, Locomotivinform, №3, 2008, pp. 44 – 45.

МОДЕРНИЗАЦИЯ МАНЕВРОВОГО ТЕПЛОВОЗА ГИБРИДНОЙ ПЕРЕДАЧЕЙ МОЩНОСТИ

Анатолий Фалендыш, Никита Брагин, Никита Володарец

Аннотация. В статье рассмотрены вопросы модернизации маневрового тепловоза гибридной передачей и разработки модели определения необходимой энергоемкости накопителя энергии и мощности силовой установки, которые установлены на нем.

Ключевые слова: маневровый тепловоз, гибридная передача, модель, энергоемкость, накопитель энергии, силовая установка.

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Enrichability curves analysis of several coals mixture

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Summary. The paper analyzes the shape of the curve enrichment few coals. The numerical experiment a mixture of four coal mines. A comparison of the curves with the curves of mixtures enrichability raw material prove the assertion of the immutability of species distribution functions boundary ash and coal density fractions in description of the fractional composition of multi-component mixtures of coal

Key words: fraction composition, weight distribution function, a mixture of several coal enrichability curves.

INTRODUCTION

Traditionally [1,2,3] among specialists in coal enrichment a table view of fractional composition is used. The process of finding a table view for a given coal mixture with equity participation from a mathematical point of view, is not complicated, but it has some significant limitations, such as, for example, the inability to obtain the characteristics of the mixture, if splitting into fractions for the terms do not match.

Actual task is to obtain the characteristics of a several coals mixture given arbitrarily, since this problem is solved as in the formation of the several coals batch, as well as directly in the calculation scheme of coal preparation plant [4,5,6,7], such as the calculation of coal preparation plant unit [8,9,10,11,12], which is the union of several coal streams from other units [13,14,15].

OBJECTS AND PROBLEMS

Recent research shows perspectivity of use weight distribution functions to describe the equations of fractional composition. A model is proposed to describe the fractional composition of the raw coal in [4,5,6], and in [7,8,9] a method of fractional composition information recovery based on the proposed model.

These results are relevant for solving a large number of coal enrichment tasks [16,17,18,19], such as the calculation the batch, the evaluation indicators of enrichment and separation, and the results of others [20,21,22,23,24].

The solution of these problems on the basis of analytical description of the raw coals mixture [9] is based on the assumption of enrichment curves form immutability, which, of course, needs no proof.

THE RESULTS OF RESEARCH

As is known, the distribution function of the density and ash content of coal fractions are [1].

Then, using the concept of enrichability [1] surface, the fractional composition can be written as:

$$\Gamma(\rho)=\frac{1}{1+\left(a_0+a_1 t_\rho\right)\sqrt{\frac{1}{t_\rho}-1}},\ t_\rho=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F(\lambda)=\frac{1}{1+\left(b_0+b_1 t_\lambda\right)\sqrt{\frac{1}{t_\lambda}-1}},\ t_\lambda=\left(\frac{\lambda-\lambda_{01}}{\lambda_{k1}-\lambda_{01}}\right)^2$$

$$U\left(\rho_{i-1},\rho_i\right)=\frac{\Lambda\left(\Gamma_i\left(\rho_i\right)\right)-\Lambda\left(\Gamma_{i-1}\left(\rho_{i-1}\right)\right)}{\Gamma_i\left(\rho_i\right)-\Gamma_{i-1}\left(\rho_{i-1}\right)}$$

$$\Lambda(\Gamma)=\int_0^\Gamma \lambda(\Gamma)d\Gamma,$$

where: a_0, a_1, b_0, b_1 – parameters on the results of the experiment.

Obviously, to get the total number of the coals mixture characteristics, given the parameters of the fractional composition equations is sufficient to obtain an algorithm for determining the distribution function parameters, for example, the density, since the distribution function in the algorithm is the same for the ash. So, let

$$F_1(t)=\frac{1}{1+(a_{01}+a_{11}t)\sqrt{\frac{1}{t}-1}} \quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_2(t)=\frac{1}{1+(a_{21}+a_{21}t)\sqrt{\frac{1}{t}-1}} \quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_3(t)=\frac{1}{1+(a_{31}+a_{31}t)\sqrt{\frac{1}{t}-1}} \quad t=\left(\frac{\rho-\rho_{01}}{\rho_{k1}-\rho_{01}}\right)^2$$

$$F_3(t)=p_1F_1(t)+p_2F_2(t).$$

Obviously, because ρ_0 it ρ_k makes sense and not just the parameters of the distribution, and are physical values, namely, the minimum and maximum density of raw materials, it is obvious that the minimum density as a result of two distribution laws superposition is $\rho_{03}=\min\{\rho_{01};\rho_{02}\}$, and accordingly, the maximum density $\rho_{k3}=\max\{\rho_{k1};\rho_{k2}\}$. Then for mathematical correctness, it is necessary to determine the distribution function as follows:

$$F(t)=\begin{cases}0, \rho<\rho_0\\ \dfrac{1}{1+(a_0+a_1t)\sqrt{\frac{1}{t}-1}}, \rho_0<\rho<\rho_k\\ 1, \rho>\rho_k\end{cases}.$$

One way of finding the distribution function parameters is the final realization of the changes in the table analytic representation, perform calculations in a table, and then perform the inverse transformation in analytical form. Although this approach at first glance looks like the easiest way to get the distribution function final parameters, it has several disadvantages, one of which is the time it takes to double conversion.

Let us introduce the auxiliary function

$$\varphi(\theta)=\left\|F_3(\theta,t)-\left(p_1F_1(t)+p_2F_2(t)\right)\right\|,$$

where: θ – vector of the desired function unknown parameters.

Then, the problem reduces to solving a standard problem of finding the minimum of the function.

The proposed approach can be used for finding the parameters of the law as a distribution by density, and by ash content. Moreover, a similar approach can be applied in the case of equations size distribution. In addition, the proposed approach allows as well to find the parameters composition of n functions.

To solve the problems we will use the information about fraction composition of four different coal mines. Fractional composition of the raw coals from the coal mines is given in tables 1-4.

Thus, the proposed algorithm for finding the parameters of the several coals fractional composition equations allows for all calculations.

Table 1. Fractional composition of the coal mine number one "Almaznaya"

ρ , t/m3	γ_{teor} ,%	A^d_{teor} ,%	γ_{exp} ,%	A^d_{exp} ,%
<1.6	30,8698	8,5999	30,87	8,6
1,6-1,8	46,9603	47,5004	46,96	47,5
>1,8	22,1699	92,1991	22,17	92,2

where: ρ – density of narrow fractions γ_{exp} – experimental output value narrow faction A^d_{exp} – experimental value of the average ash content of narrow fraction, γ_{teor} – output value narrow fraction, obtained by simulation, A^d_{teor} – the average ash content of narrow fraction, obtained by simulation.

Weight distribution function of raw materials fractional composition from coal mine "Almaznaya" have forms (fig. 1, fig. 2)

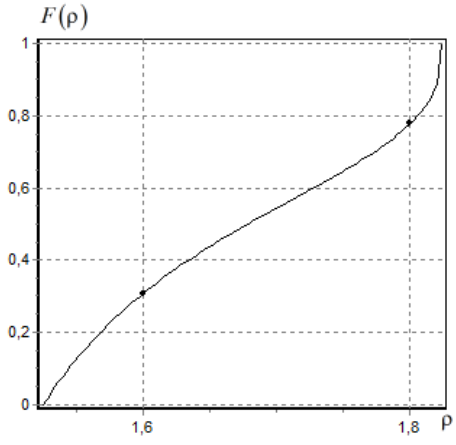

Fig. 1. The distribution function by the coal fractions boundary density

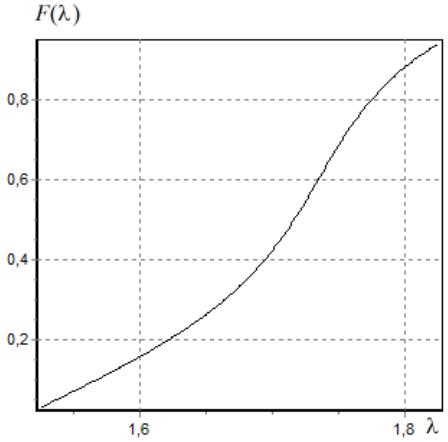

Fig. 2. The distribution function by the coal fractions boundary ash content

Table 2. Fractional composition of the coal mine number two "Zarechnaya"

ρ , t/m3	γ_{teor} ,%	A^{d}_{teor} ,%	γ_{exp} ,%	A^{d}_{exp} ,%
<1.6	75,3231	2,6104	75,3131	18,8
1,6-1,8	14,9195	5,6987	14,9195	33,1
>1,8	9,7574	20,1238	9,7674	46,7

Weight distribution function of raw materials fractional composition from coal mine "Zarechnaya" have forms (fig. 3, fig. 4) follows:

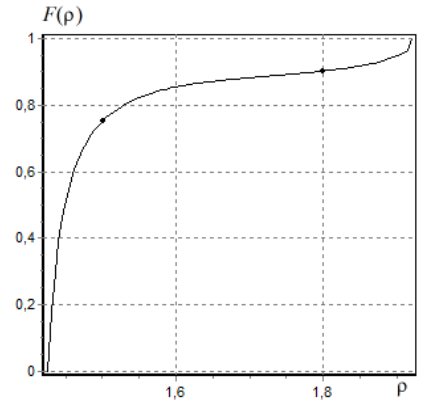

Fig. 3. The distribution function by the coal fractions boundary density

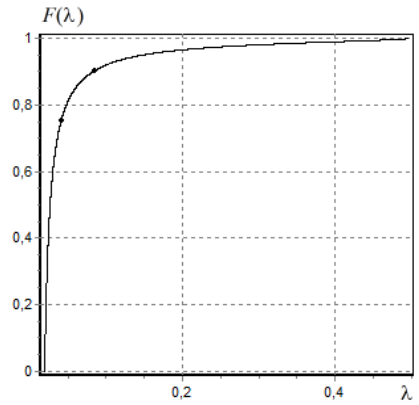

Fig. 4. The distribution function by the coal fractions boundary ash content

Table 3. Fractional composition of coal mine number 3 "Velikomostovskaya"

ρ , t/m3	γ_{teor} ,%	A^{d}_{teor} ,%	γ_{exp} ,%	A^{d}_{exp} ,%
<1.6	71,3231	2,6104	71,3231	18,8
1,6-1,8	19,6595	5,6987	19,6595	2,89
>1,8	9,7523	20,1238	9,7523	1,89

Weight distribution function of raw materials fractional composition from coal mine "Velikomostovskaya" have forms (fig. 5, fig. 6) follows:

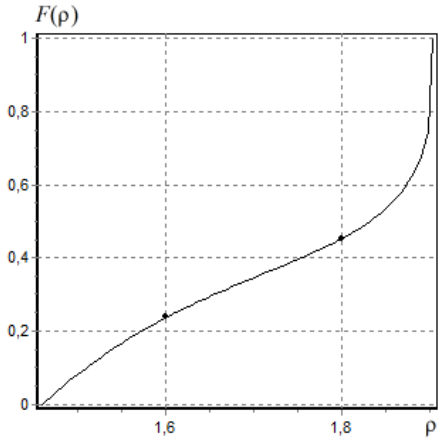

Fig. 5. The distribution function by the coal fractions boundary density

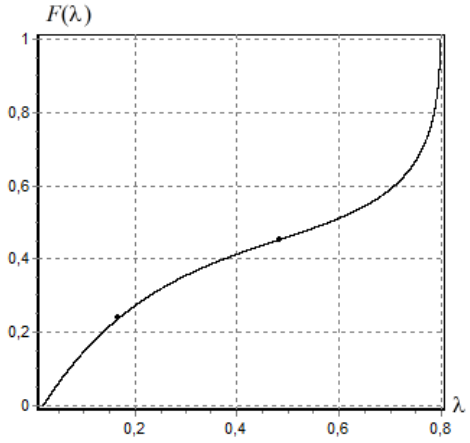

Fig. 6. The distribution function by the coal fractions boundary ash content

Table 4. Fractional composition of coal mine № 4 "Novodonetskaya"

$\rho_{т/м^3}$	γ_{teor} %	A^{d}_{teor} %	γ_{exp} %	A^{d}_{exp} %
<1.6	34,2574	9,4483	34,6	7,5
1,6-1,8	8,5149	25,126	8,6	26,7
>1,8	57,2277	83,2856	57,8	83,3

Weight distribution function of raw materials fractional composition from coal mine "Novodonetskaya" have forms (fig. 7, fig. 8) follows:

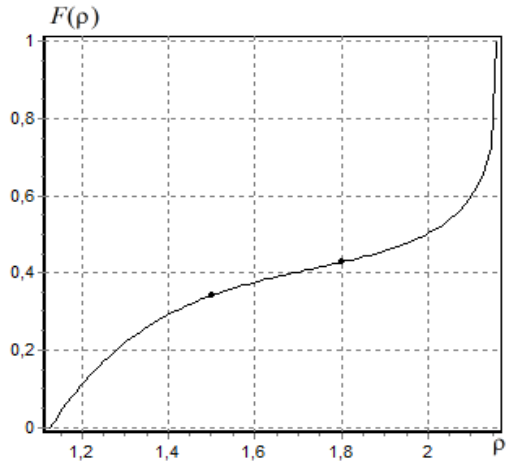

Fig. 7. The distribution function by the coal fractions boundary density

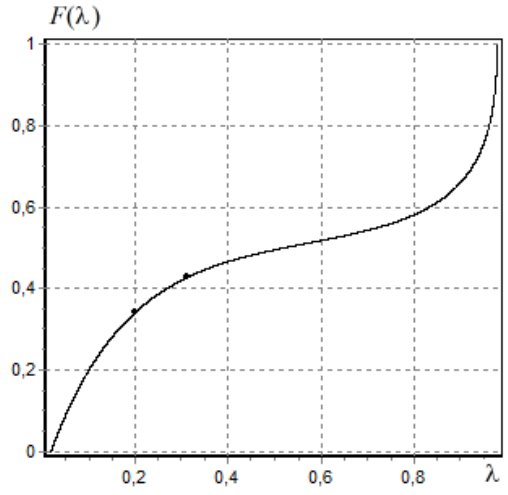

Fig. 8. The distribution function by the coal fractions boundary ash content

Fractional composition of the mixture for numerical experiments we find as a linear combination with the corresponding outputs

$$\gamma = q_1\gamma_1 + q_2\gamma_2 + q_3\gamma_3 + q_4\gamma_4,$$

where: $q_i, i = 1,2,3,4$, the batch components equity participation, and similarly for the average ash content.

The numerical experiment number 1 with equity participation: $q_1 = 0.3$, $q_2 = 0.4$, $q_3 = 0.4$, $q_4 = 0.5$ (table 5, fig. 9, fig. 10).

Table 5. Fractional composition. Numerical experiment number one

$\rho_{т/м^3}$	γ_{teor} %	A^d_{teor} %	γ_{exp} %	A^d_{exp} %
<1.6	26,64	9,39244	26,64	9,39
1,6-1,8	30,2811	23,53323	30,28	23,53
>1,8	43,0707	48,48292	43,07	48,47

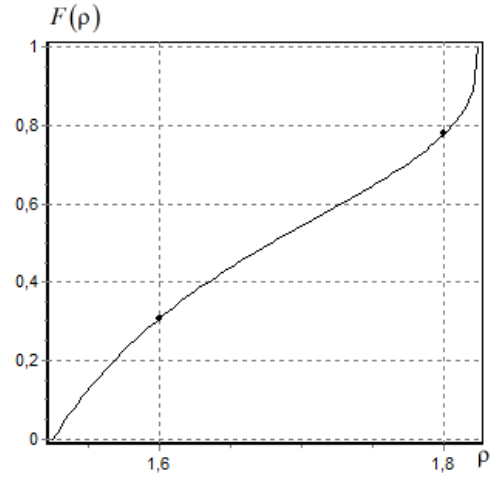

Fig. 9. The distribution function by the coal fractions boundary density

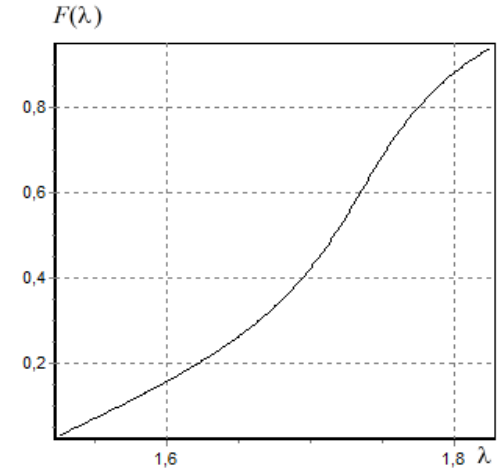

Fig. 10. The distribution function by the coal fractions boundary ash content

The numerical experiment number 2 with equity participation: $q_1 = 0.1$, $q_2 = 0.3$, $q_3 = 0.5$, $q_4 = 0.2$ (table 6, fig. 11, fig. 12).

Table 6. Fractional composition. Numerical experiment number two

$\rho_{т/м^3}$	γ_{teor} %	A^d_{teor} %	γ_{exp} %	A^d_{exp} %
<1.6	70,19694	4,83797	63,82	5,95
1,6-1,8	18,33461	14,3342	16,67	15,1
>1,8	21,46845	41,97607	19,52	44,62

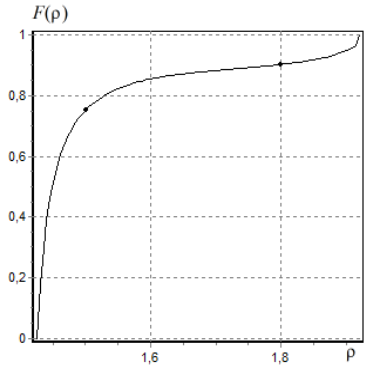

Fig. 11. The distribution function by the coal fractions boundary density

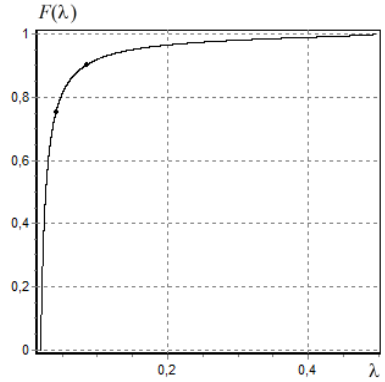

Fig. 12. The distribution function by the coal fractions boundary ash content

The numerical experiment number 3 with equity participation: $q_1 = 0.2$, $q_2 = 0.2$, $q_3 = 0.6$, $q_4 = 0.1$ (table 7, fig. 13, fig. 14).

Table 7. Fractional composition. Numerical experiment number three

$\rho_{т/м^3}$	γ_{teor} %	A^d_{teor} %	γ_{exp} %	A^d_{exp} %
<1.6	69,8581	3,5552	69,86	3,55
1,6-1,8	12,1791	8,2113	12,18	8,22
>1,8	17,9626	28,4523	17,96	28,45

Weight distribution functions have forms as follows:

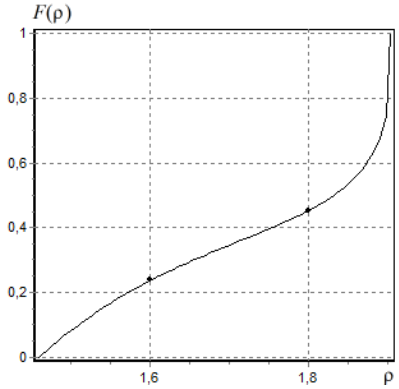

Fig. 13. The distribution function by the coal fractions boundary density

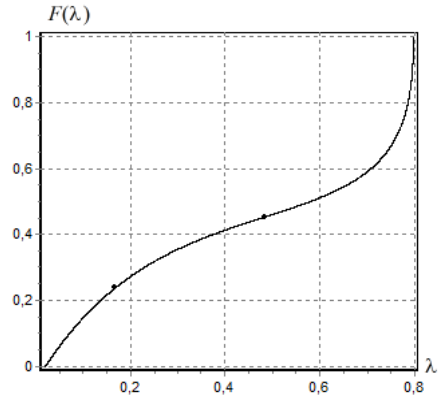

Fig. 14. The distribution function by the coal fractions boundary ash content

The numerical experiment number 4 with equity participation: $q_1 = 0.2$, $q_2 = 0.1$, $q_3 = 0.5$, $q_4 = 0.3$ (table 8, fig. 15, fig. 16).

Table 8. Fractional composition. Numerical experiment number four

$\rho_{т/м^3}$	γ_{teor} %	A^d_{teor} %	γ_{exp} %	A^d_{exp} %
<1.6	61,64504	6,12071	60,44	6,39
1,6-1,8	20,89823	20,4571	20,49	20,75
>1,8	19,45673	55,4997	19,08	56,25

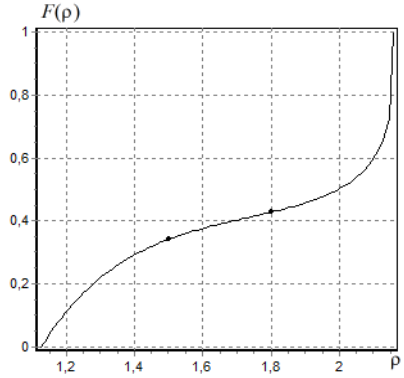

Fig. 15. The distribution function by the coal fractions boundary density

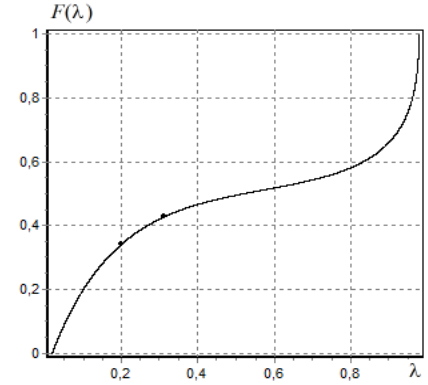

Fig. 16. The distribution function by the coal fractions boundary ash content

CONCLUSIONS

Thus, our numerical simulation shows that the weight distribution function boundary density and average ash mixture of raw coal has the same form as the weight distribution function boundary density and average ash coals involved in the formation of the charge, do not change their appearance. This result confirms the correctness of the method of fractional recovery of not only for modeling information about the raw material, but also on batch of several coal and problems of the forecast results of the division in batch of enrichment devices.

REFERENCES

1. Formalizacija rezul'tativ rozpodil'chyh procesiv u vuglezbagachenni /[V.K. Garus , O.V. Grachov, V.F. Pozhydaev , O.D. Poluljah]: Monografija. – Lugans'k: vyd. OOO «NVF» STEK», 2003. – 176 s. – ISBN 966-96298-3-2
2. **Tihonov O.N., 1985.:** Avtomatizacija proizvodstvennyh processov na obogatitel'nyh fabrikah. – M.: Nedra, – 272s.
3. **Tihonov O.N., 1973.:** Vvedenie v dinamiku massoperenosa processov obogatitel'noj tehnologii. – L.: Nedra,. – 239s.
4. **Grachev O. V., 1999.:** Praktycheskyj analyz odnogo klassa antymodal'nыh raspredelenyj s cel'ju yh analytycheskogo opysanyja // Visnyk SUDU. – № 3 (18). – S. 73-76.
5. **Grachev O. V., 2000.:** Uslovyja matematycheskogo opysanyja raspredelenyja zol'nosty uglja po frakcyjam / V. F. Pozhydaev, O. V. Grachev // Visnyk SNU – №9 Ch.1. (31). – S. 99-105.
6. **Grachev O. V., 2002.:** Vyvod zakona raspredelenija razmerov chastic kak sluchajnoj velichiny dlja razlichnyh klassov krupnosti / V. F. Pozhidaev, O. V. Grachev // Praci Lugans'kogo viddilennja MAI. – № 1 (4). – S. 72-75.
7. **Grachev O.V., 2005.:** Sistema upravlenija processom podgotovki ugol'noj shihty s cel'ju optimal'nogo razdelenija po proizvol'nomu kriteriju / O.V. Grachev, V. F. Pozhidaev, V.A. Ul'shin // Zbagachennja korisnih kopalin: Nauk.-tehn. zb. NGU. – Dnipropetrovs'k, – Vip. 22(63). - S. 158-165.
8. **Grachev O.V., 2006.:** Razrabotka algoritma vosstanovlenija parametrov funkcii raspredelenija po krupnosti po minimal'nomu objemu oprobovanija / O.V. Grachev, V. F. Pozhidaev, V.A. Ul'shin // Praci Lugans'kogo viddilennja MAI. – № 2 (13). – S. 107-110.
9. **Grachev O.V., 2007.:** Algoritm rascheta parametrov zakona raspredelenija smesi uglej // Zbagachennja korisnih kopalin: Nauk.-tehn. zb. NGU. – Dnipropetrovs'k, – Vip. 29(70) – 30(71). - S. 39-41.
10. **Pozhidayev V., Grachyov O., 2010.:** The analytical problem solution of finding the several coals mix characteristics // Teka Kom. Mot. i Energ. Roln. – OL PAN, 10B, P. 105-113.
11. **Kolmogorov A.N., 1941.:** O logarifmicheskom normal'nom zakone raspredelenija razmerov chastic pri droblenii // DAN SSSR. Novaja Serija. – M., – T.31. – №2. – S.99-101.
12. **Nepomnjawij E.A., 1966.:** Stohasticheskaja teorija gravitacionnogo obogawenija v sloe konechnoj tolwiny // Gornyj zhurnal. – Sverdlovsk, – №7. – S.23.
13. **Grachev O.V., 2002.:** Vychislenie integrala verojatnosti s tochnost'ju, obuslovlennoj vozmozhnostjami vychislitel'noj tehniki / V. F. Pozhidaev, O. V. Grachev // Visnik SNU im. V. Dalja. – №12 Ch.1. (58). – S. 178-187.
14. **Grachev O.V., 2003.:** Jeffektivnost' povyshenija stabil'nosti kachestva ugol'nyh koncentratov // Visnik SNU im. V. Dalja. – № 4 (62). – S.126-129.
15. **Grachev O.V., 2007.:** Informacionnaja model' shemy ugleobogatitel'noj fabriki / V. F. Pozhidaev, O.V. Grachev, S.A. Tarasenko // Zbagachennja korisnih kopalin: Nauk.-tehn. zb. NGU. – Dnipropetrovs'k, – Vip. 29(70) – 30(71). - S. 216-218.
16. **Grachev O.V., 2008.:** Sintez determinirovannogo i stohasticheskogo algoritmov poiska global'nogo jekstremuma s obucheniem / V. F. Pozhidaev, O. V. Grachev // Visnik SNU im. V. Dalja. – №9 Ch.1. (127). – S. 170-174.
17. **Grachev O.V., 2009.:** Sintez zadach shihtovanija i optimizacii shemy obogatitel'noj fabriki / O.V. Grachev, V. F. Pozhidaev, V.A. Ul'shin // Visnik SNU im. V. Dalja. – № 1 (131). – S. 243-250.
18. **Grachev O.V., 2009.:** Ocenka jekonomicheskoj jeffektivnosti tehnologii obogawenija uglej / V. F. Pozhidaev, O.V. Grachev, N.M. Kramar', L.F. Sycheva // Visnik SNU im. V. Dalja. – № 1 Ch.2. (131). – S. 76-80.
19. **Grachev O.V., 2009.:** Sistema upravlenija kachestvom produktov razdelenija s pomow'ju rascheta ozhidaemyh pokazatelej obogawenija / V. F. Pozhidaev, O. V. Grachev // Zbagachennja korisnih kopalin: Nauk.-tehn. zb. NGU. – Dnipropetrovs'k, – Vip. 36(77) – 37(78). - S. 197-203.
20. **Grachev O.V., 2010.:** O neizmennosti vida funkcij raspredelenija granichnyh plotnostej i zol'nostej uglja po frakcijam // Visnik SNU im. V. Dalja. – №2(144). – S. 41-46.
21. **Ulshin V., Grachyov O., 2010.:** The analytical solution method of the ordinary coals optimum batching problem // Teka Kom. Mot. i Energ. Roln. – OL PAN, 10B, P. 266-274.
22. **Grachev O.V., 2009.:** Modelirovanie granulometricheskogo sostava i analiz ego uravnenij / O. V. Grachev, V. F. Pozhidaev // Tehnicheskaja mehanika. – №4. – S.111-114.
23. **Grachev O.V., 2010.:** Analiticheskij metod rascheta rezul'tatov razdelenija dlja upravlenija kachestvom produktov obogawenija / O. V. Grachev, V. F. Pozhidaev // Zbagachennja korisnih kopalin: Nauk.-tehn. zb. NGU. – Dnipropetrovs'k, – Vip. 41(82) – 42(83). - S. 244-250.
24. **Grachev O.V., 2002.:** Vid vesovoj funkcii raspredelenija plotnosti i zol'nosti uglja po frakcijam / V. F. Pozhidaev, O. V. Grachev // Naukovci – pidpriємstvam i ustanovam regionu: Zb. nauk. prac' SNU im. V. Dalja. – Lugans'k, 2002. – Ch.2. – S. 35.

АНАЛИЗ ВИДА КРИВЫХ ОБОГАТИМОСТИ СМЕСИ НЕСКОЛЬКИХ УГЛЕЙ

Олег Грачев

Аннотация. В работе приведен анализ вида кривых обогащения смеси нескольких углей. Проведен численный эксперимент создания смеси углей четырех шахт. Сравнение полученных кривых обогатимости смеси с кривыми обогатимости исходного сырья доказывают утверждение о неизменности вида функций, распределения граничных зольностей угля по фракциям при описании фракционного состава многокомпонентных угольных смесей

Ключевые слова: фракционный состав, весовые функции распределения, смесь нескольких углей, кривые обогатимости.

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The use of upgraded hopper cars in the mining industry

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Summary. The process of transporting the roche to the dump and formation of a flat rock dump in the coal mining industry is concerned. The use of railway rolling stock in order to reduce the cost of transportation of bulk cargo in the surface mining. Prospects for the use of upgraded hopper cars with one-sided self-discharge (on one side of the railway).
Key words. transportation, rock, roche, dump, hopper car, self-unloader, expenses.

INTRODUCTION

Undeniable trend in the global mining industry development in the foreseeable future is a stable orientation to the open-cut mining method, providing the best economic performance. It falls to share up to 73% of the total volume of production of natural resources in the world (in the U.S. - 83%, in the CIS countries - about 70%). The development and improvement of open-cut transport are the main for open-cut mining.

It is known that the development of the open-cut mining method is accompanied by increasing concentration of production, increasing the depth and the spatial dimensions of pits, and the distance of transportation of rock [Melnikov, Reshetnyak 1994].

Coal industry companies transportation is a complex system of interconnected transport links, located as within the company and outside it. The smooth operation of all links of the process of the enterprise depends on precise organization of the transport process. Great importance in transportation acquires not only the reliability and efficiency of its use, but also the cost of equipment, materials and resources. The task of transport in the mining industry is to deliver a total volume of coal from the mine to the point of destination, to export rocks to dump and transport of materials with maximum speed, minimum cost and with the traffic safety.

Thus, we can identify the main directions of development of transport in the coal industry: the modernization of the rolling stock, resources, cost reduction of the coal produced in the enterprise [Yakovlev, Vityazev 2004]. It is known that more than half the cost of coal is the cost of its transportation to the destination and transport of rock in the dump. Consequently, at present reducing the cost of transporting waste rock to the dump of the mine is a very urgent task.

OBJECTS AND PROBLEMS

Increased attention to coal mining industrial transport in most countries, the search for ways to reduce the significant transport costs inside industry traffic and sharp increase in the volume of scientific and research work in this area led to significant changes in the development of technical equipment and industrial transport in the coal mining industry. In recent years, an intensive search for new ways to develop the most appropriate transport for the coal industry, which is used to handle the roche and form the dump [Anistratov 2011].

Modern vehicles for roche handling should be easy to use and powerful. Currently, about 80% of the rock is transported by road, due to the possibility to travel long climbs in operation in open mining. The main limitation of the use of road transport in the mining industry continues to be a high cost of transportation of the rock mass [Kulichkin, Konopelko, Biryukov 2011, Parunakyan V.E., Artamonova Y.V., 2007]. In

addition, open-cut mining road transport is a major source of negative human impact on the environment in open cast mining and handling the rock to dump. Share of the cost for transporting rocks reaches 40% of the total cost of the work in the quarry or mine, so this problem of the current world requires special attention [Popov, Kaplunov 2010, Yakovlev, Vityazev 2004, Baron 2009, Pomazkov 2010].

Under present conditions in the largest iron ore, coal and asbestos quarries in the CIS countries one of the major technological transport of the industry is railway [Yakovlev, Bahturin, Stolyarov 2002, Parunakyan 1966]. Longstanding experience using the electrified rail in deep pits shows its high performance when used in preferred mining conditions of operation [Yakovlev, Vityazev 2004]. Analysis of the scientific, technical and design solutions allows us to state that in the future as for the existing as for the newly developed deposits the electrified railway will remain one of the principal modes of transport. The main advantages of electrified railway are the following [Yakovlev, Popov, Kotyashev, Kosnarev 2002]:

- higher average running coefficient of efficiency;
- cost effectiveness (relatively low prime cost of transportation of rocks) and operational reliability;
- the possibility of a significant overload of electric locomotives;
- easy to operate and maintain.

All these advantages are the result of the centralized electric energy supply. It should, however, be noted that the centralized energy supply requires a fairly large infrastructure (traction substations, contact networks, etc.) that, the high cost of locomotives and large volumes of runaway pit to accommodate the communications cause the high capital intensity of rail transport. Important benefits of electrified rail transport are also saving non-renewable liquid fuel, the almost complete absence of exhaust gas pollution, a small dependence on climatic conditions.

As noted in [Gubacheva, Andreev, Ryabtseva 2009, Debelle 2006, Parunakyan., Lozynskyy 1962, Parunakyan, Yasyuchenya 1962] been based on the availability of narrow-gauge railway transport infrastructure in the mines the mine electric locomotives have been widely used to maintain the mines, quarries and rock transportation.

The main disadvantage of rail transport is relatively low average of longitudinal slope of the road. The main directions of development and improvement of rail transport is increasing the road slope to 60 - 80% [Golubenko Gubacheva, Andreev 2009, 2010, Yakovlev, Fesenko, Neugodnikov 2001].

Train sets for rocks transportation are dumping cars, side-dumping cars [Parunakyan, Sinianskaya 1969, Parunakyan, Yasyuchenia 1960]. However, the use of the rolling stock is not effective due to the high level of metal consumption, complexity and design of the car body tilting mechanism, the necessity of much effort to self-discharge, significant deterioration of all its parts.

Thus, the aim of this work is to reduce the cost of handling the rock to the dump, formation of a flat waste dump in the mining industry.

A special role in solving this problem belongs to the creation of new designs of specialized wagons for transportation the bulk cargoes.

When you create a specialized self-unloading wagons of new generation for bulk cargo (rock) is an extremely important problem of improving the choice of rational parameters of the type of cars that are in the early stages of their design will identify promising options for car design and individual functional units [Savushkin 2003]. This paper proposes the creation of a new generation of rolling stock for transportation of bulk cargoes - upgraded hopper car with a one-sided self-discharge (on one side of the railway).

The main feature of the hopper cars is their ability to self-discharge. This attribute determines the conceptual scheme of constructive discharge device and a corpse of bunker wagon. Choice of rational parameters of unloading hopper car defines one of the most important for this type of car commercial indicators, which is easy to end operations.

Hopper-car open model 20-40-15 for transportation of hot pellets and sinter is known [Kuzmich 1978]. The car design provides a mechanized loading through an open body and automatic unloading of the two sides of the railway line through the two side door. The car is equipped with unloading pneumatic mechanism and automatic locking system to ensure reliable locking of manhole covers and automate the unloading process. Open hopper has a remote automated unloading of cargo on both sides of the railway track, driven by compressed air from the power plant of the locomotive.

Essential disadvantage of hopper car is incomplete self-discharge of bulk cargo, which requires additional manual unloading, and the impossibility of mechanized forming single flat blade of bulk cargo when unloading.

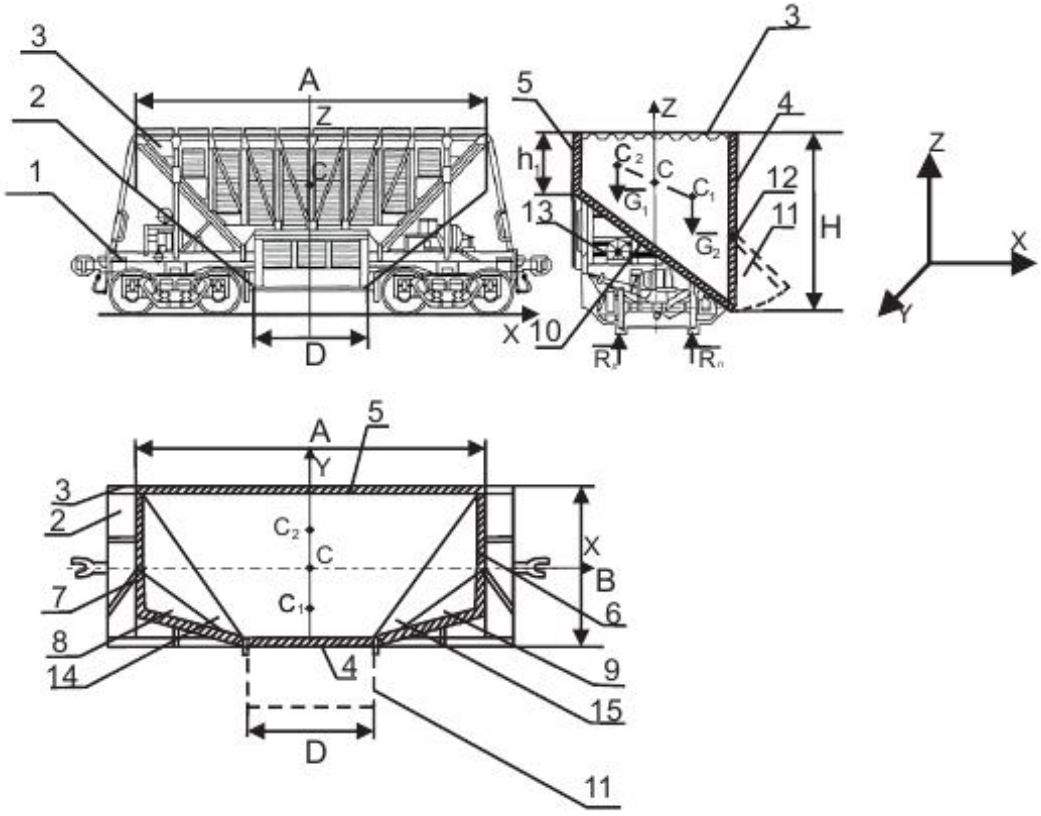

Fig.1. Hopper car with a one-sided self-discharge

The studies have shown that to ensure a complete unloading of bulk cargo on the right side of the railway track on relative motion of the car is possible by improving the known hopper car with a constructive change of body shape (fig. 1).

Figure 1. shows a hopper car front view, top view and side view [Gubacheva, Andreev, Leonova 2012]. . Hopper car includes a frame 1, carcass 2, metal body 3, consisting of the side walls 4 and 5, the end walls 6 and 7, the transition walls 8, 9 and 14, 15, part of the side wall is transformed into the floor 10 of the body, unloading equipment as inclined to bottom of the hatch with cover 11 attached to the hinge 12 to the side wall 4 and the linkage 13 with pneumatic cylinders for opening, closing and locking cap 11, the upper part of the cross section of the bunker in the plan looks like joined up large bases along the longitudinal axis of the rectangle and trapezoid with lateral transition parties and the small base on the discharge side of the side wall.

Transitional walls 8, 9, and 14, 15 provide the increase of body useful volume and improvement of indexes of hopper car load through an open body.

In a hopper car one discharge hatch with a cover hanging on the front hinged vertical side wall of the discharge is preserved, and all other walls are made obliquely.

In the place of dump formation the unloading cover of the hopper car, hanged in the hinges to the side wall, using the lever mechanism with driven pneumatic cylinders, opens and under the load own weight self-discharge is carried out through a hatch hopper car on one side of the railway track (on the right side with respect to the movement).

In terms of rail transport operation in the mining industry it is important to ensure the sustainability of the rolling stock and safety [Gorbunov, Kostyukevich, Kravchenko, Kovtanets 2011, Basov, Kireev, Lysak 2010].

The hardness and safety of upgraded hopper car motions (fig. 1) is achieved with the permanent coincidence of the mass center C of bulk cargo at full unloading with a central vertical axis of the body. This is provided by asymmetrical bunker of a hopper car subjected to the equilibrium points of the weight G_1 of the right side cargo and G2 of the left side cargo full bunker with the relative to the center C. Herein the conditions for the transfer of the same load from the static forces on all eight wheels is created that helps to improve

the technical characteristics in the process of movement and self-discharge.

To calculate the weighing of cargo and the time of unloading, the cargo bay of the hopper car is broken into four parts (upper, middle, and two of the end) [Gubacheva, Andreev, Leonova 2012]. After determining the geometric characteristics of the components of the body load compartment the dependences was found. It identifies the rational size to transport different types of cargo:

- height of the body back wall h_1:

$$h_1 = H\frac{(A+7D)}{(9A-D)}, \quad (1),$$

where: A and B are the length and width of the cargo hold, respectively;

D - discharge gate width;

H - the height of the front side of the cargo bay.

- obliquing angle α of the main rolling down surface (at H ≈ B):

$$tg\alpha = \frac{H-h_1}{B} \quad (2),$$

- the volume of cargo compartment taking into account the dimension of the rolling stock and transitional walls that increase the usable volume of the hopper car:

$$V = 0{,}28B\left[A(H+2h_1)+DH\right] \quad (3)$$

Having studied the process of cargo unloading from the body of the upgraded car it was found that its efficiency depends on the width of the discharge gate D. That allowed to get the dependences (fig. 2) of the hopper unloading time Tp = $f_1(\frac{D}{A})$, obliquing angle of the main rolling down surface $tg\alpha = f_2(\frac{D}{A})$, total cargo compartment capacity $V = f_3(\frac{D}{A})$ on the width of the discharge gate.

Analysis of the dependences showed, that additional transitional walls provide increase the useful volume of the car body, change in time of unloading, which in its turn depends on the obliquing angle of the rolling down surface and simplifies the process of loading the hopper car ensuring the sustainability of the rolling stock moving in the rail track.

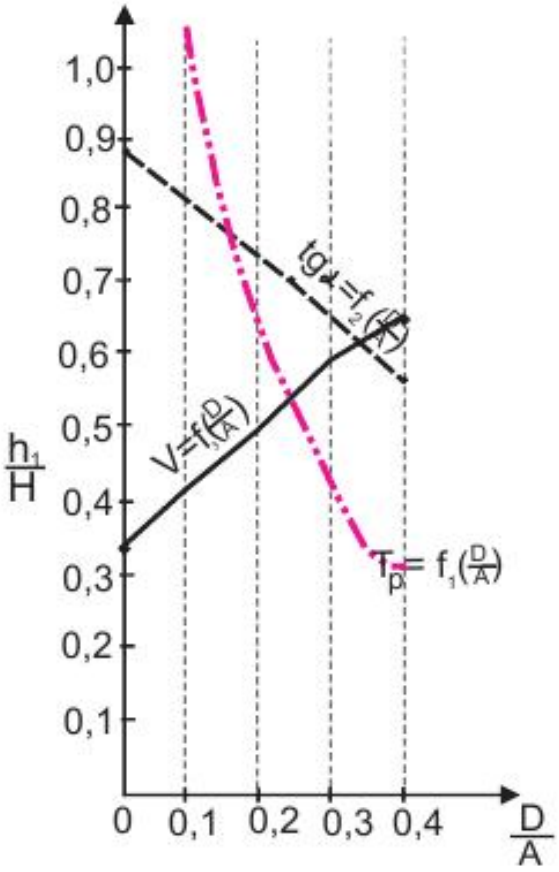

Fig. 2. Dependence of the time discharge hopper $T_p = f_1(\frac{D}{A})$, on the angle of the main roll off surface $tg\alpha = f_2(\frac{D}{A})$, general cargo capacity $V = f_3(\frac{D}{A})$ on the width of the discharge gate.

CONCLUSIONS

The use of the upgraded hopper car with a modified asymmetric body design in the mining industry will facilitate the process of transportation of rock and formation of the dump, reduce transportation costs (on 10%) and therefore reduce the prime cost of the coal produced in the enterprise.

On the basis of the achieved dependencies it is possible to select the required size of the car body to transport a particular type of cargo in various industries.

REFERENCES

1. **Anistratov K.Y., 2011.:** Substantiation of the structure of the park dump trucks class load of 40-100 tons. Open pit mining in the XXI century / Collection of the international scientific and practical conference. Krasnoiarsk. MVDC «Sibir», p. 105-111.
2. **Baron Y.L., 2009.:** The Energy Strategy of Russia until 2030 to develop the coal industry. Summit "CIS Coal". M., p.16-18.
3. **Basov G., Kireev A., Lysak D., 2010.:** Improvement of testiong operations during diagnosing of wheelpair tyres of railway vehicles. TEKA Commission of Motorization and Power Industry in Agriculture. XC, pp.12-18.
4. **Golubenko O.L., Hubacheva L.O., Andreev O.O. and others., 2009.:** Electric locomotive - Patent of Ukraine № 44271, B61C 3/00, publ. 25.09., Bull. Number 18.
5. **Gorbunov N., Kostyukevich A., Kravchenko K., Kovtanets M., 2011.:**:Influence of operational factors on redistribution of wheel pairs vertical loads upon rails. TEKA Commission of Motorization and Power Industry in Agriculture. XIA, pp.30-32.
6. **Hubacheva L.O., Andreev O.O., Leonova S.O., 2012.:** Hopper car with a one-sided self-discharge. Vestnik V.Dahl EUNU. Scientific Journal №4 (175), pp.69-74.
7. **Hubacheva L.O., Andreev O.O., Ryabtseva S.O., 2009.:** Electric locomotive - Patent of Ukraine №38592, B61C 3/00, issued 12.01., Bull. №1.
8. **Golubenko O.L., Hubacheva L.O., Andreev O.O., 2010.:** Prospects for the creation and use of narrow gauge traction units // Bulletin V.Dahl EUNU. Scientific Journal №10 [152], Part 1, p.32-39.
9. **Debeliy B., Debeliy, L., Melnikov, S. 2006.:** The main trends of mine locomotive transportation. Coal of Ukraine. Scientific Journal №6, C. 30-31.
10. **Kuzmich L.D., 1978.:** Wagons.: M, «Mashinostroenie», p.204-207.
11. **Kulichkin P.S., Konopelko S.A., Biryukov A.N., 2011.:** Experience of operation dump trucks TEREX TRI 00 with 91t capacity on cuts of Kuzbass. Mining Industry. №4 (98). - p. 30-34.
12. **Melnikov N.N., Reshetnyak S.P., 1994.:** Prospects of solving scientific issues at working off powerful deep pits. Mining: IGD SO RAS. – Yakutsk. – p. 14–23.
13. **Parunakyan V.E., 1966.:** On improving the quarry railway transport // Technique and technology of mineral development: Col. papers / NIIOGR. – M., – Issue 5.
14. **Parunakyan V.E., Artamonova Y.V., 2007.:** Impact assessment of key technical and operational parameters of the service life of heavy-duty dump trucks BelAZ-7540 // Bulletin of Azov State Technical University: collection of scientific papers. - Mariupol. - Vol. 17. – Pp. 189-192.
15. **Parunakyan V.E., Lozinskiy, V.N., 1962.:** On some issues of improving the quarry electric locomotives // Uhli (Czechoslovakia). - № 6/62.
16. **Parunakyan V.E., Sinianskaya R.I., 1969**.: Experience in dealing with sticking and freezing of the overburden to the working surfaces of the dump cars in quarries in the USSR and abroad // Techniques and technology of mineral development: Collections of papers / NIIOGR. - M. - Vol. 7. - pp. 148-158.
17. **Parunakyan V.E. Yasyuchenya V.V., 1960.:** Experience in operating motorized dump cars on Korkinsky coal mine. // Izv. Vuzov. Mining Journal. - №11. - pp. 157-162.
18. **Parunakyan V.E. Yasyuchenya V.V., 1962**.: The use of 200-ton electric transport in quarries // Izv. Vuzov. Mining Journal. - № 2. – pp. 128–130.
19. **Pomazkov M.V., 2010.:** Routing and resource for heavy dump trucks BELAZ in steel plant. Bulletin V.Dahl EUNU, №10 (154), V.2, pp.141-145.
20. **Popov M.S., Kaplunov V.Y., 2010.:** The problem of environmental and economic decision-making on the use of of dumps and heaps in the coal industry in Russia. Mining informational-analytical bulletin. №7. - p. 241-254.
21. **Savushkin R.A., 2003.:** Improving the design of self-unloading hopper cars for the transportation of bulk cargo: the dissertation of the candidate of technical sciences: 05.22.07.- St. Petersburg, p. 100-134.
22. **Yakovlev V.L., Bahturin Y.A., Stolyarov V.F., 2002.:** Some promising research areas in the field of quarry transportation. Proceedings of the International Scientific and Technical Conference on Quarry Transport. – Yekaterinburg. – p.15–20.
23. **Yakovlev V.L., Vitiazev O. V., 2004.:** Guidelines on Energy Conservation on the quarry railway transport //Mining Journal. № 10. – p. 66–68.
24. **Yakovlev V.L., Popov V.Y Kotyashev A.A. Kosnarev E.S., 2002.:** Improving safety and operational efficiency of rail transport in open cast mining / / Problems of pit transport: International Scientific Technical Conf. - Yekaterinburg: RAS. c.94–97.
25. **Yakovlev V.L., Fesenko S.L., Neugodnikov D.N., 2001.:** Promising methods for high-angle rock lifting rail transport / / Open-cast Transportation: Problems and Solutions. - Yekaterinburg, c.38–43.

ИСПОЛЬЗОВАНИЕ МОДЕРНИЗИРОВАННЫХ ВАГОНОВ-ХОППЕРОВ В ДОБЫВАЮЩЕЙ ПРОМЫШЛЕННОСТИ

Лариса Губачева, Александр Андреев, Светлана Леонова

Аннотация. Рассмотрен процесс транспортирования горной породы в отвал и формирование плоского породного отвала в угледобывающей промышленности. Применение железнодорожного подвижного состава с целью снижения затрат на перевозку сыпучих грузов на открытых горных разработках. Перспективы использования модернизированных вагонов-хопперов с односторонней саморазгрузкой (по одну сторону от железнодорожного пути).

Ключевые слова: транспортирование, порода, отвал, вагон-хоппер, саморазгрузка, затраты.

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Operational aspects of screw feeder of transport gasifier with pellet burner

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S u m m a r y . The article presents experimental investigation of the influence of worm conveyor load index and screw pressure by fuel column on the working conditions of the transport gasifier feeder with pellet burner.
K e y w o r d s : pellets, industrial transport, transport gasifier, automatic pellet burner, entire screw, ribbon screw.

INTRODUCTION

The decrease of expenses for transportation by industrial vehicle can be achieved by partial transformation into local alternative fuels use [Samylin 2005]. This could be performed by equipping the vehicles with the producer plant system generating producer gas from the agricultural wastes, forest and wood processing industry. The global vehicle park concentrated in this sphere is 10 - 120 billions items. [Geletukha 1998, Samylin 2005].

Currently, all the professionals who are interested in the technology and design of transport gasifiers, face a shortage of technical information [Ovsyanko 2007, Fomin 2005, Yudushkin 1955, Obemberger 1998, Shchadov 2007].

OBJECTS AND PROBLEMS

Development of the transport gasifier construction is connected, first of all, with the choice of the original fuel. The analysis of the current literature shows that pellets should be considered as the most promising solid fuel for transport gas generator. Straw, sunflower and buckwheat husks, canola, hemp, wood wastes are the raw material for the pellets production [Geletukha 1998, Obemberger 1998].

For pellets gasification a pellet burner is used. The conveying body of it is the screw [Hasler Ph , Jorgensen 1996].

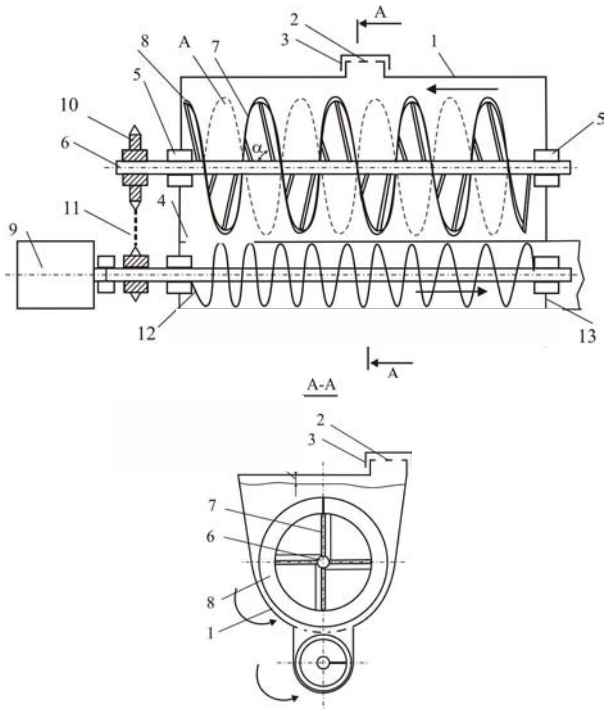

Fig. 1. The scheme of the screw feeder of transport gasifier with the pellet burner: 1 – hopper - turner; 2 – loading hatch; 3 – hatch cover; 4 – discharge window; 5 – bearing assemblies; 6 – upper ribbon screw shaft; 7 – transient ribs-blades; 8 – ribbon screw; 9 – actuator; 10, 11 – drive wheels; 12 – lower entire screw; 13 – housing

To transport fuel to the pellet burner we have developed and patented the scheme shown in fig. 1 [Samylin 2005, Yudushkin 1955, Tokarev 1955]. The basic working elements are: the upper ribbon screw 8 in the hopper 1 low entire screw auger 12 in the housing 13. The fuel is transported from the hopper 1 by the ribbon screw 8 into the housing 13 through the discharge window 4. Further the fuel is transported with screw auger 12 into the pellet burner.

To get into the combustion zone, the fuel must rise to a certain height. A pillar of fuel, putting pressure on the lower screw, may change the terms of its operation. Simultaneously the working conditions of the lower screw will be affected by the coefficient of filling it with fuel.

The purpose of the work was to study the joint effect on the lower screw, which is a part of the gas generator feeder, the coefficient of filling the screw and pressure on him by the rising pillar of fuel.

Wood pellets were used for the research. Their physical and mechanical properties are shown in table. 1.

Table 1. Physical and Mechanical Properties of the Pellets

Properties	Numbers
Friability:	
Coefficient of internal friction, f	0,3076
Coefficient of internal shear , f_σ	0,3307
The angle of repose, α_0 hail	25
Efficient angle of friction, $\delta_Э$	0,3255
Mobility Index, m_i	0,0554
The bulk density of compacted pellets, kg/m3	690
The coefficient of friction at rest:	
on steel f_c	0,671
on plastic $f_п$	0,444
Bridging:	
Bridging holes diameter	40
Fluidity:	
Diameter of the outlet, mm	41
Discharge coefficient	0,315
Exhaust velocity cm3 / min.	15

The design parameters of the lower screw: screw housing diameter - 80 mm, diameter of the screw on the outer edge - 60 mm, the step of the auger thread - 60 mm, the diameter of the screw shaft - 20 mm. The frequency of rotation of the lower auger - 80 rev/min (constant in all the experiments). The fill index of the lower screw was ranged between 0.2 - 0.6 by changing the frequency of rotation of the upper ribbon screw. Discharge window size between the upper and lower screws remained constant at 55 mm. Discharge window size was taken from the experimentally defined diameter of bridging holes - 40 mm. Through the hole of less size the fuel is not flowing.

To the output end of the housing, where the lower screw is situated, we fixed the pipe simulating the lift part of pellet burner. Nozzle height is 250 mm. The pipe had a calibration scale of fuel lifting height, mm. The calibration of pipe was pre-made, determining the mass of fuel corresponding to different heights it goes up: 10, 20, 30 ... 250 mm. With the ribbon screw the fuel from the tank - agitator was evenly fed into the housing of lower screw till jamming of the lower screw. At the time of jamming of the lower screw the power of the setting was turned off. After that we fixed the height of the pillar of fuel referring to the plate where the housing of the lower screw was installed. The pipe, filled with the fuel, was removed, and fuel was weighed. Critical pressure of the fuel on the lower screw, at which the jamming of the lower screw took place, was defined as the ratio of the mass of fuel in the nozzle at the jamming moment (G_m) to the efficient surface square of the screw (F):

$$P_{кр} = \frac{G_m}{F}. \quad (1)$$

When the diameter of the screw on the outer edge is 60 mm and the diameter of the screw shaft is 20 mm $F = 2400\ mm^2$.

The performance of the screw feeder was determined with the ratio:

$$П = \frac{G}{t}, \quad (2)$$

where: G – the current mass of the fuel in the pipe, corresponding to a given height of its healing;

t – the lifting time of fuel to this height.

Current pressure of the fuel on the screw was calculated by the equation:

$$P = \frac{G}{F}. \quad (3)$$

Experiments have shown that as the loading index of the lower screw increases from 0.2 to 0.6 so the maximum height of fuel healing in the nozzle decreases rapidly, and the most intense as increasing the loading index from 0.2 to 0.4.

When the loading index of the lower screw is 0.2 the maximum height of fuel healing is 190 mm, with a loading index 0.4 - 90 mm, with a loading index 0.6 - 70 mm (fig. 2).

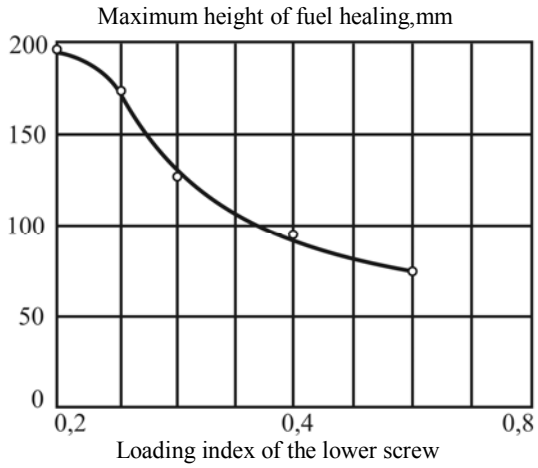

Fig. 2. The influence of the lower screw load index on the maximum lift height of the fuel in the pellet burner

Similarly, as the loading index of the lower screw increase the maximum mass of the fuel in the nozzle changes (fig. 3) and the maximum fuel pressure to the lower screw (fig. 4), defined with the formula (1).

The observed deeds in the lower screw acting can be explained by using the basic principles of the theory of passive areas. Passive areas are formed on the auger surface of the screw. In the passive areas the fuel particles with the friction forces are pressed against the surface of the screw and are not transported, rotating along with the screw. When the height of the pillar of fuel over the screw increases the mass of the fuel over the screw and the fuel pressure at the screw increases. As a consequence, the friction between the auger surface of the screw and fuel enlarges. The increase of the friction between the surface of the screw and the fuel enhances the passive area on the screw.

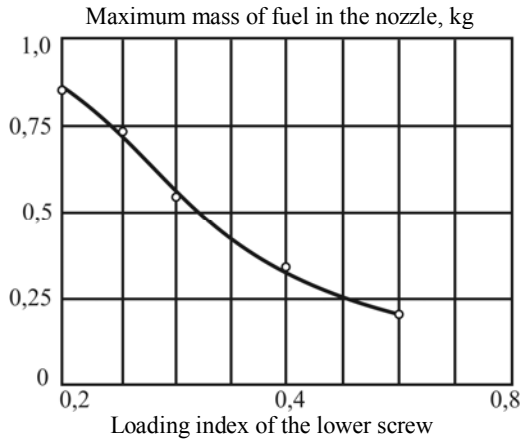

Fig. 3. The influence of the load index of the lower screw on the maximum weight of fuel in the nozzle over the screw

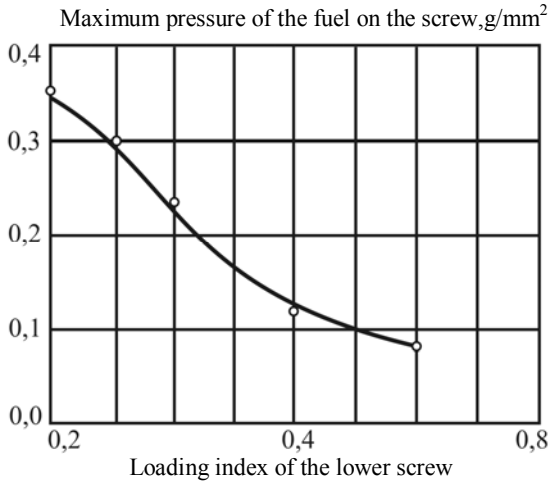

Fig. 4. The influence of the load index of the lower screw on the maximum fuel pressure on the screw

Having passed the passive area, the fuel particles are moved back through the screw shaft, thus reducing its efficiency. At some critical loading index of the screw and a certain critical pressure fuel on the screw the fuel volume, thrown-back over the screw blades will exceed the amount of the fuel transported forward. In this case the jamming of the screw will inevitably happen. To jam the screw to beat the working space around two or three outgoing blades is enough. This supposition is confirmed by a recorded video of the operating process and jamming the lower screw, and also the decrease of the screw productivity with rising fuel pressure on it (fig. 5). Before the jamming the screw outgoing blades extensively stoke the fuel back, and the intensity of such abandonment strongly increases with the lower screw load index increase.

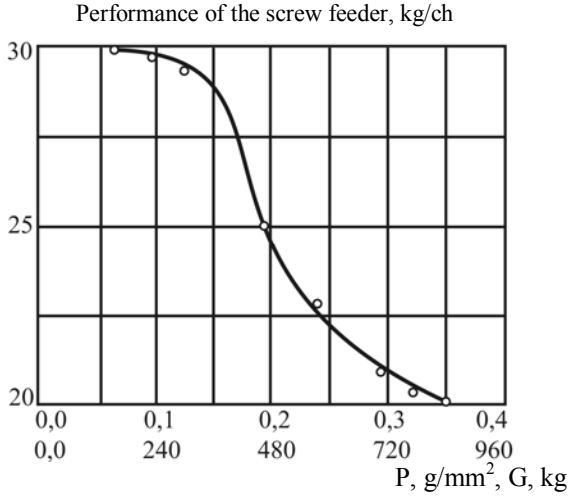

Fig. 5. The effect of fuel pressure on the screw (P) on the feeder performance of the transport gas generator with pellet burner at the loading index of the screw 0.2

Thus, while designing the screw feeder it is necessary to consider the pressure of fuel in the pellet burner on the screw. The range of the influence of fuel pressure on the feeder functioning is highly dependent on the loading index of the screw. With the increase of the loading index of the screw, the maximum allowed fuel pellet pressure on the screw is reduced considerably. The higher pressure leads to screw jamming. With increasing fuel pressure on the screw, the feeder performance is greatly reduced.

CONCLUSIONS

1. The approach of constructing was proved in the frame of the planned experiment of the regressing dependence of the screw auger performance on the following factors: the loading index of the screw, fuel pressure on the screw, screw angle to the horizon, the frequency of rotation of the screw.

2. At increasing the loading index of the conveying screw, the allowable fuel pressure on screw is greatly reduced, and, consequently, the allowable height of the fuel healing. With the loading index of the screw 0.2, the allowable fuel pressure on it is 0.35 g/mm2, with the loading index of the screw 0.3 - 0.23 g/mm2, with the loading index of the screw 0.4 - 0.14 g/mm2, with the loading index 0.6 - 0.09 g/mm2.

3. The recommendations on the limiting the loading index of the screw while increasing the fuel pressure on the screw are general in nature and could be implemented for screws of any diameter.

REFERENCES

1. **Los' L.V., Ivantsov V.V. 2010.:** Researches on the peculiarities of the construction of the transport gasifiers for gasification of crushed and briquetted straw // Visnyk ZhNAEU. № 2. – p. 118 – 139.
2. **Samylin A.A., 2005.:** Automobile Gas Generator - The Technology Of The Future // LesPromInform. №8 (30), p. 80-84.
3. **Geletukha G.G., Zheleznaya T.A., 1998.:** Technology Review Electricity Generation, Received From The Biomass While Gasification // Environmental Technology And Resource Conservation. № 3, p. 3-11.
4. **Aniskin V.I., Golubkovich A.V., Kurbanov K.K. 2005.:** Fuel made of agricultural biomass. Energy: economics, mechanics, ecology. № 1. – p. 47 - 50.
5. About The Alternative Kinds Of Liquid And Gaseous Fuels: Law Of Ukraine 14 January 2000 VR № 1391-XIV // The Bullitein of Verkhovna Rada of Ukraine. - 2000. - № 12.
6. The Cabinet of Ministers of Ukraine «On approval of the Energy Strategy of Ukraine till 2030» March 15, 2006 № 145.
7. **Bridgwater A.V.**, 8-10 April 2002.: Thermal conversion ofbiomass and waste: the status. Proc. of Conference "Gasification: the Clean Choice for Carbon Management", Noordwijk, the Netherlands, pp. 1-25.
8. **Fomin A.P., Neshin Y.I., Potapenko A. F., 2005.:** Processes For Obtaining Cobbed Fuel // Solid Fuel Chemistry, p. 36-43.
9. **Geletukha G.G., Zheleznaya T.A., 1999.:** An overview of modern technologies of burning wood for heat and electricity Part 1. // Environmental Technology And Resource Conservation. № 5, p. 3-12.
10. **Geletukha G.G., Zheleznaya T.A., 1998.:** Overview Of Biomass Gasification Technology // Environmental technology and resource conservation. № 2, p. 24-29.
11. **Hasler Ph , Candinas T. Nussbaumer Th**. Utilization of Ashes from the Combustion of Hay. Miscanthus, Hemp, Straw and Wood as of the 10th Europ. Bioenergy Conf. p. 192-195.
12. **Jorgensen U, Kristensen E.F., 1996.:** Europen Energy Crops Overview. Country Report for Denmark. Copenhagen : MAF, p. 83.
13. **Obemberger J., 1998.:** Decentralized Biomass Combustion : State of the Art and Future Development/ /Biomass and Bioenergy.Vol.l3, №1, p. 33-56.
14. **Ovsyanko A.D., 2007.:** Reference Book. Pellets: Russia, Belarus, Ukraine / A.D. Ovsyanko / St. Petersburg, Biofuel Portal WOOD-PELLETS.COM, p. 200.
15. **Pogrebnoi S.N., 2003.:** "GAZELLE" 3302/2705 / S.N. Pogrebnoi, A.A. Vladimirov / Third Rome, p. 342.
16. **Samylin A.A., 2005.:** Automobile Gas Generator - The Technology Of The Future // LesPromInform. №7 (29), p. 74-76.
17. **Shchadov V.M**., **2007.:** Integrated Processing Of Coal And Improving The Efficiency Of Its Use // M.: STC "Track", p. 292.
18. **Tokarev G.G., 1955.:** Vehiclar Gas Producer / G.G. Tokarev / Mashgiz. p. 205.
19. Technological Aspects Of Biofuel Burning// Alternative Energy,2007.: № 1,p.17-21.
20. **Yudushkin N.G., 1955.:** Generating tractors / N.G. Yudushkin / State Scientific And Technical Publication Engineering Literature, p. 242.
21. **Gubacheva L.**, **Andreev A., Shevchenko D. 2012.:** Alternativt fuels for transhort. TEKA Commission of Motorization and Power Industry in Agriculture, XIA, p. 99-107.
22. **Golubenko A., Tsyvenkova N., Mulyar O., Romanushun O. 2012.:** Biomass standization as a base for its sufficient use. TEKA Commission of Motorization and Power Industry in Agriculture, XIA, p. 85-92

ОСОБЕННОСТИ РАБОТЫ ШНЕКОВОГО ПИТАТЕЛЯ ТРАНСПОРТНОГО ГАЗОГЕНЕРАТОРА С ПЕЛЛЕТНОЙ ГОРЕЛКОЙ

Лариса Губачева, Александр Андреев, Дарья Шевченко

Аннотация. В работе экспериментально исследовано влияние коэффициента загрузки винтового транспортера и давления столба топлива на шнек на условия работы питателя транспортного газогенератора с пеллетной горелкой.

Ключевые слова. Пеллеты, промышленный транспорт, транспортный газогенератор, автоматическая пеллетная горелка, сплошной шнек, ленточный шнек.

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Basic principles of the management of region as the ecological-economic system

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Summary. The article describes basic principles of the management of region. It describes a region as a complex ecological-economic system. Proposed economic mechanisms to manage the ecological-economic systems.
Key words: Ecological-economic system, regional management, environment, economy, management mechanisms.

INTRODUCTION

Ecological-economic system is a complex dynamic system, which is based on the relationship between the material structures created by man and nature. Thus, the Ecological-economic system is a combination of co-operating environmental and economic systems. For a region ecological-economic system is limited to a certain area of the ecosphere in which the natural, social, economic and production processes, associated mutually supportive flows of matter, energy and information. [Gorlova A., 2011]

Ecological-economic system is a complex system and requires management. It should be noted that the ecological-economic system has several differences from the economic system, which is why the mechanisms of economic management systems cannot always be applied to ecological and economic system. These mechanisms do not take into account the features of the system.

Society has realized the need to review existing management mechanisms of ecological-economic systems, evidenced by international environmental programs. Foreign scientists, politicians and companies pay much attention to sustainable development but it's not possible without a balanced system of environment and economy. The economy must obtain sustainable development in the long run.

In recent years many countries are trying to make an economy more ecological. [Danylyshyn B., 2008]. Society provides benefits of environmental goods more often. Some countries have built so-called "ecological economic regions", specializing in "pure" forms of production. Some Swiss cantons can be considered to be ecological-economic regions. They specialize in producing organic food catering, recreation and financial services.

OBJECTS AND PROBLEMS

Analysis of recent research and publications shows that today many researchers pay much more attention to ecological economics, among them Walter Isard, O. Balatskaya, D. Belishev, J.E. Brydun, Z. Gerasymchuk, W. Gurman, S. Dorohuntsov, B. Danylyshyn [Danylyshyn B., 2008], O. Rumin, S. Ramazanov and others.

Many foreign scholars, such as B. Myeryeyan, F. Samson, F. Tyeutberh, V. Dahl [Dale V.H., Virginia H., English M. R., 1999], M. Alonso [Marta S. Alonso, Irene M. Rubioá., 2008] studied the issue of environmental management

The problems involved in environmental economics: R. Goodland, H. Daly [Daly H.E., 2007], J. Cumberland, R. Costanza [Thomas Prugh, Robert Costanza, Herman E. Daly., 1999], R. Norhaard.

Scholars, involved in study of administration were: V. Bykovsky B.I. Gerasimov, O.V. Korobov. They deal with restructuring of the management of the region. In the study of environmental management and economic systems were involved: N.V. Burkov, D. Novikov, D. Nurmahanbetov, S. K. Ramazanov, A. P. Syromyatnikova, A. Shchepkin. These scientists have made great contribution in development of mechanisms for management of ecological-economic systems at different levels of management.

The aim of the research is to solute the problem of economical grows to the prejudice of ecology by creation the system of management of region as ecological-economic system.

In recent decades steps were made to counter the dominance of monetary thinking in relation to environmental issues. These steps can be considered as institutionalizing and expanding of the use of environmental impact assessment, increased use of life-cycle analysis in business and other organizations. Overall, standardized environmental management system such as ISO 14000 was created for various organizations.

In the USA environmental assessment projects are used. Thus, state body that receives the project of any organization should thoroughly investigate it and find out how that project will change the environment. The state body should reveal whether exist alternative projects involving less serious consequences for the ecosystem. There are also rules for participation in decision-making.

Generally there is a progress towards the sustainable development of the concept of the eco-efficiency. Argued that the concept makes seven basic requirements for companies:

- reduce material consumption of goods and services;
- reducing energy intensity of goods and services;
- reduce toxic dispersion;
- improving materials processing;
- maximum sustainable use of renewable energy sources;
- extend the durability of products;
- increase the service intensity of goods and services.

The "Greening" of management as a process of ecological and economic optimization of economic growth that will achieve economic security and sustainable development units. Any region represents a complex dynamic Ecological-economic system, which includes environmental, economic entities, market and the governing body.

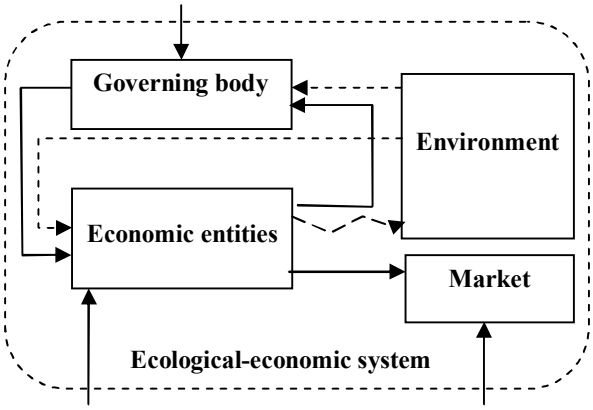

Fig. Graphic representation of Ecological-economic system of the region

Management of Ecological-economic system represents the relationship between two subsystems: subsystem that manages - the subject of management and control subsystem - subject to control. According [Korobov O., Gerasimov B., Bykovsky V., 2002] system that manages is regional governments, and the system that control - economic entities and population. All elements of the system are linked to data communication. Regional governments are informed about the current status of entities and information from the external environment and government. In [Syromyatnikova O., 2011] the entity presented as a system with two levels of subsystems of state and regional management and subsystem of specific users of nature in the face of government enterprises. Together they form the system of management functions performance.

The Ecological-economic system has specific management tasks: at first, the results of the economic actors are multifaceted and they depend on many uncontrollable random factors, and secondly there are substantial conflicts of interests of all stakeholders of the system.

Unfortunately entrepreneurs do not take into account the possible consequences of their business when they take management decisions. It's not just the fault of enterprises, the thing is that they usually do not have enough information to determine the actual amount of ecological and economic losses from the activity. At the same time, the government of the region has enough power and sources of information for environmental regulation of economic processes.

There are four main methods of management: economic, organizational, administrative and social.

Economic management practices based on economic mechanisms of motivation and encouragement of active production (at least - non-productive) activities. The economic management methods used at the country level include: tax system and credit-financial mechanism.

Organizational and administrative methods solve the same task as the economic methods, but in different forms and methods. Organizational and administrative methods have a direct impact on the controlled object with orders, instructions of operating and monitoring of their implementation.

Unlike organizational and administrative, economic management is focused less on administrative influence but on economic incentives and rewards for active and effective operations. Economic methods allow managers to choose different forms and techniques of influence to solve a problem; organizational and administrative suggest the same methods of an unambiguous effect, dictated by the order or instruction. The importance of economic management is increasing sharply in the development of market relations, focused on profits and possibly higher income. Therefore, the focus is on economic management mechanisms.

The use of economic instruments to implement the environmental and economic management of a wide range of possibilities. Economic mechanisms can be considered as any mechanism aimed at changing the behavior of economic agents and reducing environmental costs. Various mechanisms have advantages in different areas and not used elsewhere.

There are economic mechanisms that can be instruments of Ecological-economic management such as:

- Tax system;
- Decision Making Systems
- Environmental Management System

The tax system can force to use natural resources more efficiently. Instead of taxing the income received by workers and enterprises, it will tax the bandwidth stream, preferably in a place where resources are obtained from the biosphere. Such a tax is more efficient use of resources in production and consumption, and relatively easy to control.[Söderbaum P., 2000]

Introduction of the environmental decision-making systems allow individuals who make decisions objectively evaluate projects and alternative measures. Decision Making Systems should cover all aspects of Ecological-economic system. Prediction that influences only on the part of the system may be worse than the absence of any prediction, because it can lead to irrational decisions. [Jørgensen S. E., Bendoricchio G., 2001] Environmental solutions are often complex and multifaceted, including many different stakeholders with different priorities and goals.

CONCLUSIONS

The environmental management system serves as a tool to improve environmental performance. ISO has developed standards to help organizations comply active approach to environmental issues: standards ISO 14000 series of environmental management that can be implemented in organization of any kind, public or private sector - from companies to administrative and municipal organizations. ISO helps to solve the problem of climate change, establishing emission rates of gases that affect the greenhouse effect, control and emissions trading and measuring the carbon footprint of products. ISO also develops standard documents to facilitate the coordination of business and environmental interests by encouraging the inclusion of environmental characteristics of the design (development) products.

REFERENCES

1. **Burkov V., Novikov D., Shchepkin A., 2008.**: Control mechanisms ecological-economic systems., Ed. SN Vasiliev S., Moscow: Publishing House of Physical-Mathematical Literature, 244.
2. **Dale V.H., Virginia H., English M. R., 1999.**: Tools to aid Environmental Decision Making, New York: Springer, 225.
3. **Daly H.E., 2007.**: Ecological economics and sustainable development, selected essays of Herman Daly: Edward Elgar Publishing, 270.
4. **Danylyshyn B., 2008.**: Environmental component of sustainable development, Donetsk: LLC "South-East Co., Ltd.", 256.
5. **Gorlova A., 2011.**: Innovative approaches to manage the impact of rail transport on the environment [E-resource]: http://ivdon.ru/magazine/archive/n1y2011 /page/3/
6. **Grigoriy Nechaev, Galina Garkusha, Marina Makarenko., 2011.**: Mainpower role in transport logistics in globalization condition. TEKA Commission of Motorization and Power Industry in Agriculture, XI.A., p 184-189.

7. **Gurman V., Ryumina E., 2001.**: Modeling socio-ecological-economic system of the region, Moscow: Nauka, 175.
8. Informational portrait of Lugansk region. Ecology. [E-resource]: http://www.irp.lg.ua
9. **Jørgensen S. E., Bendoricchio G., 2001.**: Fundamentals of ecological modeling: Gulf Professional Publishing, 530.
10. **Korobov O., Gerasimov B., Bykovsky V., 2002.**: Regional Economy: Restructuring of the management of development in the region, Ed. Gerasimov B., Tambov: Tambov Acad. State. tech. University Press,104.
11. **Lena Reshetnyak, Inga Pastushkova, Lena Yatsura., 2010.**: Financial globalization and its positive and negative outcomes for economy development of the countries. TEKA Commission of Motorization and Power Industry in Agriculture, X.D., p. 226-229.
12. **Lyashenko I., 2006.**: Fundamentals of mathematical modeling of economic, ecological and social processes: Tutorial in "Applied Mathematics" for the universities, Kiev: Educational book - Bogdan, 304.
13. **Marta S. Alonso, Irene M. Rubioá., 2008.**: Ecological Management: New Research: Nova Science, 262.
14. **Nikonov J., Sizov S., Ovcharuk V., 2007.**: Operation and development of ecological and economic subsystems (theory and methodology), Ed. AG Ivasenko, Novosibirsk: SSGA, 201.
15. **Runsheng Yin, Minjuan Zhao., 2012.**: Ecological restiration programs and payments for ecosystem services as integrated biophysical and socioeconomic processes – China`s experience as an example. [E-resource]: http://www.sciencedirect.com/science/ article pii/S0921800911004848
16. **Söderbaum P., 2000.**: Ecological economics: a political economics approach to environment and development: Earthscan, 152.
17. **Syromyatnikova O., 2011.**: Improving the mechanism for regional control of local ecological-economic systems Electronic scientific journal "Economics and economic management" № 2. [E resource]: http://economics.open-mechanics.com /articles/407.pdf
18. **Syromyatnikova O., 2011.**: The concept of eco-economic system as an object of control. Electronic scientific journal "Economics and economic management" № 1. [E resource]: http://economics. open-mechanics.com/articles/314.pdf
19. **Thomas Prugh, Robert Costanza, Herman E. Daly., 1999.**: The Local Politics of Global Sustainability: Island Press, 191.
20. **Zhukov E., Kapaeva T., Litvinenko L., 2000.**: International Economic Relations: A Textbook for Universities, Ed. Zhukov E., Moscow: UNITY-DANA, 485.

ОСНОВНЫЕ ПРИНЦИПЫ УПРАВЛЕНИЯ РЕГИОНОМ КАК ЭКОЛОГО-ЭКОНОМИЧЕСКОЙ СИСТЕМОЙ

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Аннотация. В работе описываются основные принципы управления регионом. Регион представлен как сложная эколого-экономическая система. Предложены экономические механизмы управления эколого-экономическими системами.

Ключевые слова: эколого-экономическая система, управление регионом, окружающая среда, экономика, механизмы управления.

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Use of the numerical experiment at the design stage of piston pulp pumps

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Summary. The results of numerical experiment on kinematic mathematical models of piston Pulp pumps with various modifications of the crank-connecting rod drive mechanisms and the number of cylinders. The recommendations on the rational choice of their number, the angular pitch of cranks and the ratio of their length to the length of the rod, and eccentricity to the radius of the crank mechanism.

Keywords. Pulp piston pump, the kinematic model, numerical experiment, crank, slider crank, the uneven flow and pressure, the angular pitch of cranks.

INTRODUCTION

Piston pumps are used for hydraulic transportation of abrasive media (solid minerals and waste of its production, different mortars) [1-3], and the drilling of exploratory and development wells for oil and gas [4-8].

These are powerful, heavy and cumbersome machines of maximum power (to 1500 kW) and weight (to 65t) [1; 9-12]. Their research and operational development by means of the physical experiments on natural samples is difficult, expensive, and often impossible.

For faster and better solutions to the problems of existing pumps improvements and creating new prospective pump it is necessary to change the ratio of physical and numerical simulation for the latter. To do this, we developed [13], mathematical (kinematic and dynamic) models of the workflow pumps and software for the numerical simulation by computer.

OBJECT OF RESEARCH

In developing the conceptual design of pumps it is enough to research them on simple kinematic models, in which the motion of the fluid in the pipes is determined only by the number of chambers and the kinematics of the propellants, depending on the selected driver and ratios of linear and angular measurements to specific units. The numerical experiments allow us to find not only the impact of these factors on the kinematics of the fluid and on changing its flow rate in the inlet and outlet pipes, but also to identify each time the theoretical values of the coefficients of uneven flow and pressure pump, which is very important.

The very study of pumps on kinematic models allow us to determine feasibility of using one or the other pump design concept for future settlement of design development and implementation of a numerical experiment on a dynamic model.

RESULTS

First there studied piston pumps with single acting cylinders and traditional central slider-crank drive mechanisms. The independent variables in this case are the number of cylinders Z and ratio r / l r (the radius of the crank rod to length l). The result of each experiment could be obtained graphical dependences of the relative displacement, velocity and acceleration of the piston, the relative flow rates of the suction and discharge piping, and calculated the theoretical

values of the coefficients of the uneven flow and pressure in them. The latter are determined by the expressions (1), the latter of which is valid at the pump for a short pipe with throttle load.

$$\Delta = \frac{Q_{\max} - Q_{\min}}{Q_{av}},$$

$$\delta = \frac{Q^2{}_{\max} - Q^2{}_{\min}}{Q^2{}_{av}}. \qquad (1)$$

Some of the results are shown in table. 1. Their analysis shows:

for odd Z increasing r/l leads to significant increase Δ, especially δ;

for even Z with equal angular increments cranks value r/l has no effect on the coefficients of Δ and δ, the values of which are respectively more than the nearest pumps with odd Z.

In addition, it was found that for pumps with an even number of cylinders (6, 10, 12, etc.) that are divisible by an odd number, you can greatly reduce uneven flow in pipelines. To do this, all of the number of cylinders Z = m * k should be divided into m groups with an odd number of cylinders k in a group and equal angular cranks increments $\alpha = 2\pi / k$, but the groups rotate relative to each other at an angle Δα, whose value is determined for each Z at each r / l [14]. For example, when Z = 6 * (step-uniform angular pitch of the cranks – the last two columns in table 1), m = 2, k = 3, α =120°, and $\Delta\alpha = \pi / Z = 30°$, r / l = 0. With increasing r / l efficiency of the process decreases, i.e. Δ and δ worsen (increase). At r / l = 0, 1 Δα = 38,3°, and at r / l = 0,2 Δα = 44,3° [14].

It should be noted that, in contrast to the diameter d_s in the suction pipe, which depends only on the pump flow Q and pistons diameter D, which depends also on their number Z, the value of their stroke S and the number of double strokes n, effect, but in different ways, the ratios ψ = r / l, [13] and table 2. At equal angular step cranks [16]: for pumps with even Z>2 S and n are equal at different ψ and Q and the same Z; for pumps with both odd Z and with even Z, but having the step-uniform angular step cranks, when ψ increases, the piston stroke length is increased while n at the same time is decreased.

Dependences to determine the d_s, D, S, and n obtained in [14] with the durability of the cylinder-piston pair [17] and the suction capacity of the pump, but without the reliability of the valves in the high-viscosity fluids. Therefore, the found value of strokes n = 225,3 stroke / min (the third row of table. 2) should be treated with caution. To confirm that value an additional numerical experiment on a dynamic mathematical model is to be provided plus physical experiment.

Investigated pumps with traditional design schemes include slides to protect pistons and cylinder liners from the effects of shear forces – that increases their service life, but causes significant increase in the size and weight of the pumps.

Table 1. Dependences of Δ and δ on the ratio r / l

r/l	Z=3		Z=4		Z=5		Z=6		Z=7		Z=6*	
	Δ,%	**δ,%**	Δ,%	**δ,%**	Δ,%	**δ,%**	Δ,%	**δ,%**	Δ,%	**δ,%**	Δ,%	**δ,%**
0	14,03	27,41	32,5	61,9	4,97	9,87	14,03	27,4	2,52	5,03	3,45	6,85
0,1	19,09	36,54	32,5	61,9	6,2	12,23	14,03	27,4	3,1	6,16	8,87	17,3
0,2	25,1	47,27	32,5	61,9	7,55	14,82	14,03	27,4	3,73	7,39	12,54	24,4

Table 2. Technical Data Pulp pumps with different number of single-acting cylinders Z and ψ

Q, l/s	Z	d_s, m	D, m	ψ=0,0		ψ=0,1		ψ=0,2	
				S, m	n, str/min	S, m	n, str/min	S, m	n, str/min
28	3	0,205	0,168	0,223	112,7	0,246	102,4	0,268	93,9
	5		0,130	0,134	187	0,147	170	0,161	156,4
	6		0,119	0,223	112,7	0,223	112,7	0,223	112,7
	6*		0,119	0,112	225,3	0,144	174,3	0,173	145,9

To address this issue the constructive diagram of the double-shaft membrane-piston pump without the original slide was synthesized [15], as shown in fig. 1 (the kinematics of one of its mirrored halves – in fig. 2).

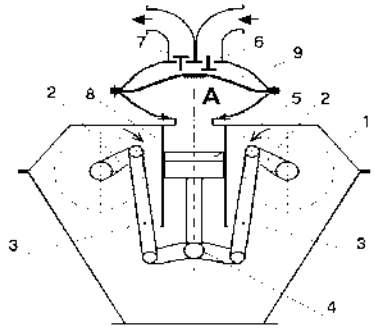

Fig.1. Half-constructed scheme of the pulp membrane-piston pump. No slide-block

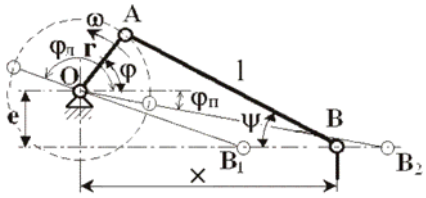

Fig.2. Kinematic scheme of the half of the drive mechanism

Two crank shaft 2 rotate synchronously in opposite directions, allowing the piston 5 reciprocates. Forces that arise in each half of the drive – normally to the direction of the piston motion – close and get mutually balanced on the beam 4. A cavity between the piston and the diaphragm is filled with oil that protects the cylinder-piston pair from abrasion and prevents the pumped liquid in the sump pump. Location of hydraulic parts inside the drive allows, as we will see, significantly reduces the weight of the machine.

Kinematic study of the drive mechanism [4] showed that at the **e / r > 0** and **r / l > 0**:

angles of the suction and discharge of the crank shaft may differ significantly from 180°;

so, dependences of the speed of the piston in the suction and discharge cycles and uneven fluid flow in the inlet and outlet pipes will be different;

the stroke of the piston S may be more than 2r, in contrast to the central drive mechanism, when e = 0 and S = 2r.

Comparing effect of the ratio dimensions of the drive r / l and e / r onto the change of the instantaneous pump flow is shown graphically in figure 3 and figure 4 according to its relative value for each cylinder and for both five-cylinder pumps (top – blowing, lower – absorption) at different **e / r** and **r / l**. Total relative feed pump differs not only by the oscillations amplitude, but by their frequency as well (for the second version – 2 times more).

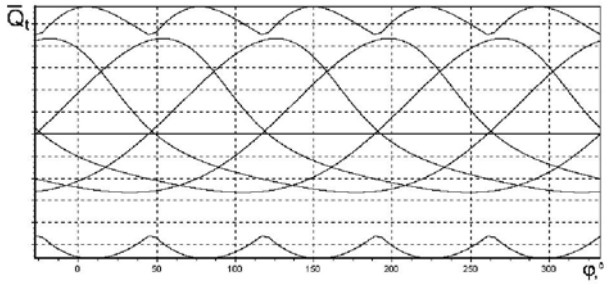

Fig. 3. The changes in the relative supply of the pump at z = 5, e/r = 2 and r/l = 0,3

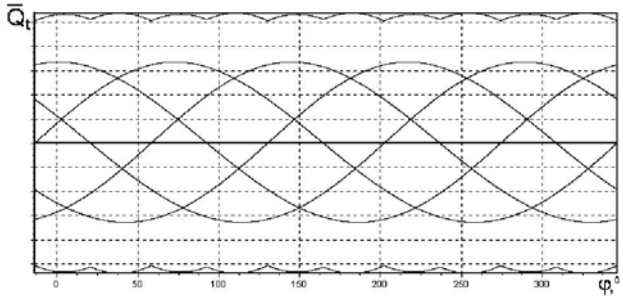

Fig. 4. Changes in the relative supply of the pump at z = 5, e/r = 2 and r/l = 0,05

The coefficients of unevenness of the flow and pressure rates at the inlet and outlet of each pump are shown in table 3. But in the second version they are several times less than in the first one as being respectively equal to the suction and discharge piping ($\bar{\Delta}_в = 3{,}22$; $\bar{\Delta}_н = 4{,}05$; $\bar{\delta}_в = 3{,}17$; $\bar{\delta}_н = 3{,}99$).

According to the table 3 data, for the off-center drivers **S > 2r** always is, what is most notably seen at higher meaning **e/r** and **r/l** (see line 3, table 3), which near of degeneration of the mechanism. But at that the discharge angle φ_n decreases sharply, while the coefficients of unevenness of the flow and pressure rates overly increases (as much as 5,2 and 15,7 – by comparison with version 2). Respectively the coefficients of unevenness of angular velocity and torque of the crank shaft increases, which is unacceptable. As for the step-uniform angular pitch cranks, even in machines with such a drive, it can also be effective (see fig. 5 and fig. 6), provided the rational choice of the values of **e/r** and **r/l**.

Table 3. Research results of the five-cylinder pumps without slider-blocks
With various ratios of the sizes of the drive components

Z	e/r	r/l	S/r	φ_d °	Δ_s,%	Δ_d %	δ_s %	Δ_d %
5	2	0,3	2,64	148,48	19,16	24,07	37,35	47,01
	2	0,05	2,07	178,52	6,04	6,04	11,97	11,97
	3	0,25	4,0	126,87	31,38	94,19	63,28	189,95

Table 4. Specifications of piston pumps with a crank drive for hydraulic coal with Q = 250 m3, p = 10 MPa and ηp = 0.94

Design scheme of the machine	Z	n, str/min	D, mm	S, mm	Δ, %	δ, %	F, кН	L_{tr}, m/s	M, t	M̄, кg/кW
Duplex (double-acting cylinders)	2	68	240	400	44	85	450	0,9	38,2	55
Triplex and cup. valves **r/l = 0,15**	3	120	250	260	19,1	36,5	488	1,04	28,7	41,3
Triplex with ring. valves **r/l = 0,15**									24,3	35
Double-shaft triplex without slide-blocks **e/r=1, r/l=0,05**	3	125	250	240	17,6	34,7	488	1,17	15,9	22,7
Double-shaft without slide-blocks, with step-equal. angular. step cranks r/l = 0,05, e/r = 0,5	6*	157	200	150	11	21	292	1,17	17,1	24,4

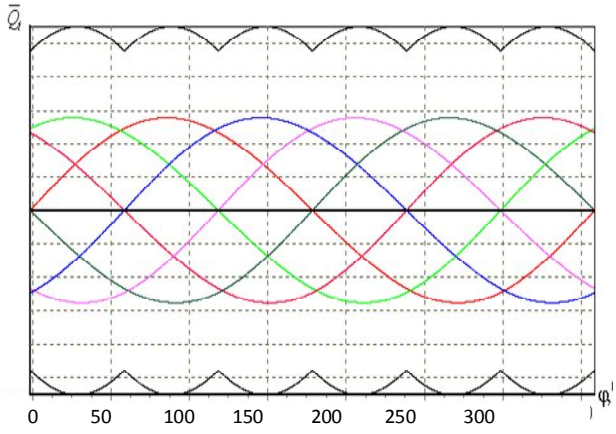

Fig. 5. Changes in the relative supply six-cylinder pump with a uniform angular step of cranks and r / l = 0,2

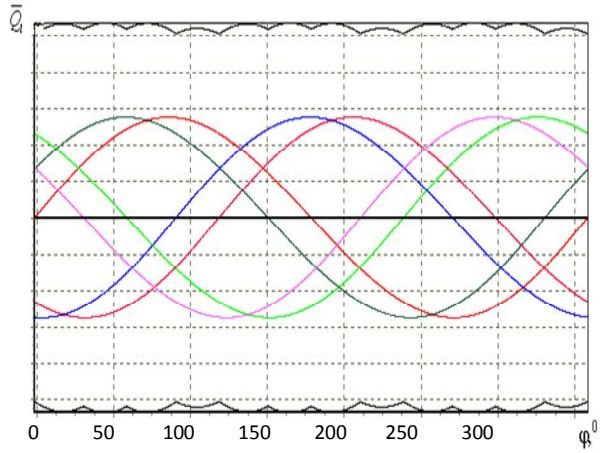

Fig. 6. Changes in the relative supply six- cylinder pump with e/r = 0,5, step-uniform angular step of cranks and r/l = 0,05

By the results obtained by numerical experiments were carried out five projects sketch of the pulp pumps at the same parameters of their work. The first three projects - the traditional design scheme (see table 4, lines 1-3), the last two - on the proposed scheme (see table 4, lines 4-5).

Specifications and performance of all the machines are listed in table 4. In a third embodiment poppet valves replaced with ring [14; 18], which led to a noticeable reduction in the weight of the pump. Besides, repeated decrease of the harmful volume will increase its delivery rate, especially when pumping gas-containing solutions, which is almost always the case. Versions 4 and 5 were performed with annular valves and seals.

In the table 4: η_d – delivery rate, F_p - the pressure on the piston, L_{tr} – road of pistons friction at a time, M – mass of the pump, M̄ – the mass-to-pump-power.

Obviously, proposed technical solutions are superior to the now produced traditional design Pulp pumps by the parameters of uneven flow and pressure, especially the mass

CONCLUSIONS

The numerical experiment on the effect on the kinematics of the fluid and the degree of irregularity of its costs and the pressure in the inlet and outlet pipes piston pumps, the relative magnitude of the geometric dimensions of the

main parts for the drivers of cars with conventional and synthetic design schemes.

The results obtained and executed settlement and design work can be recommended for development of advanced Pulp pumps adopts the proposed original design scheme. This should give preference to vehicles with an odd number of cylinders or even number of cylinders z = 6 *, but with a staggered-uniform angular step of cranks and values relations e / r ≤ 1 and r / l ≤ 0,05. If there is not any need to use an off-center of the drive crank mechanism (e > 0), it is better to use the center, which has e = 0.

Desire to increase stroke, significantly more than twice the radius of the crank through the use of non-central (e > 0) of the drive mechanism is futile due to a sharp deterioration in this unevenness of the pump and torque on its shaft, deterioration of the pump suction capacity due to a sharp increasing the speed of the fluid in the inlet pipe, and therefore the inertia pressure.

REFERENCES

1. Valume pumps for pumping of highly concentrated of hydromixture.// Review information. Series pulpbiuilding. – Moscow: CINTIHIMNEFTEMASH. - 1987. 48 p.
2. **Gurevich E.S. 1982.:** Possibilities research of piston pumps using for hydrotransport on long distance. Moscow: Machinebuilding industry,. - 112 p.
3. **Yunisov R.M. 1984.:** Research and substantiation of working characteristics of pulping pumps for main hydrotransport. Ph.D. dissertation. Moscow.
4. **Verzilin O.I. 1987.:** Modern drilling pumps. – Moscow: Mashinebuilding.– 256 p.
5. http://www.ronglii.com/indexru.html
6. www.lukoil.ru
7. www.derrick.ru
8. www.vzbt.ru/products/S
9. www.upetgroup.ro
10. http://www.rongliicom/indexru.html
11. uhkirf.com
12. http://www.compair.com
13. **Kossenko-Belinsky Yu. A, 2011.:** Piston Pulp pumps: monograph. / Lugansk: Izd VNU them. Dahl, - 211s.
14. **Kossenko-Belinsky Yu, 1997.:** Piston pumps for abrasive slurries: monograph. / Lugansk: Publishing House of VSU,. - 142s.
15. Pat. 21029 (Ukraine). Piston unit. Yu. A. Kossenko-Belinsky. 2007
16. **Roman Ray, Miroslava Ray, 2010:** The method for the definition of reduced coefficient of frictionin crank-connecting mechanism of Pump. Polish Academy of Sciences Branch in Lublin, Lublin University of Technology, Volodymir Dal East – Ukrainian National University of Lugansk. Teka: Commission of Motorization and Power Industry in Agryculture, Lublin University of Technology, Volodymir Dal East- Ukrainian National University of Lugansk. Volume XB. Lublin 2010. P. 125-128.
17. **Taras Zamota, Alexander Kravchenko, 2010.**: Improvement of tribotechnical characteristics of piston ring surface at running in. Polish Academy of Sciences Branch in Lublin, Lublin University of Technology, Volodymir Dal East – Ukrainian National University of Lugansk. Teka: Commission of Motorization and Power Industry in Agryculture, Lublin University of Technology, Volodymir Dal East- Ukrainian National University of Lugansk. Volume XB. Lublin. P .323 - 330.
18. **Kossenko-Belinskiy Yu., 2010.:** Determination of characteristics of circular distributor valve piston pulp pump. Polish Academy of Sciences Branch in Lublin, Lublin University of Technology, Volodymir Dal East – Ukrainian National University of Lugansk. Teka: Commission of Motorization and Power Industry in Agryculture, Lublin University of Technology, Volodymir Dal East- Ukrainian National University of Lugansk.Volume XA. Lublin. P.294-302.

ИСПОЛЬЗОВАНИЕ ЧИСЛЕННОГО ЭКСПЕРИМЕНТА НА СТАДИИ ПРОЕКТИРОВАНИЯ ПОРШНЕВЫХ ПУЛЬПОВЫХ НАСОСОВ

Юрий Косенко-Белинский

Аннотация. Приведены результаты численного эксперимента на кинематических математических моделях работы поршневых пульповых насосов с различными модификациями кривошипно-шатунных приводных механизмов и числом цилиндров. Даны рекомендации по рациональному выбору их количества, углового шага кривошипов и отношения их длины к длине шатуна, а также эксцентриситета механизма к радиусу кривошипа.

Ключевые слова. Поршневой пульповый насос, кинематическая модель, численный эксперимент, кривошип, ползун, шатун, неравномерность подачи и давления, угловой шаг кривошипов.

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Increase of coupling characteristics and profitability of the locomotive modernization of system of supply of sand

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S u m m a r y . The article provides the analysis of inefficiency of the locomotive sand system. A new technical solution is proposed and experimentally confirmed. It will reduce the cost of equipping materials, improve safety, reduce maintenance costs, improve traction quality, and eliminate other system disadvantages of the sand supply.
K e y w o r d s : coefficient of adhesion, sand system, wheel, rail, saving equipping materials.

INTRODUCTION

The tendency to increase the mass and the speed of the train leads to a significant increase in general and specific power of locomotives.

With increasing specific power of rolling stock, there arises the problem of reliable adhesion of wheels with the rails under any weather and climatic conditions, as well as with various kinds of surface pollutions, because traction and braking forces are passed through this node.

One of the most important economic indicators - the cost price of transportations, is mainly determined by the mass of the train, which depends on the parameters of the interaction of the wheel and the rail significantly. In addition, the quality of the work of the «wheel-rail» friction unit has an impact on the speed of movement of trains, traffic safety and a number of other economic and operational characteristics of the work of railway transport [Gorbunov N, Kostyukevich A., Kravchenko K., Kovtanets M., 2011].

THE MAIN OBJECTIVE OF THE ARTICLE

Development of a method and adaptive devices for improvement of interaction in the «wheel-rail» system by supplying sand directly in the zone of contact in one layer.

RESEARCH ANALYSIS

The aim to realize the higher values of the adhesion coefficients led to the emergence of many scientific schools and a number of directions for improvement of adhesion of wheels of a locomotive with rails that can be classyfied into two main groups [Luzhnov U.M., 2003]:

1. Researches aimed at more efficient use of existing properties of the wheels and rails.

2. Researches on the influence on the adhesion coefficient, contributing to the stabilization and improvement of friction properties of wheels and rails.

The second group contains the method of increase the adhesion of the wheel and the rail, which is the most widely spread on the railways of the world and consists of the supply of quartz sand under the wheels of moving locomotive. The detailed examination of the sand locomotive system made it possible to identify its main disadvantages [Lucyk V.S., Kamenskiy V.B., Bashkatova L.V., 2001, Gorbunov N.I., Kovtanets M.V., Gorbunov N.N., Nozhenko V.S., Kravchenko K.A., 2011, Gorbunov N.I., 1987,

Sokolov G.S., 1944, Kovtanets M.V., Naysh N.M., Kravchenko K.A., Kara S.V., 2011]:

– *excessive* and *uncontrolled supply* of sand reduces the efficiency of its use (the maximum effect is achieved when sand is applied in one layer) and contaminating the ballast prism and rail lattice;

– *increase resistance to motion* of the rolling stock which is especially noticeable when passing the curve sections of the track, where the presence of residues of sand on rails makes difficulties in cross movement of train wheels and prevents proper setting of carriages in the direction of the curve and, respectively, increases the consumption of fuel and energy resources (fig. 1);

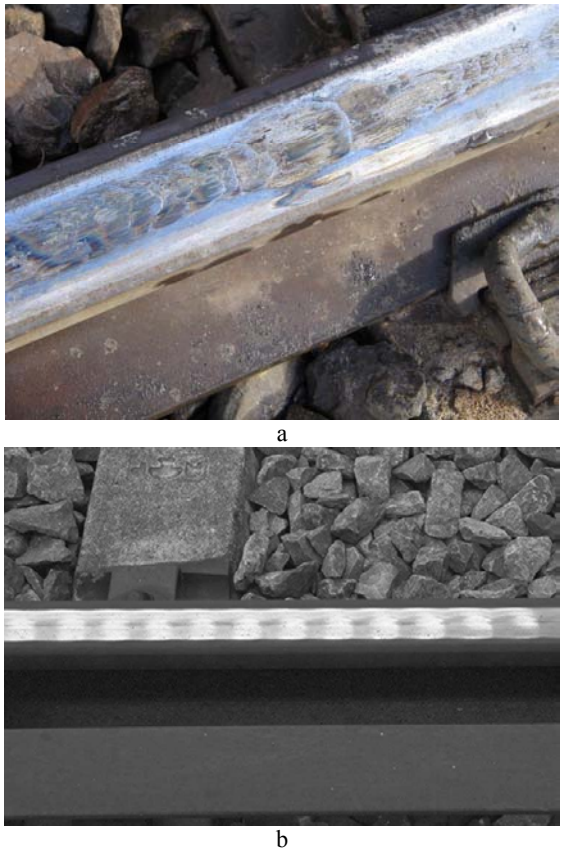
Fig. 1. Presence of residues of sand on rails

– *sand caking* leads to decrease in reliability of work of the injector and hoppers for storage of sand;

– *increased deterioration or damage* rails and the bandages of the locomotive in the form of defects № 14 (wheel slippage of the rails in the mode of sustainable slippage) and № 40 (wave deformation of the rail head - short waves) shown at fig. 2;

– in case of submission of sand *while passing a railroad switch* the surplus sand fills the gap between wit and side rail, thus violating the normal functioning of the switch mechanism;

– *inability to provide an accurate submission of necessary quantity of sand* in the zone of friction contact, as the pipeline with a nozzle mounted on the car frame, which does not repeat complex trail of movement of a wheel. This causes diversion of sand on the side surfaces of the ridge of the bandage and the rail and acceleration of their wear;



a

b

Fig. 2. Kinds of defects caused by excessive supply of sand a – defect № 14; b – defect № 40

– *clogging of elastic gaskets* between the soles of rails and sleepers that causes them to wear and leads to a change of rigidity of the rail lattice;

– *allocation of the condensate* in snowy, wet weather in the steel pipelines and the ends of the pipes that under negative temperature of ambient air makes it freeze inside, preventing the normal functioning of the sand system;

– *possibility of oscillations* (in case of increased thickness of the layer of sand) in a traction drive during slippage that is inevitably accompanied by significant dynamic and shock loads in the elements of the drive and suspension.

Considering aforementioned issues, the existing (operating) locomotives sand system requires modernization of its main units for the effective use of sand and to increase and control the state of the interaction in the «wheel-rail» system.

PROBLEM SOLUTION

It is known that the general tendency of the development of sand system is its simplification and a gradual switch to systems with the low pour of sand. In [Kamenev N.N., 1968, Osenin U.I.,

1994, Osenin U.I., Shvedchikova I.A., 1997, Kravchenko K.A., 2010] the authors have shown that providing high traction locomotive characteristics to contact of wheel and rail dose-amount of sand should be supplied. The maximum possible coefficient of adhesion of the wheel with the rail is achieved by filling the contact sand saturation 0,6 kg/m^2 [Gorbunov N., Kostyukevich A., Kravchenko K., 2010].

Modernization of locomotive sand system to improve traction-adhesion qualities of a locomotive can be implemented in three stages.

1. Reduce the labor and material consumption of production and operation of new sand system through making the nozzle and pipe, connecting nozzle with injector, of rubber (fig. 3), and reducing the diameter of the pipe and the outlet nozzle comparing to existing design of the sand system.

2. The creation of adaptive, repeating almost all movements of the wheel the sand system [Gorbunov N.I., Kravchenko K.A., Kovtanets M.V., Nozhenko V.S., Garkushin E.A., 2010, Kovtanets M.V., 2012, Gorbunov N.I., Kovtanets M.V., Slashov V.A., Kravchenko K.A., Prosvirova O.V., 2012], by fixing rubber nozzle and pipe with the help of the bracket to the bush for accurate batching of sand (fig. 3, 4). Free run of the wheel set comparing to the upper part is 2 mm, that will allow the nozzle mounted on bush perform the move with smaller amplitude, than when attached to the frame of the carriage, and compensate this movement with angle of the spray sand-air jet.

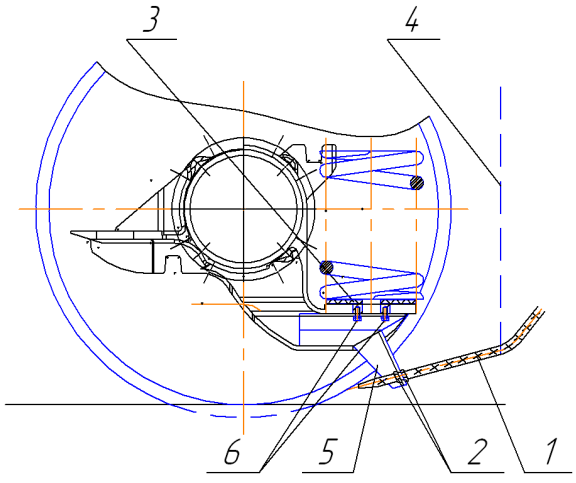
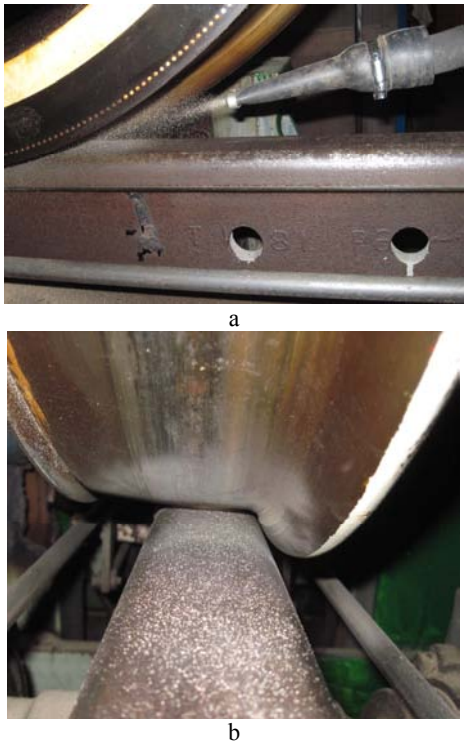


Fig. 3. General view of the upper part of the tri-axial locomotive carriage equipped with a modernized sand system 1 – rubber pipe, 2 – lug nuts, 3 – springs reliance, 4 – safety chain with clip, 5 – bracket, 6 – bracket bolts



a

b

Fig. 4. The operation of the modernized sand system a – the process of submitting the sand directly in contact; b – supply on the surface of the rail

3. Reduction of the consumption of sand by its submission in one layer in the contact of wheel and rail (fig. 4) [Gorbunov N.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Osenin U.U., 2010,].

To confirm the expediency of application of the modernized sand system of the locomotive, experimental study was carried out on a field stand «Wheel-Rail» (fig. 4), which was built according to the scheme, where the geometrical axis of rotation of the wheel has no longitudinal (along the axis of the road) movement, sliced moves only rail mounted on rollers [Gorbunov N.I., Kashura A.L., Popov S.V., Kravchenko K.A., Osenin U.U., 2008]. The design of the stand allows to create vertical forces to 130 kN, longitudinal - up to 40 kN in the zone of contact. The wheel is revolved special drive, traction force is simulated by the brake force longitudinally moveable rail. The efforts, speed of the wheels and the rails are recorded on an oscilloscope.

For the experiment the standard diesel locomotive wheel was used (diameter 1,05 m and rail brand R65) withdrawn from operation, and therefore has libel and little wear of the tread surface. Parameters of loading and modes of implementation of the tractive force is consistent with the work of the locomotive wheel pairs of locomotive 2TE116.

Physical adhesion coefficient ψ_0 was found by limiting value of longitudinal force P, which should be attached to the rail to move it comparatively the wheel wedged in bush bearings with vertical loading $P_в = 115$ *кН , so* $\psi_0 = P/P_в$.

The experiments were carried out for three states of the rail surface: a clean and dry; covered with water; covered with a thin layer of used oil taken from the operated diesel locomotive.

As a result of the performed experimental studies and processing of the results, obtained dependences (fig. 5) of physical coefficient of friction ψ_0 from the sliding speed ε, under different frictional conditions.

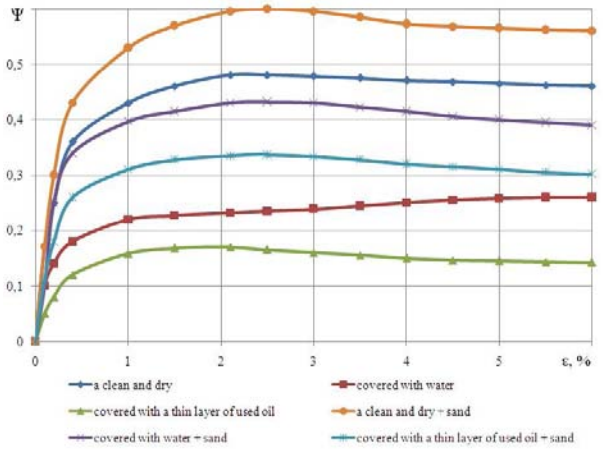


Fig. 5. Dependence of physical coefficient of friction on sliding

Analysis of the results (fig. 5) shows, that the use of the proposed method of submission of sand directly in one layer in the wheel and rail contact allows increasing the physical adhesion coefficient ψ_0 by:

– 20% for a clean and dry rail;
– 39,8% for rail covered with water;
– 49,5% for rail covered with used oil.

To verify the reliability of the upgraded sand system in use, the installation of the design of the system on the shunting locomotive CHME3 №2247 (fig. 6) and the trunk locomotive 2TE116 №1077 (fig. 7) operated in the Kondrashevskaya-Novaya depot.

During the operation installed project sand system showed: the implementation of a high coefficient of friction, lower consumption of sand, the lack of sand on the surface of the rail lattice, the lack of sand get into the gap between the wit and side of the rail, while passing switches, the positive feedback of mechanics in its maintenance in comparison with the sand systems installed on similar models of locomotives.

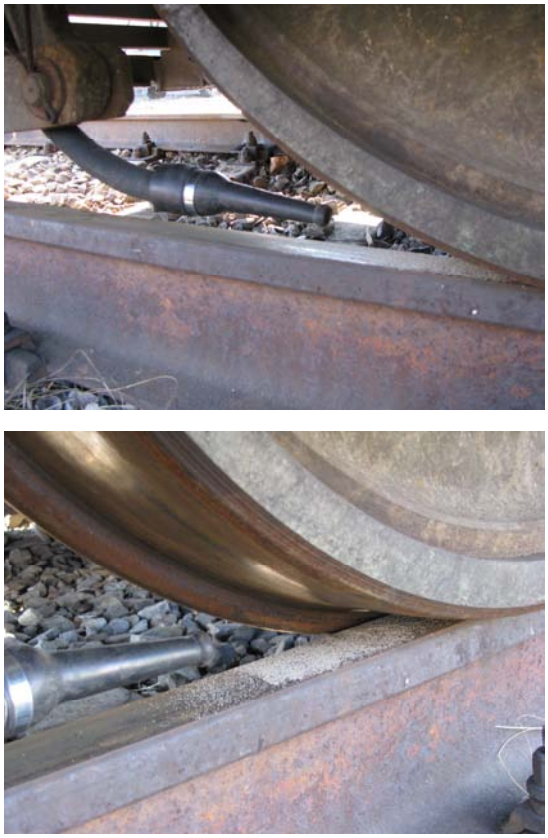


Fig. 6. Installation of the upgraded system on shunting locomotive CHME (№2247)

Fig. 7. Installation of the upgraded system on trunk locomotive 2TE116 (№1077)

As known from [Kravchenko K.A., 2010] the effect of the use one layer of sand will allow to reduce the consumption of sand by 25 times in comparison with the classical supply of sand on the surface of the rails. According to the data of the operation of the locomotive depot Kondrashevskaya-Novaya for the period 2009-2010, the flow of sand Q by the park of locomotives is $389m$ per year, the cost of one ton of sand – $P = 72\ UAH$. The cost of the sand with the account of the expenses connected with cleaning of ballast of the top structure of a way from sand pollution is taken into account by the coefficient $\mu = \left(1 + \frac{32}{26}\right) = 2,23$ according to the data of the operation of diesel locomotives on the railway network.

Complete cost of the sand used in one year by locomotive park of Kondrashevskaya-Novaya depot will be:

$$P_1 = Q \cdot P \cdot \mu = 389 \cdot 72 \cdot 2,23 = 62458\ UAH \quad (1)$$

Cost of the sand used in one year by locomotive park of Kondrashevskaya-Novaya depot using the modernized sand system will be:

$$P_2 = Q \cdot P \cdot \mu = 16 \cdot 72 \cdot 2,23 = 2569\ UAH \quad (2)$$

Consequently, the savings due to the modernization of sand system of the park of locomotives will be:

$$\Delta Э = P_1 - P_2 = 62458 - 2569 = 59889\ UAH \quad (3)$$

As one of the promising solutions for the modernization of locomotive sand system is the completion of the covering of injector from the set of dismountable elements (segments) made of rubber. The proposed nozzle will reduce the cost of its production (having refused from the nozzle made of metal by casting), as well as the complexity of its repairs. Also a set of various number of segments will change the capacity of the mixing chamber the sand-air mixture and consequently the performance of sand system for various types of locomotives.

CONCLUSIONS

It is offered to modernize the existing sand systems used on the locomotives which will allow to achieve the following advantages

– achieve a high and stable coefficient of friction of the wheels of a locomotive and rails;

– reduce the labor intensity and material intensity of production due to the refusal of complex work in the production of metal pipes for the supply of sand, that often break in case of shock loads;

– realization of nozzles and pipes from rubber to eliminate the connections between them and gaskets and reduce the possibility of a moisture penetration conducive to the emergence of clogging of sand in pipelines;

– mounting of pipe and nozzle of sand system on bush reduces labor costs in the production of carriage (abandoning the mounting brackets for sand tubes), improves the use qualities of the locomotive and the terms of its service;

– supply of sand directly in wheel and rail contact in one layer will allow to reduce the consumption of sand in 25 times, increase the coefficient of adhesion of the wheel and rail, which causes the expediency of reduction of discharge nozzle and pipe diameter, and will reduce the capacity of the reservoir for storage of sand in the locomotive, that will reduce time spent on equipping of the sand system with other comparable circumstances and prevent rail lattice pollution;

– eliminates the ingress of sand in the gap between the wit and rail that will reduce the impact loads, enhance safety when driving in switches, so will increase the life expectancy of the elements of the switch and bogie.

According to the proposed modernization of locomotive sand system developed a technical proposal for the drawings 2ТЭ116.30.48.003 СБ. The method [Gorbunov N.I., Kovtanets M.V., Gorbunov N.N., Nozhenko V.S., Kravchenko K.A., 2011] is created and there are reserches on development a system to disable the sand supply in switches, as well as a promising way to improve the adhesion is [Golubenko A.L., Gorbunov N.I., Kashura A.L., Kostyukevich A.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Krusanov M.A., 2011] using dry ice capsules.

REFERENCES

1. **Golubenko A.L., Gorbunov N.I., Kashura A.L., Kostyukevich A.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Krusanov M.A., 2011.:** Declarative patent on an invention № 94498, cl. B61C 15/10, Method of increase of coupling in the zone of contact of wheel with a rail. p. 6.
2. **Gorbunov N.I., 1987.:** Increase of hauling internalss of diesel engines due to the improvement of resilient connections of light carts, Dnipropetrovsk. p. 180.

3. **Gorbunov N.I., Kovtanets M.V., Gorbunov N.N., Nozhenko V.S., Kravchenko K.A., 2011.:** Providing of safety of exploitation of railway transport vehicles creation of innovative decisions of the sandy system of locomotive, "Scientific news of Dahl of university. Engineering sciences. Electronic scientific professional edition. http://www.nbuv.gov.ua/e-journals/Nvdu /2011_3 / Tehno/11gnipsl.pdf.
4. **Gorbunov N.I., Kravchenko K.A., Popov S.V., Kovtanets M.V., Osenin U.U., 2010.:** Declarative patent on an useful model №48520, cl. B61F 15/00, Method of increase of coupling of wheel with a rail. p. 6.
5. **Gorbunov N.I., Kravchenko K.A., Kovtanets M.V., Nozhenko V.S., Garkushin E.A., 2010.:** Declarative patent on an useful model №50800, cl. B61C 15/00, Device for the serve of sand in the zone of contact of wheel with a rail. p. 4.
6. **Gorbunov N., Kostyukevich A., Kravchenko K., 2010.:** Efficiency function for evaluation of the locomotive traction and adhesion qualities / TEKA Commission of Motorization and Power Industry in Agriculture V. X, Poland. p. 80-86.
7. **Gorbunov N, Kostyukevich A., Kravchenko K., Kovtanets M., 2011.:** Influence of operatonal factors on redistribution of wheel pairs vertical loads upon rails / TEKA Commission of Motorization and Power Industry in Agriculture XIA. Poland. p. 92-99.
8. **Gorbunov N.I., Kovtanets M.V., Slashov V.A., Kravchenko K.A., Prosvirova O.V., 2012.:** Adaptive system of serve of sand, Lugansk. p. 108-113.
9. **Gorbunov N.I., Kashura A.L., Popov S.V., Kravchenko K.A., Osenin U.U., 2008.:** Declarative patent on an useful model № 31716, cl. G01M 1/04, Stand for research of coupling of wheel with a rail and test of elements of an axlebox spring suspension of railway rolling stock. p. 12.
10. **Kamenev N.N., 1968.:** Effective use of sand for traction of trains, Moscow: «Транспорт». p. 87.
11. **Kovtanets M.V., 2012.:** Increase of efficiency of hauling-coupling internals of locomotives due to the direct serve of sand in the contact of wheel with a rail, Collection of scientific works №3. Donetsk. p. 85-88.
12. **Kovtanets M.V., Naysh N.M., Kravchenko K.A., Kara S.V., 2011.:** An improvement of method of work of the sandy system of locomotive is in pointer translations, Lugansk. p. 74-78.
13. **Kravchenko K.A., 2010.:** Ground of backlogs of increase of hauling internalss of locomotive and their realization by the management of skidding in the system of wheel with a rail, Lugansk. p. 215.
14. **Lucyk V.S., Kamenskiy V.B., Bashkatova L.V., 2001.:** Reliability of railway, Moscow: «Транспорт». p. 286.
15. **Luzhnov U.M., 2003.:** Coupling of wheels with rails(nature and conformities to law), Moscow: «Интекст». p. 144.
16. **Osenin U.I., 1994.:** Prognostication and management by friction properties of tribotechnical system "wheel-rail", Lugansk. p. 39.
17. **Osenin U.I., Shvedchikova I.A., 1997.:** Friction co-operating of wheel with a rail, Lugansk. p. 227.
18. **Sokolov G.S., 1944.:** Guidance to the locomotive machinist, Moscow: "Трансжелдориздат". p. 548.

ПОВЫШЕНИЕ СЦЕПНЫХ ХАРАКТЕРИСТИК И ЭКОНОМИЧНОСТИ ЛОКОМОТИВА МОДЕРНИЗАЦИЕЙ СИСТЕМЫ ПОДАЧИ ПЕСКА

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Аннотация. Представлен анализ неэффективности работы песочной системы локомотива. Предложено и экспериментально обосновано новое техническое решение, которое позволит снизить затраты экипировочных материалов, повысить безопасность движения, снизить затраты на обслуживание, повысить тягово-сцепные качества локомотива, а также устранить другие присущие песочной системе недостатки.

Ключевые слова: коэффициент сцепления, песочная система, колесо, рельс, экономия экипировочных материалов.

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Deformation of rubber-metal vibration and seismic isolators

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Summary. The different going is considered near the decision of task about the tensely-deformed state of rubber-metal vibration isolators are considered The method of the solution of a task about deformation of constructions from nearly incompressible material on application moment scheme of finite elements is offered. For the decision of task of nonlinear viscoelasticity deformation of construction the newton-Kantorovich method is used.
Keywords: finite element method, vibration isolator, nearly incompressibility.

INTRODUCTION

The considerable part of the population of the globe lives in the seismoactive territory. Therefore protection of buildings, constructions, infrastructure objects against adverse effect of pulse and vibration loadings of a geological and technogenic origin is actual. Traditional systems of seismoprotection provide seismic stability at the expense of increase of bearing ability of designs and their connections that stimulates creation of stronger, rigid and monolithic constructions. Thus construction cost in seismic countries in comparison with not seismic increases by 4-12% depending on seismodanger size.

Use of nonconventional systems of vibroseismoprotection allows to provide safety of buildings and constructions at earthquakes and technogenic influences. Thus the budget cost of construction decreases by 3-6%, a material capacity of buildings and constructions for 5-10%, and also the scope of standard designs by control of areas with the increased seismicity extends, height of buildings increases when using the same designs.

Among nonconventional ways of vibration and seismic protection the most perspective is application of vibration and seismic isolators on the basis of rubber-metal designs. On many parameters – simplicity of production, reliability, dimensions, costs such designs surpass traditional schemes of the same appointment. They allow to find essentially new constructive solutions of responsible knots of protection of modern technical systems The analysis of world practice of vibration and seismic protection of cars, buildings and constructions shows that systems with use of rubber-metal blocks is the most perspective. Such systems allow to protect cars and buildings at seismic influences not only in the horizontal and vertical planes, but also from torsion. Besides, application of rubber-metal layered vibration isolators allows to protect buildings and the people who were in them from influences of the subway, motor and railway transport Besides, application of rubber-metal layered vibration isolators allows to protect buildings and the people who were in them from influences of the subway, auto and railway transport. The problem of calculation intense the deformed condition of polymeric elements of designs is rather actual [Lavendel E. E. 1976, Dymnikov S. I. 1968, Kirichevskiy V. V. 2005, Biderman V. L, Sukhova N. A. 1968, Malkov V. M 1998, Ray M. 2010, Dyrda V. I. 2010, Grigolyuk E. I., Kulikov G. M. 1988, Peng R. W. Landel R. F. 1975, Mooney M.A., 1940].

RESEARCH OBJECT

Rubber elements of vibration isolators have rather simple form. However conditions of loading are defined not only external loadings, but also a form of the metal elements of vibration isolators interfaced to them. Besides, rubber possesses weak compressibility. Calculation of parameters intense the deformed condition of such elements of designs probably various methods – experimental, empirical, approximate analytical, numerical. One of the main characteristics of a vibration and seismic isolators is rigidity on compression at vertical loading.

RESULTS OF RESEARCH

Let's consider the multilayered vibration isolators consisting of three metal plates of rather big thickness and two rubber blocks of a cylindrical form. For such vibration and seismic isolators during static tests rigidity on compression was defined at the various size of loading of rubber blocks: diameter 400mm, height 120mm. As a result of simple recalculations it is possible to define dependence between an deformation of a support and the enclosed loading:

$$\Delta = \frac{P}{C_{st}}, \qquad (1)$$

where: Δ – seismic support contraction; P – compression loading; C_{st} – vertical rigidity of a seismic support.

On the other hand, for small deformations ($\varepsilon < 0.1$) Dyrda V.I. received analytical dependence between an contraction of a cylindrical rubber layer with free end faces and enclosed loading by the method of Ritz:

$$\Delta = \frac{P_0 h}{3\pi R^2 G}\left(1 - \frac{R}{h\sqrt{6}} th \frac{h\sqrt{6}}{R}\right), \qquad (2)$$

where: P_0 – compression loading on rubber layer with free end faces; h – height of a rubber layer R – radius of a rubber layer; G – module of shift of rubber.

At axial compression for small deformations ($\varepsilon < 0.1$) dependence between an contraction of a rubber layer and enclosed loading is defined by a formula;

$$\Delta = \frac{P_0 h}{3\pi R^2 G}. \qquad (3)$$

At calculation of seismic support it is necessary to consider that end faces of a rubber layer is vulcanized to metal plates. Then instead of loading P_0 it is necessary to insert the corrected value of real loading P which considers increase in rigidity at the expense of fixing of end faces into formulas (2) and (3):

$$P_0 = \frac{P}{\beta}, \qquad (4)$$

where: $\beta = 1 + 0.413\rho^2$ [Payne A. R., 1959] or $\beta = 0.92 + 0.5\rho^2$ [Lavendel E. E., 1976].

V. I. Dyrda suggested to calculate coefficient β on a formula:

$$\beta = 1 + 0.83\rho^2, \qquad (5)$$

where: $\rho = \frac{R}{h}$; β – coefficient of increase in rigidity at the expense of fixing of end faces.

Universal numerical method of calculation of rubber vibration and seismic isolators which allows to consider asymmetry of loadings and fixing, and also to receive a full picture intense the deformed condition is finite element method. Thus the traditional final element method doesn't allow take account for a weak compressibility of rubber. For constructions from elastomers the moment scheme of finite elements with use of threefold approximation a component of a vector of movement, a tensor of deformations and function of change of volume of rubber is used. Approximating functions are accepted in the form of square polynoms:

$$\begin{aligned}
u_i &= \omega_i^{(000)} + \omega_i^{(100)}\psi^{(100)} + \omega_i^{(010)}\psi^{(010)} + \\
&+ \omega_i^{(001)}\psi^{(001)} + \omega_i^{(110)}\psi^{(110)} + \omega_i^{(101)}\psi^{(101)} + \\
&+ \omega_i^{(011)}\psi^{(011)} + \omega_i^{(111)}\psi^{(111)} + \omega_i^{(200)}\psi^{(200)} + \\
&+ \omega_i^{(020)}\psi^{(020)} + \omega_i^{(002)}\psi^{(002)} + \omega_i^{(210)}\psi^{(210)} + \\
&+ \omega_i^{(201)}\psi^{(201)} + \omega_i^{(120)}\psi^{(120)} + \omega_i^{(021)}\psi^{(021)} + \\
&+ \omega_i^{(102)}\psi^{(102)} + \omega_i^{(012)}\psi^{(012)} + \omega_i^{(211)}\psi^{(211)} + \\
&+ \omega_i^{(121)}\psi^{(121)} + \omega_i^{(112)}\psi^{(112)}, \\
\varepsilon_{11} &= e_{11}^{(000)} + e_{11}^{(001)}\psi^{(001)} + e_{11}^{(010)}\psi^{(010)} + \\
&+ e_{11}^{(011)}\psi^{(011)} + e_{11}^{(100)}\psi^{(100)} + e_{11}^{(110)}\psi^{(110)} + \\
&+ e_{11}^{(101)}\psi^{(101)} + e_{11}^{(020)}\psi^{(020)} + e_{11}^{(102)}\psi^{(102)} + \\
&+ e_{11}^{(111)}\psi^{(111)} + e_{11}^{(021)}\psi^{(021)} + e_{11}^{(012)}\psi^{(012)}, \\
\varepsilon_{22} &= e_{22}^{(000)} + e_{22}^{(001)}\psi^{(001)} + e_{22}^{(100)}\psi^{(010)} + \\
&+ e_{22}^{(101)}\psi^{(101)} + e_{22}^{(001)}\psi^{(001)} + e_{22}^{(110)}\psi^{(110)} + \\
&+ e_{22}^{(011)}\psi^{(011)} + e_{22}^{(002)}\psi^{(002)} + e_{22}^{(102)}\psi^{(102)} + \\
&+ e_{22}^{(111)}\psi^{(111)} + e_{22}^{(201)}\psi^{(201)} + e_{22}^{(012)}\psi^{(012)},
\end{aligned}$$

$$\begin{aligned}
\varepsilon_{33} &= e_{33}^{(000)} + e_{33}^{(100)}\psi^{(100)} + e_{33}^{(010)}\psi^{(010)} + \\
&+ e_{33}^{(110)}\psi^{(110)} + e_{33}^{(001)}\psi^{(001)} + e_{33}^{(200)}\psi^{(200)} + \\
&+ e_{33}^{(020)}\psi^{(020)} + e_{33}^{(101)}\psi^{(101)} + e_{33}^{(011)}\psi^{(011)} + \\
&+ e_{33}^{(210)}\psi^{(210)} + e_{33}^{(120)}\psi^{(120)} + e_{33}^{(111)}\psi^{(111)}, \\
\varepsilon_{12} &= e_{12}^{(000)} + e_{12}^{(001)}\psi^{(001)} + e_{12}^{(100)}\psi^{(100)} + \\
&+ e_{12}^{(110)}\psi^{(110)} + e_{12}^{(100)}\psi^{(100)} + e_{12}^{(101)}\psi^{(101)} + \\
&+ e_{12}^{(011)}\psi^{(011)} + e_{12}^{(002)}\psi^{(002)}, \\
\varepsilon_{13} &= e_{13}^{(000)} + e_{13}^{(100)}\psi^{(100)} + e_{13}^{(010)}\psi^{(010)} + \\
&+ e_{13}^{(001)}\psi^{(001)} + e_{13}^{(110)}\psi^{(110)} + e_{13}^{(020)}\psi^{(020)} + \\
&+ e_{13}^{(011)}\psi^{(011)} + e_{11}^{(020)}\psi^{(020)}, \\
\varepsilon_{23} &= e_{23}^{(000)} + e_{23}^{(100)}\psi^{(100)} + e_{23}^{(010)}\psi^{(010)} + \\
&+ e_{23}^{(001)}\psi^{(001)} + e_{23}^{(001)}\psi^{(001)} + e_{11}^{(200)}\psi^{(200)} + \\
&+ e_{11}^{(110)}\psi^{(110)} + e_{11}^{(101)}\psi^{(101)}, \\
\theta &= \xi^{(000)} + \xi^{(100)}\psi^{(100)} + \xi^{(010)}\psi^{(010)} + \\
&+ \xi^{(001)}\psi^{(001)} + \xi^{(101)}\psi^{(101)} + \xi^{(110)}\psi^{(110)} + \\
&+ \xi e^{(011)}\psi^{(011)} + \xi^{(111)}\psi^{(111)},
\end{aligned} \tag{6}$$

where: u_i - components of a vector of movements; ε_{ij} – components of a tensor of deformations; θ - function of change of volume; $\omega_i^{(pqr)}$ – decomposition components; $\psi^{(pqr)}$ – a set of sedate coordinate functions of a look

$$\psi^{(pqr)} = \frac{\left(x^1\right)^p}{p!}\cdot\frac{\left(x^2\right)^q}{q!}\cdot\frac{\left(x^3\right)^r}{r!}, \ (p, q, r = 0, 1, 2). \tag{7}$$

Let's find to a contraction for a two-layer seismic support under the influence of loading $P = 50\kappa N$, (the module of shift of rubber $G = 0.63MPa$). Dyrda V. I. Lisitsa N.I., etc. received the solution of a nonlinear task a precipitation of the continuous cylinder taking into account toughening at end faces by means of the accuracy Runge-Kutt method of the fourth order. he received value a seismic insulator precipitation ($\Delta = 0.0127m$) rather well coincides with experimental data.

The analysis of behavior of vibration and seismic isolator at imposition of cyclic or impulsive loading requires the account of viscoelastic properties of rubber elements. A viscoelasticity determines it dumping properties. For description of viscoelasticity deformation it is possible to take advantage of Volterra's equalizations

$$\sigma = E_0\left[\varepsilon - \int_0^t R(t-\tau)\varepsilon(\tau)d\tau\right]. \tag{8}$$

where: $R(t-\tau)$ – kernel of relaxation.

In addition, for description of behavior of nearly incompressible material different nonlinear laws are used. For example, Peng-Landel's law [Peng R. W., Landel R. F., 1975.]

$$\begin{aligned}
\sigma^{ij} = I_3^{1/2}\Bigg[&\mu\left(\left(-I_3^{-1/3} + \frac{2}{9}(2I_1 - 3)(I_3 - 1)\right)G^{ij} + \right. \\
&\left. + I_3^{-4/3}g^{ij}\right) + \frac{B}{2}(I_3 - 1)G^{ij}\Bigg],
\end{aligned} \tag{9}$$

where: I_1, I_3 are invariants of tensor of deformations; μ, B are constant of material, G^{ij} is a metrical tensor.

We replace resilient permanent is the module of compression B and module of shear μ we get the Volterra's operators

$$\begin{aligned}
\sigma^{ij} = I_3^{1/2}\Bigg[&\mu\left(\left(-I_3^{-1/3} + \frac{2}{9}(2I_1 - 3)(I_3 - 1)\right)G^{ij} + \right. \\
&\left. + I_3^{-4/3}g^{ij}\right) + \frac{B}{2}(I_3 - 1)G^{ij} - \\
&- \mu\int_{-\infty}^{t} R_\mu(t-\tau)\left(-I_3^{-1/3} + \frac{2}{9}(2I_1 - 3)(I_3 - 1)\right)G^{ij}d\tau - \\
&- \mu\int_{-\infty}^{t} R_\mu(t-\tau)I_3^{-4/3}g^{ij}G^{ij}d\tau \\
&- \frac{B}{2}\int_{-\infty}^{t} R_b(t-\tau)(I_3 - 1)G^{ij}d\tau\Bigg].
\end{aligned} \tag{10}$$

The tensor of deformations can be presented as a sum linear and nonlinear constituents

$$\begin{aligned}
\varepsilon_{ij} &= \varepsilon_{ij}^l + \varepsilon_{ij}^n, \\
\varepsilon_{ij}^l &= \frac{1}{2}\left(c_j^k u_{k,i} + c_i^k u_{k,j}\right), \\
\varepsilon_{ij}^n &= \frac{1}{2}u_{k,i}u_{,j}^k.
\end{aligned} \tag{11}$$

Then the invariants of Cauchy- Green's tensor of deformations also can be presented as a sum linear and nonlinear parts

$$\begin{aligned}
I_1 &= I_1^l + I_1^n, \\
I_1^l &= \varepsilon_{11}^l + \varepsilon_{22}^l + \varepsilon_{33}^l, \\
I_1^n &= \varepsilon_{11}^n + \varepsilon_{22}^n + \varepsilon_{33}^n.
\end{aligned} \tag{12}$$

We put (12) in (10) and we lay out I_3 in the Taylor series about with $I_3 = 1$ as the center of the circle of convergence. Then we cast aside by virtue of weak compressibility of material members of decomposition the second order of trifle and we get the linearized correlation. For the decision of task of nonlinear deformation of constructions different methods are used [Dymnikov S.I., 1968, Lavendel E.E., 1980, Kirichevskiy V.V., 2005]. Most effective among them is the modified Newton-

Kantorovich method. At the use of this going near the decision of task on every step on loading get the specified linearized equalization

$$Ku^{i+1} = -N(u^i) - P_k, \qquad (13)$$

where: K is matrix of inflexibility of construction; $N(u^i)$ is a vector of the nonlinear additions, conditioned by physical and geometrical non-linearity; P_k is vector of key forces; u is a vector of the key moving. On the basis of this approach the task of determination is decided seismic support.

The problem is also solved on the basis of the moment scheme of finite elements on the basis of the obtaining complex «MIRELA+». In fig. 1-4 are presented finite element model and distribution of movements and tension in the radial section of a rubber element

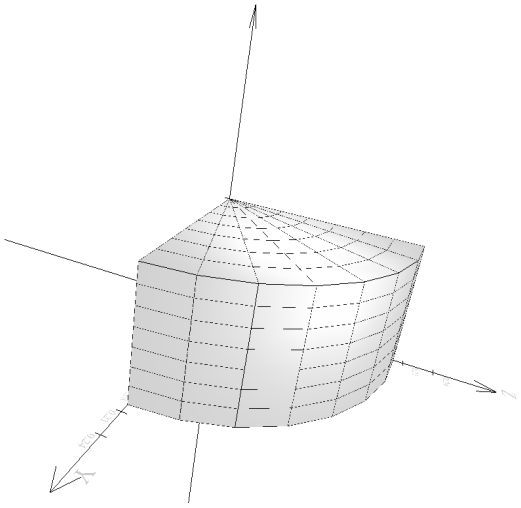

Fig. 1. Finite element model

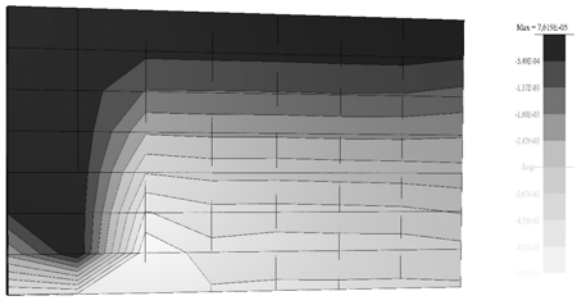

Fig. 2. Axial movement

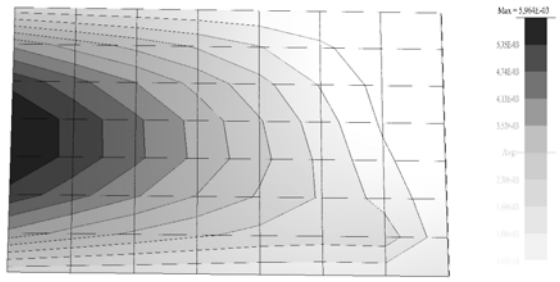

Fig. 3. Radial movement

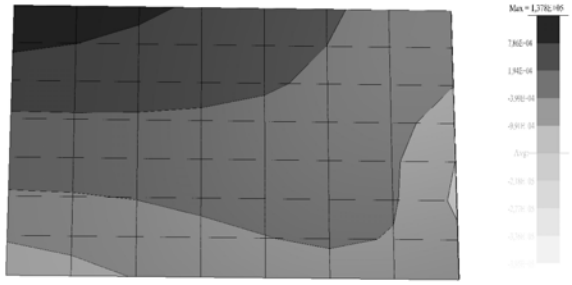

Fig. 4. Stress σ_{12}

As comparison we will give a calculation example a precipitation of a rubber layer of a seismic support on formulas (2) and (3). Results of calculations are given in table.

Table. Seismic support contraction

Indicator	Experiment	Formula		FEM
		(2)	(3)	
Δ, m	0.012	0.0084	0.0128	0.0122

CONCLUSIONS

The method of calculation of vibration and seismic isolators is developed. The analysis of the received results shows that use of a finite element method allows to receive a complete picture of distribution of tension and movements on the volume of an element of a design taking into account weak compressibility of a material.

REFERENCES

1. **Bate K., Vilson E., 1982.:** Numerical methods of analisys and finite element method. Moscow, Stroyizdat, 470p.
2. **Biderman V.L. Sukhova N.A., 1968.:** Calculation of cylindrical and rectangular long rubber shock-absorbers of compression. Calculations on durability. N 13. pp. 55–72.
3. **Dokhnyak B.M., Kozub Y.G., 2002.:** Account of previously stressed constructions from elastomers. Proc. 13 Symp. "Problems of tyres and rubber-cord composits", 14–18 October, Moscow, SRITI, pp. 119 –123.
4. **Dymnikov S.I., 1968.:** Analysis of rubber details at average deformations. Mechanics of polymers. N 2. pp. 271-275.
5. **Dyrda V.I., Agaltsov G.N., Kozub Y.G., Roschupkin S.V., 2010:** Vibration protection of heavy cars by means of rubber elements. Geotechnical mechanics. N 86. pp. 171-195.
6. **Dyrda V.I., Goncharenko A.V., Zharko L.V., 2010.:** Solution of a task on compression of the viscoelastic cylinder by a method Ritz's. Geotechnical mechanics. N 86. pp. 113-124.
7. **Dyrda V.I., Maryenko N.G., 2009.:** Analysis and choice of parameters of rubber-metal seismic support. Geotechnical mechanics. N 84. – pp. 17–23.
8. **Grigolyuk E.I., Kulikov G.M., 1988.:** Multilayered reinforced covers. Moscow, Mashinostroyenie, 288p.
9. **Kirichevskiy V.V. Dokhnyak B.M. Kozub Y.G., Gomenyuk S.I., Kirichevskiy R.V., Grebenyuk S.N., 2005.:** Finite element method in obtained complex "MIRELA +". Kyiv, Nukova dumka, 403p.
10. **Kirichevskiy V.V., 2002.:** Finite element method in mechanics of elastomers. Kyiv, Naukova dumka, 655p.
11. **Kirichevskiy V.V. Dokhnyak B.M., Vysotskaya N.D., Kozub Y.G., 1992.:** FEM in the nonlinear viscous elasticity of elastomer constructions. Proceeding of 6 International Scientific and Technical Conf. "ELASTOMERS", Riga, p.97.
12. **Lavendel E.E., 1976.:** Calculation of rubber products: monograph. Moscow, Mashinostroyenie, 232p.
13. **Lavendel E.E., 1980.:** Methods of applied calculation for production from high elasticity materials. Riga, Zinatne, 238c.
14. **Malkov V.M., 1998.:** Mechanics of multilayed elastomeric constructions. Sant-Petersburg, 320p.
15. **Mooney M.A., 1940.:** Theory of Large Elastic Deformation. J. Appl. Phys, N 11, pp. 582–592.
16. **Ogden R. W., 1972.:** Large deformation isotropic elasticity on correlation of theory and experiment for incompressible rubber-like solids. Proc. Roy. Soc. London. Ser. A, Vol. 326, pp.565-584.
17. **Payne A. R., 1959.:** Shape factors and functions in rubber engineering. Engineer, Vol. 207, N 5379, pp. 51–59.
18. **Peng R. W., Landel R. F., 1975.:** Stored energy function and compressibility of compressible rubber like materials under large straine. J. Appl. Phys, N 6, Vol.46, pp. 2599–2604.
19. **Ray A., Ray M., 2010.:** Anvil-block vibration damping by means of friction force. TEKA Commission of Motorization and Power Industry in Agriculture, OL PAN, 10C, Lublin, pp. 242–249.
20. **Ray R., Ray M., 2010.:** The definition of reactions of motion system of no-anvil hammer. TEKA Commission of Motorization and Power Industry in Agriculture, OL PAN, 10C, Lublin, pp. 250–254.
21. **Sukhova N. A., Biderman V. L., 1962.:** Calculation of rubber shock-absorbers worked on compression. Calculations on durability, N 8, pp. 200–211.
22. **Vashizu K., 1987.:** Variational methods in elasticity plasticity. Moscow, Mir, 542p.

ДЕФОРМИРОВАНИЕ РЕЗИНОМЕТАЛЛИЧЕСКИХ ВИБРОСЕЙСМОИЗОЛЯТОРОВ

Юрий Козуб

Аннотация. Рассмотрены различные подходы к решению задачи о напряженно-деформированном состоянии резинометаллических виброизоляторов. Предложен метод решения задачи о деформировании элементов конструкций из слабосжимаемого материала основанный на применении моментной схемы конечных элементов. Для решения задачи нелинейного вязкоупругого деформирования конструкции используется метод Ньютона-Канторовича.

Ключевые слова. Метод конечных элементов, виброизолятор, слабая сжимаемость.

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Method of a choice of parameters of the air cooling machine of a cascade pressure exchange

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S u m m a r y. The algorithm of calculation of the basic dimensional parameters of compound units of the system realizing running cycle of the air refrigerating machine of the cascade pressure exchange of set cooling capacity and object cooling depth is resulted. The technique of an estimation of expenses of thermal and mechanical energy on realization of a cycle of the air refrigerating machine is presented.
K e y w o r d s : cascade pressure exchanger, mass-exchange, air cooling machine, recuperation, refrigerating capacity.

INTRODUCTION

Along with search of ways of decrease heat expenditure cold production more and more the attention is given to ecological safety of a refrigerating machinery. A serious environmental problem of planetary scale is the exhaustion of an ozone layer of an aerosphere, substantially in an influence kind galogen hydrocarbons (freons), widely used as a working body in a refrigerating machinery of compressor type.

According to opinion of scientists at conservation of dynamics of technogenic influence on an atmosphere predicted rates thining an ozone layer will make 7 % in 60 years [Rowland 1994, Anderson 2002].

It is necessary to notice, that operation of a refrigerating machinery on transport is interfaced to the raised probability of leaks of a coolant in view of high vibrating loadings and the limited possibility of the timely control of tightness of system in vehicle movement.

OBJECTS AND PROBLEMS

Now interest to air refrigerating machines (ARM), having a more potential of low temperature coolings without use ozone destroy coolants renews. The refrigerating factor of air installations at rather small relations of ambient temperature and cooled object concedes to indicator steam compression installations, however in the field of deep cooling the running cycle air ARM with regeneration realises higher power efficiency.

At the same time, approved ARM on base blade units of compression and expansion are expensive in manufacturing and in view of high frequency of rotation of rotors turbine-compressor unit have the limited resource, demand high level of maintenance service. Insufficiently high power efficiency of turbine-compressor ARM is caused by the limited possibility of the further efficiency increase of working processes of blade machines, reached by considerable complication of a design of the last.

Possibility of reduction in price ARM contacts use as the detander-compressor of a wave pressure exchanger (WPE) similar on a design to the unit of air supply of system of pressurization ICE "Comprex" [Ersmambetov 2000]. In a rotor of WPE in the course of a direct exchange of energy between compressing and compressed environment along with cooling of an air stream compression to 25 … 30 % of a coolant is carried out. The coolant most part is compressed in a separate, basic step of the compressor resulted from an external source of mechanical energy. Simplicity and reliability of a

design of the device concerns advantages of the wave detander-compressor, and also lower concerning a turbine unit frequency of rotation of a rotor (6500 … 10000 minutes^{-1}).

However, wave character of an exchange of energy predetermines high sensitivity of working process of WPE to a picture of interacting of primary waves with forward edges of gas-distribution ports. The deviation of an operating mode of WPE from settlement conditions on frequency of rotation of a rotor, pressure and temperature of working environments is accompanied by sharp deterioration of indicator of its work as owing to a mismatch of phases of movement of primary waves, and owing to incompleteness of replacement of compressed air from rotor cells. The increase in a share of the compressed air which has remained in a cell at the moment of its dissociation with port of a high pressure, caused almost proportional decrease of efficiency, to similarly negative effect of so-called "dead" volume in the piston compressor. Besides, inevitable dissipation the phenomena in processes of formation and interaction of strong shock waves limit of efficiency of the best samples of wave pressure exchangers on settlement modes values 0,55 … 0,56 [Krajniuk 2000].

Considerably much reserve of perfection of operational indicator of ARM is connected with use in quality detander, and also as the basic compressor of essentially new version heat exchange devices - a cascade pressure exchanger (CPE) of prof. A.I. Krajniuk [Krajniuk 2004]. On fig. 1 the modified scheme of air refrigerator is shown.

In given article attempt to reflect the basic laws of work ARM CPE with probably more simple engineering dependences within the limits of a statement of algorithm of a choice of dimensional parameters and definition of effective indicators of work of system is undertaken. Remarks to a choice of initial parameters of system of the settlement scheme.

The demanded temperature mode in the chamber of cooled object and corresponding cooling capacity of ARM CPE can be realized with various combination of temperature T_3 and consumption G_3 of an air coolant submitted to the chamber. In turn decrease in temperature forced ARM CPE of an air coolant can be reached increase in throughput (dimensions) of the CPE unit of a compensatory step (CPEII) or increase of the maximum temperature of heating of air T_5 in a contour of a high pressure a source of a supply of warmth. The combination of noted regime parameters influences a parity of expenses of the thermal and mechanical (electric) energy spent for realization of a refrigerating cycle. For example,

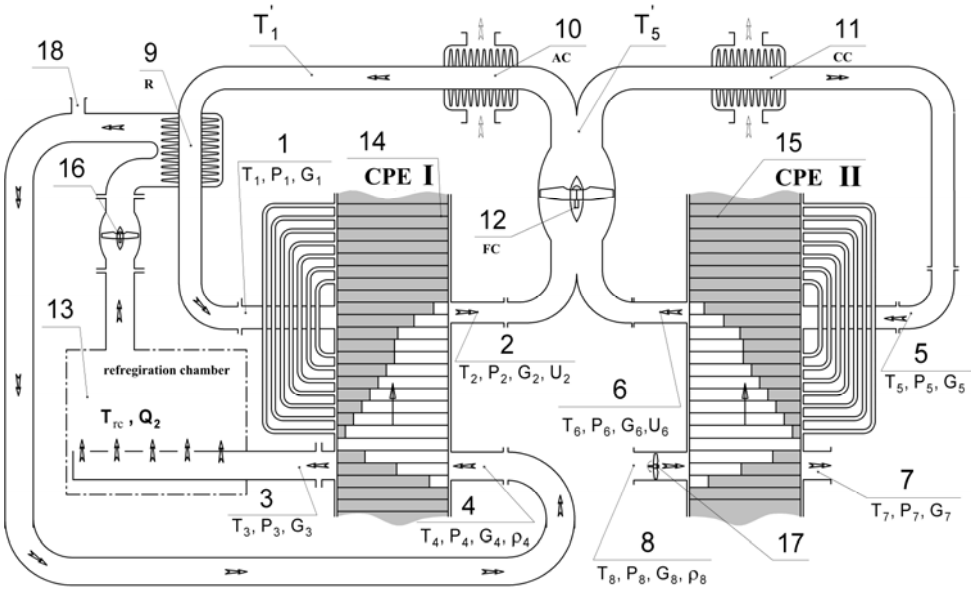

Fig. 1. The settlement scheme of an air refrigerator with a cascade exchanger of pressure:
1, 2, 5, 6 - ports of supply and tap high pressure (HPS and HPT) accordingly CPEI and CPEII; 3, 4, 7, 8 - ports of low tap and supply pressure (LPT and LPS) accordingly CPEI and CPEII; 9 - regenerative heat exchanger; 10 - air cooler; 11 - warmth supply source; 12 - circulating fan; 13 - refrigerating chamber; 14, 15 - cascade pressure exchangers CPE1 and CPE2; 16, 17 - blowing-off fans, 18 - branch pipe.

decrease of temperature T_3 (increase of expansion degree π_p in CPEI) at the expense of increase T_5 or increase of CPEII dimensions is accompanied by increase in expenses of thermal energy in a source of a supply of warmth at simultaneous reduction of expenses of mechanical energy by a drive of the circulating fan. Thus, the choice of rational parameters ARM CPE depends from parity of the developed prices on electric and thermal energy and, finally, is reduced to search of the regime conditions providing the minimum sum of cost equivalents thermal and mechanical energies, spent for realization of running cycle ARM CPE.

The algorithm of calculation of the basic dimensional parameters of compound units of the system realizing running cycle ARM CPE with following set initial data is more low resulted: 1 – cooling capacity Q_2, 2 - temperature of cooled object T_{rc}, 3 - the minimum temperature of cycle T_3 (temperature of air arriving in the refrigerating chamber), 4 - the maximum temperature of cycle T_5.

As the basic assumptions of calculation one-dimensionality of a current of a working body in flowing elements of system, absence of leaks of a working body through backlashes in mobile interfaces and heat exchange with walls, absence of a zone of hashing of compressing and compressed environments, and also full replacement of the compressed environment from cells of rotors and a full purge of cells a fresh charge is accepted.

Completeness of replacement and purge is estimated by corresponding factors. The purge factor in CPEI and CPEII ($\psi_{\text{ЛПІ}}$, $\psi_{\text{ЛПІІ}}$) represents relation of consumptions of air through ports of a supply of low pressure to mass throughput of a rotor

$$\psi_{\text{LPI}} = \frac{G_4}{g_{\text{I}}},\ \psi_{\text{LPII}} = \frac{G_8}{g_{\text{II}}}. \qquad (1)$$

Mass throughput accordingly rotors CPEI and CPEII is defined as

$$g_{\text{I}} = \frac{V_{\text{RI}} \cdot n_{\text{RI}} \cdot \rho_4}{60},\ g_{\text{II}} = \frac{V_{\text{RII}} \cdot n_{\text{RII}} \cdot \rho_8}{60}, \qquad (2)$$

where: V_{RI}, V_{RII}, n_{RI}, n_{RII} - volumes of a flowing part and frequency of rotation of rotors accordingly CPEI and CPEII, ρ_4, ρ_8 - density of a working body in ports of a supply of low pressure accordingly CPEI and CPEII.

Similarly, the replacement factor accordingly in CPEI and CPEII (ψ_{HPI}, ψ_{HPII}) represents itself the consumption relation through ports of tap of a high pressure to mass throughput of a rotor

$$\psi_{\text{HPI}} = \frac{G_2}{g_{\text{I}}},\ \psi_{\text{HPII}} = \frac{G_6}{g_{\text{II}}}. \qquad (3)$$

The dimensions of rotor CPEI of the detander-compressor are from a condition of conformity of mass throughput of a rotor to the consumption of coolant in the chamber cooled object.

The coolant consumption, providing set cooling capacity of ARM, is calculated by the formula

$$G_3 = \frac{Q_2}{Cp_a \cdot (T_{rc} - T_3)}, \qquad (4)$$

where: Cp_a - a mass heat capacity of air.

Accepted above an assumption of completeness of replacement and a blowing (ψ_{HPI}=1, ψ_{LPI} =1) in essence suggest, that, on the one hand, all compressed air arriving in cells of a rotor through port 1, after expansion is taken away in the refrigerating chamber 13 through port 3 and, thus $G_1 = G_3$, on the other hand, all air charge arriving in cells of a rotor through port 4, after compression is taken away through port 2 $G_2 = G_4$.

In a kind noted easily also to show, that the consumption ratio in high pressure port can be expressed through a ratio of densities of air in a line of low pressure

$$\frac{G_1}{G_2} = \frac{\rho_{\text{res1}}}{\rho_4}. \qquad (5)$$

Here ρ_4 - air density in port 4 CPEI; ρ_{res1} - density of the rotor which has extended in cells of air, during the moment previous their connecting with port of low pressure.

$$\rho_4 = \frac{P_4}{R \cdot T_4},\ \rho_{\text{res1}} = \frac{P_{\text{res1}}}{R \cdot T_{\text{res1}}}, \qquad (6)$$

where: P_4 - the pressure created by the blowing fan 16, T_4 - air temperature in port 4, P_{res1}, T_{res1} - pressure and temperature extended in a cell rotor CPEI of air, R - a gas constant of air.

In turn air temperature in port 4 with ratio of water equivalents of flows in the regenerative heat exchanger 9 is calculated with formula:

$$T_4 = T_{rc} + \varepsilon(T_1' - T_{rc}), \qquad (7)$$

where: ε - regenerator efficiency, for plate-fin recuperators reaches values 0,8 … 0,85; $T_1^{'}$ - air temperature in a line of a high pressure to a regenerator 9.

Then, air temperature in port 1 is defined from the equation of heat balance of a regenerator 9

$$T_1 = T_1^{'} - \frac{G_3 C_p (T_4 - T_{rc})}{G_1 C_p}. \qquad (8)$$

Residual pressure P_{res} in a cell of rotor CPEI in moment previous its connection to port of low pressure, can be found from resulted below the analytical dependence received by authors as a result is settlement-experimental researches of row of CPE models [2, 3]:

$$P_{res} = P_4 + \frac{P_2 - P_4}{z_\kappa - 1}, \qquad (9)$$

where: $z_{\kappa 1}$ - number of mass-exchange channels in CPEI.

Pressure in port 2 tap of high pressure P_2 depends on difference of pressure between ports HPS and HPT ΔP_{1-2}, created with circulating fan 12.

$$P_2 = P_1 - \Delta P_{1-2}. \qquad (10)$$

The choice of value ΔP_{1-2} is corresponded with compromise search between overall dimensions of exchanger and expenses of power for a drive of the fan 12 which are the basic consumer of mechanical energy ARM CPE.

Pressure in port 1 is determined on the equation polytropic

$$P_1 = P_3 \left(\frac{T_1}{T_3}\right)^{\frac{n_{e1}}{n_{e1}-1}}, \qquad (11)$$

where: n_{e1} - an indicator of a polytropical of expansion of air in CPEI.

Temperature residual coolant T_{res} in a rotor cell in moment previous its connecting with a port of low pressure

$$T_{res} = T_1 \left(\frac{P_{res}}{P_1}\right)^{\frac{n_{e1}-1}{n_{e1}}}. \qquad (12)$$

The parameters of working environments found thus allow according to the equations (4), (5) and (6) to define air consumption in a port 2 CPEI

$$G_2 = G_3 \frac{P_1}{P_{res}}. \qquad (13)$$

The area of section of port through passage 3 HPT

$$F_2 = \frac{G_2}{\rho_4 \cdot \left(\frac{P_2}{P_4}\right)^{\frac{1}{n_{c1}}} K_{\rho 2} \cdot U_2 \cdot (1 - \delta_{c1})}, \qquad (14)$$

where: n_{c1} - an indicator of a polytropical of compression in CPEI; U_2 – mean speed of flow in port 2; δ_{c1} - thickness of crosspieces of rotor CPEI; κ_{p2} = 0,96-0,97 - factor unoredimentions, considering change of speed of a flow on section of port 2 owing to throwing compressing gas.

In works [2, 4] various ways of calculation of mean speed of flow U_2 in section of port 2 are shown. However, the analysis of experimental researches of CPE shows, that at a stage of a preliminary choice of parameters for rather small relations of pressure in ports 1 and 2 (P_1/P_2=1,01 … 1,03) possibility of equation Bernoulli with empirical factor of decrease speed (κ_{u2} = 0,3 … 0,4), considering various kinds of losses (the distributed friction along rotor cells, tear-off sections in boundary conditions in the cells, flooding of jet unsteady flow, etc.) is possible.

$$U_2 = K_{U2} \cdot \sqrt{2 \cdot R \cdot T_1 \cdot \frac{\kappa}{\kappa - 1} \cdot \left[1 - \left(\frac{P_2}{P_1}\right)^{\frac{\kappa - 1}{\kappa}}\right]}. \qquad (15)$$

At cell connection to high pressure port (HPS and HPT) to process of replacement of air in port HPT precedes compressing up air in the considered cell, preliminary compressed as a result of cascade mas-exchange. Therefore the area of section of a port through passage 1 (F_1) must exceed value F_2 on 10-15 %.

The area of a face surface of a rotor

$$F_{\Sigma R1} = F_2 \cdot \frac{360}{\varphi_2}, \qquad (16)$$

where: φ_2 - a corner of disclosing of port 2.

The length and frequency of rotation of rotor CPE1 are corresponded by the parity as a matter of fact representing a condition of full replacement of a fresh charge from a cell of a rotor:

$$L_1 \cdot n_1 = \frac{\left(\frac{P_2}{P_4}\right)^{\frac{1}{n_{c1}}} \cdot U_2 \cdot \varphi_2}{6}. \quad (17)$$

Pressure of circulating fan should be sufficient for overcoming of hydraulic resistance of elements of a contour of high pressure CPEI (air cooler - ΔP_{AC}, a regenerator - ΔP_R, connecting pipelines - ΔP_{CPI}) and creations of nominal difference of pressure between ports 1 and 2.

$$\Delta P_{CF} = \Delta P_{AC} + \Delta P_R + \Delta P_{CPI} + \Delta P_{1-2}. \quad (18)$$

Passing to definition of design data CPEII, we will notice, that taking into account hydraulic resistance of elements of a contour of a high pressure of a compensatory step difference of pressure between port 5 and 6 CPEII is as

$$\Delta P_{5-6} = \Delta P_{CF} - \Delta P_Q - \Delta P_{CPII}. \quad (19)$$

Where: ΔP_Q - hydraulic resistance of a source of a supply of warmth, ΔP_{CPII} - hydraulic resistance of connecting pipelines.

Condition of coordinated work CPEI and CPEII is completion by a compensatory step of deficiency of the consumption in a contour of high pressure CPEI:

$$G_1 - G_2 = G_6 - G_5. \quad (20)$$

By analogy to calculation CPEI for CPEII it is possible to write down

$$\frac{G_5}{G_6} = \frac{\rho_{res2}}{\rho_8}, \quad (21)$$

where: $\rho_8 = \rho_0$ - air density in port 8 CPEII, ρ_{res2} - density of air which has extended in rotor CPEII in the moment previous connection of a cell with port of low pressure.

$$\rho_{res2} = \frac{P_{res2}}{R \cdot T_{res2}}. \quad (22)$$

The temperature of residual gases in a cell of rotor CPEII T_{res2} is defined on the polytropic equation:

$$T_{res2} = T_5 \cdot \left(\frac{P_{res2}}{P_5}\right)^{\frac{n_{e2}-1}{n_{e2}}}, \quad (23)$$

where: n_{e2} - an indicator of a polytrack of expansion in CPEII, $P_5 = P_6 - \Delta P_{5-6}$ - pressure in port 5 CPEII.

Residual pressure in cell P_{res2} is defined under the empirical formula:

$$P_{res2} = P_8 + \frac{P_6 - P_8}{Z_{K2} + 2}, \quad (24)$$

where: $P_6 = P_2$ - pressure in port 6 CPEII, P_8 - pressure 17 air forced by the blowing fan, $Z_{к2}$ - quantity mass-exchange channels in CPEII.

According to the equations (20) and (21) expense G_6 and G_5 are defined as air expenses in port of high pressure CPEII:

$$G_6 = \frac{(G_1 - G_2)\cdot \rho_8}{\rho_8 - \rho_{res2}}, \; G_5 = G_6 - G_1 + G_2. \quad (25)$$

Basic constructive and regime parameters CPEII, it is similar CPEI, are under following formulas:

- the area of section of a window through passage 6 HPT

$$F_6 = \frac{G_6}{\rho_8 \cdot \left(\frac{P_6}{P_8}\right)^{\frac{1}{n_{c2}}} \cdot K_{\rho 6} \cdot U_6 \cdot (1 - \delta_{c2})}; \quad (26)$$

$$U_6 = K_{G2} \cdot \sqrt{2 \cdot R \cdot T_5 \cdot \frac{\kappa}{\kappa - 1} \cdot \left[1 - \left(\frac{P_6}{P_5}\right)^{\frac{\kappa-1}{\kappa}}\right]}, \quad (27)$$

where: $K_{\rho 6}$ - factor un-one-dimensions, considering change of speed of flow on section of port 6 owing to throwing compressing gas;

- the area of a face surface of rotor CPEII

$$F_{\Sigma R2} = F_6 \cdot \frac{360}{\varphi_6}, \quad (28)$$

where: φ_6 - the corner of disclosing of port of tap of a high pressure 6, gets out according to resulted above recommendations.

The length of rotor CPEII and frequency of its rotation are connected by the equation

$$L_2 \cdot n_2 = \frac{\left(\frac{P_6}{P_8}\right)^{\frac{1}{n_{c2}}} \cdot U_6 \cdot \varphi_6}{6}. \quad (29)$$

Expenses of thermal energy for realization of working process ARM are defined by air heating in a source of a supply of warmth

$$Q_3 = G_5 \cdot Cp \cdot \left(T_5 - T_5'\right), \qquad (30)$$

where: T_5' - temperature of air mix behind the fan 12. In a running cycle of the elementary scheme ARM CPE without recycling the residual temperature extended in CPEII hot air are calculated off on the equation:

$$T_5' = \frac{T_6 \cdot G_6 + T_2 \cdot G_2}{G_6 + G_2} \cdot \left(\frac{P_6 + \Delta P_{CF}}{P_6}\right)^{\frac{\kappa - 1}{\kappa}}, \qquad (31)$$

where: T_6 and T_2 - temperature accordingly in port 6 CPEII and port 2 CPEI:

$$T_6 = T_8\left(\frac{P_6}{P_8}\right)^{\frac{n_{c2}-1}{n_{c2}}}, \; T_2 = T_4\left(\frac{P_2}{P_4}\right)^{\frac{n_{c1}-1}{n_{c1}}}, \qquad (32)$$

here: n_{c2} - an indicator of a polytropic of compression in CPEII.

Quantity of the warmth which is taken away from a coolant in a cooler 10:

$$Q_1 = G_1 \cdot Cp \cdot \left(T_5' - T_1'\right). \qquad (33)$$

Expenses of mechanical energy for a drive of each of fans of ARM CPE consist of expenses for a drive of each of fans 12, 16 and 17, defined by adiabatic work of compression of corresponding flows of air with the fan efficiency

$$N_{fi} = G_i \cdot Cp_{ai} \cdot T_{beg}i \cdot \left[\left(\frac{P_{begi} + \Delta P_i}{P_{begi}}\right)^{\frac{k-1}{k}} - 1\right] \cdot \frac{1}{\eta_{fi}}, \qquad (34)$$

where: G_i - the mass consumption of air through the corresponding fan, T_{begi} - temperature of a stream arriving in the fan, P_{begi} - pressure in front of the fan, ΔP_i - a pressure of the corresponding fan, η_{fi} - efficiency of the corresponding fan, k - an indicator of an adiabatic curve of compression.

CONCLUSIONS

The resulted algorithm allows to define the dimensions of each of cascade pressure exchangers as a part of the air refrigerator realizing demanded cooling capacity for accepted various conditions of the organization of a running cycle (T_5, T_3), and also estimations of expenses of thermal and mechanical energy on realization of cycle ARM CPE. The divergence of results of calculation with experimental researches of skilled installation with cooling capacity 10 kW at T_{rc} =-40°C on expenses of electric energy does not exceed 10 %, on thermal energy expenses - no more than 15 %.

Engineering availability and comprehensible accuracy of a considered technique predetermines possibility of its use as the tool of expansion of search of the regime conditions providing peak efficiency of work ARM.

REFERENCES

1. **Anderson, S.O., Sarma, K.M., 2002.:** Protection the Ozone Layer, Earthscan Publications Ltd, US.
2. **Ersmambetov V.S., Beleski A., 2000.:** US Patent №6138471, F25D 9/00, 31.10.2000. Device for air conditioning.
3. **Krajniuk A.I., Starcheous J.V., 2000.:** Systems of gas-dynamic supercharging. – Publ. EUSU. Lugansk., 224 p.
4. **Krajniuk A.I., Krajniuk A.A., 2004.:** The cascade pressure exchanger. Patent UA №77261A, International patent classification 7 F 02 B 33/00/ ,-№20040806986; it is declared 21.08.2004; it is published 15.11.2006, bulletin №11.
5. **Krajniuk A. 2010.:** Thermal compressor of cascade exchange by pressure. Problemy transportu. Miedzynarodowe czasopismo naukowe, Tom 5 zeszyt 1, Wydawnictwo politechniki slaskiej Gliwice, pp.15-22.
6. **Krajniuk A.I., Krajniuk A.A, Bryantsev M.A, 2008.:** Use of the principles of a cascade exchange by pressure in a running cycle of gas refrigerators / Internal combustion engine, NTU "HPI" Scientific and technical journal.-. Kharkov. - No. 1. - page-57-61.
7. **Krajniuk A.I., Krajniuk A.A, Alexeev S.V., Bryantsev M.A, 2007.:** Calculation and choice of key parameters of a cascade exchanger of pressure / Internal combustion engine, NTU "HPI" Scientific and technical journal.-. Kharkov. - No.1. - page-57-62.
8. **Krajniuk A.I., Alexeev S.V., Bryantsev M.A, 2006.:** Features of working process of a cascade exchanger of pressure / Internal combustion engine, NTU "HPI" Scientific and technical journal.-. Kharkov. - No. 2. - page-102-105.

9. **Krajniuk A.I., Storcheous J.V., Gogylya A.M., Danileychenko A.A., Bryantsev M.A, 2001.:** Calculation of processes of a heatmass exchange in blowing-off volumes of heatpower plants. / Politechnika szczecinska. Wydzial mechaniczny. Katedra eksploatacji pojazdow samochodowych. Towarzystwo wiedzy powszechnej oddzial regionalny w szczecinie. Eksploatacja silnikow spalinowych. Zeszyt Nr.3.
10. **Krajniuk A.I., 2010.:** New schemes and principles of the organization of working processes of heat power cars. / The messenger of the East Ukrainian national university of V. Dahl, - Lugansk: Publ. EUSU , - № 7(125). P.21.- page.-197-200.
11. **Krajniuk A.I., Krajniuk A.A., 2005.:** Features of the organization of working process of units of cascade compression and some directions of their application / The messenger of the East Ukrainian national university of V. Dahl, - Lugansk: Publ. EUSU , - № 8(90). - page.-169-173.
12. **Krajniuk A.I., 2009.:** Thermal compressor of cascade pressure exchange/ Silesian university of technology publication faculty of transport. I International Scientific Conference. Transport problems, Katowice-Kroczyce. №17-19.- p.186-191.
13. **Krajniuk A.I., 2010.:** Development of supercharging systems of internal combustion engines with the cascade pressure exchanger /TEKA Komisji Motoryzacji i Energetyki Rolnictwa. – OL PAN, Lublin , №10A, p.303-310
14. **Krajniuk A.I., 2010.:** The Krajniuk's cascade exchanger and new principles of the organization of working process of the gas-turbine engine/ TEKA Komisji Motoryzacji i Energetyki Rolnictwa. – OL PAN, Lublin, №10C, p.151-162
15. **Krajniuk A.I., 2010.:** The organization of working process and sampling of parameters of Krajniuk cascade-recuperative pressure exchanger / TEKA Komisji Motoryzacji i Energetyki Rolnictwa. – OL PAN, Lublin, №10C, p.140-150
16. **Krajniuk A.I., Alexeev S.V., Krajniuk A. A., 2009.:** The ICE supercharge system with boosting air deep cooling // Internal combustion engine, NTU "HPI" Scientific and technical journal.-. Kharkov. - No. 1. - page-57-61.
17. **Krajniuk A.I., Alexeev S.V., Kovtoon A.S., 2011.:** The cascade pressure exchange supercharge system with boosting air deep cooling test results / Aerospace equipment and technology: collection of works: Thermal engines and power installations. Kharkov. №10(87), - page 168-172.
18. **Krajniuk A.I., Bryantsev M.A., 2010.:** Krajniuk's air refrigeration unit / Alternative kilowatt. Russia, Rybinsk, Publishing house "Media grandee ". -№5. - page -40-45.
19. **Krajniuk A.I., Bryantsev M.A., Krajniuk A.A., 2010.:** The new principle of transport refrigeration installation working process organization on Krajniuk's cascade pressure exchanger base. The messenger of the East Ukrainian national university of V. Dahl, - Lugansk: Publ. EUSU , - № 5(147). P.1.- page.-168-177.
20. **Krajniuk A.I., Bryantsev M.A., 2010.:** The Krajniuk's cascade-recuperative pressure exchange refrigeration unit. / Carload park. International information scientific and technical magazine, – Harkov: Publishing house Rolling stock of Tekhnostandart corporation, - № 11.- page.-25-30.
21. **Krajniuk A.I., 2011.:** The new schemes and principles of heat-power machines working processes organization. / The messenger of the East Ukrainian national university of V. Dahl, - Lugansk: Publ. EUSU, № 12(166). P.1.- page.-94-106.
22. **Krajniuk A.I., Krajniuk A.A., 2004.:** Cascade exchanger of pressure. Patent UA №77261A, International patent classification F 02 B 33/00, request №20040806986; it is declared 21.08.2004; it is published 15.11.2006, bulletin №11.
23. **Krajniuk A.I., Pushov V.V, Klyus O.V., Krajniuk A.A., 2010.:** Pressure exchanger. Patent RF №2382240, International patent classification F 02 B 33/00, request № 2008143154/06; it is declared 30.10.2008; it is published 20.02.2010, bulletin №5.
24. **Krajniuk A.I., 2009.:** Krajniuk's air refrigeration unit. Patent UA №44210, International patent classification F 25 B 9/00, request № U200903450; it is declared 10.04.2009; it is published 25.09.2009, bulletin №18.
25. **Rowland, F.S., Molina, M.J., 1994.:** "Ozone Depletion: 20 Years the Alarm", Chemical and Engineering News, Vol. 72, pp: 8-13.

МЕТОД ВЫБОРА ПАРАМЕТРОВ ВОЗДУШНОЙ ХОЛОДИЛЬНОЙ МАШИНЫ КАСКАДНОГО ОБМЕНА ДАВЛЕНИЕМ

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Аннотация. Приведен алгоритм расчета основных размерных параметров составных агрегатов системы, реализующей рабочий цикл воздушной холодильной машины каскадного обмена давлением заданной холодопроизводительности и глубины охлаждения объекта. Дана методика оценки затрат тепловой и механической энергии на осуществление цикла воздушной холодильной машины.

Ключевые слова: каскадный обменник давления, массообмен, воздушная холодильная машина, рекуперация, холодопроизводительность.

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Influence of locomotive operating characteristics on wheels in contact with the rails

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S u m m a r y. The article describes the main factors that determine the realizable thrust. The results of the investigation of the parameters of the contact wheel and rail, depending on operational factors and add to the load of devices due to the body with a cart. The improved design adds to the load device, which improves traction and braking as the locomotives. The results of changes the coefficient use of coupling weight in the implementation of traction.

K e y w o r d s: the coefficient use of coupling weight, slick wheels in contact with the rail, adds to the load device, operational factors.

INTRODUCTION

Achieving high traction qualities in the design and operation of a modern locomotive is an urgent task. Redistributing static loads of wheel sets on the rails in use is the main cause of the deterioration of the locomotive traction qualities, their accelerated wear, high impact on the way and, as a result, causes a decrease in freight and railway capacity and disorders of the track.

MAIN MATERIAL AND RESULTS OF INVESTIGATION

When designers of locomotives believe [Konyaev A.N., Spiryagin I.K., 1971], that the static load of wheelset to the rails are the same, they have deviations from the calculated values [Gorbunov N.I., Kravchenko K.A., Popov S.V., 2009, Gorbunov N.I., 2006]. Redistribution of loads from the wheel set on the rails is estimated the coefficient use of coupling weight η. Redistribution of loads from the wheel set on the rails is estimated utilization of adhesion weight η. Changing loads from of wheel sets on the rails depends on various design and operational factors [Belyaev A.I., Bunin B.B., Golubyatnikov S.M., 1984, Golubenko O.L., 1999, Ivanov V.N., Belyaev A.I., Oganiyan E.S., 1979]. Based on the analysis set and expressed as a percentage of them major influence on the efficiency of coupling weight in fig. 1 [Gorbunov N.I. Kashur A.L., Popov S.V., Kravchenko K.A., Fesenko A.I., 2008, Gorbunov N.I., Kostyukevich A.I., Kravchenko K.A., Fesenko A.I., 2010, Fufryanskiy N.A., Dolganov A.N., Nestrakhov A.S. 1988, Sapronova S., 2010, Cherneckaya N., Kolodyazhnaya L., 2010]. In the implementation of the traction the most unfavorable conditions for a skid are created for one wheelset, which has the least load on the track, all other things being equal. When reducing the actual load wheel pair, compared to the calculated (nominal), there is a proportional reduction of its maximum thrust and efficiency of the locomotive as a whole.

Redistribution of loads from the wheel set on the rails changes the contact area and the distribution of normal stresses on it. Of particular interest is the identification of the influence of operational factors and add to the load on the device parameters of the contact.

For this purpose, the program POISK and NZD which composed on Fortran 2008 have developed at the chair of railway transport of Volodymyr Dahl East Ukrainian National University.

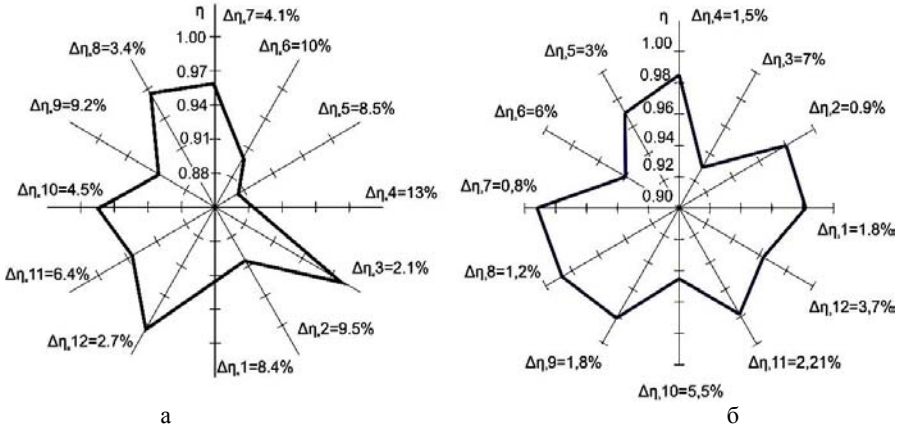


Fig. 1. The effect of parameters on the efficiency of the locomotive coupling weight:
а – structural ($\Delta\eta_к1$ - distance from the center to the outer bogie poles; $\Delta\eta_к2$ - elastic longitudinal bracing; $\Delta\eta_к3$ - optimum stiffness ratio of the first and second stage spring suspension; $\Delta\eta_к4$ - base bogie; $\Delta\eta_к5$ - angle to the horizontal leashes; $\Delta\eta_к6$ - the distance between the first and second wheel sets; $\Delta\eta_к7$ - body weight; $\Delta\eta_к8$ - weight of the bogie; $\Delta\eta_к9$ - location of the traction motors; $\Delta\eta_к10$ - kind of connection with the wheel bogie frame pair; $\Delta\eta_к11$ - the location of the pivot hinge above the rail head; $\Delta\eta_к12$ - distance from the center of bogie to the internal supports locomotive);
б – operating ($\Delta\eta_э1$ - weight change first wheelset; $\Delta\eta_э2$ - body weight change due to the expense outfit materials; $\Delta\eta_э3$ - force generated add to the load device; $\Delta\eta_э4$ - stiffness of the first stage spring suspension; $\Delta\eta_э5$ - stiffness of the second stage spring suspension; $\Delta\eta_э6$ - friction damper; $\Delta\eta_э7$ - rigidity parts, joins damper to axle boxes; $\Delta\eta_э8$ - stiffness of the end support the second stage spring suspension; $\Delta\eta_э9$ - stiffness of the supports of the second stage spring suspension; $\Delta\eta_э10$ - controlled spring suspension; $\Delta\eta_э11$ - frequency disturbances from the twitch of the fixed and variable component forces thrust; $\Delta\eta_э12$ - wear bandage rolling circle first wheelset)

With the program POISK determined coordinates of the initial contact with a rail wheel set track. These coordinates enter for the program NZD, intended to build a function of the initial gap and the iterative solution of normal contact problem [Golubenko A.L., Kostyukevich A.I., 1989, Kostyukevich A.I., 1991].

In the programs, the following symbols: *P* – vertical load on the wheel on the rail; *YR, YK* – coordinates of the initial contact; *TT* – angle, the value of which is determined by solving the problem of finding the initial point of contact; *YN, FI* – transverse displacement and rotation of the wheelset with respect to rail track; *N1, N2* – dimension of the surface grid; *DX, DY* – step of the surface grid O_Ai и O_Aj respectively; *E* – defined by the accuracy of the solution; *NR N*K – codes form contact surfaces; D4 – the accuracy with which the equation is solved initial points of contact; *ddy* – displacement of the origin of system O_Aijk along O_Aj; *A1* - coefficient a_{ll}; *ITER* – the number of cycles of iterations to achieve the desired accuracy of the solution; *FK* – contact area; *PSI* – average specific contact pressure.

All calculations were performed for not threadbare wheel profile shunting locomotive TEM103 according to GOST 52366-2005.

Table 1 and figure 2 shows the calculated normal tasks for the first shunting locomotive wheelset TEM103, adjusting the vertical load of the action add to the load devices [Kravchenko K.A., 2010]. The angle of rotation relative to the wheelset rail track - 0 º, lateral shift – 0 mm, the vertical load from the first to the direction of travel wheels on rails - 103 kN. From fig. 2, and shows the distribution of specific pressures on cells of contact, the maximum of which is for the contact is 650 MPa. The shape of the contact is shown in fig. 2b. The results which were calculated are shown in table 2.

Table 1. Input data and results of the solution of the problem of normal

Input							
P, кг	*YR*, mm	*YK*, mm		*TT*, rad	*YN*, mm		*FI*, gr
10292	.04	-797.63		.0000E+00	.00		.0
N1	*N2*	*DX*, mm	*DY*, mm	*E*	*NR*	*NK*	*D4*, mm
16	22	1.0	1.0	10.560	0	0	.1941E+00
The calculated results							
ddy	*A1*			*ITER*	*FK*, mm **2		*PSI*, N/mm **2
-	.1890E-03			22	239.0		43.1*9.81

The analysis of table 2 shows that with the increase of the vertical load from 88 kN to 132 kN contact area increases from 211 mm^2 to 281 mm^2, with an average surface pressure is increased from 426 MPa to 478 MPa, the maximum pressure - 620 MPa to 680 MPa.

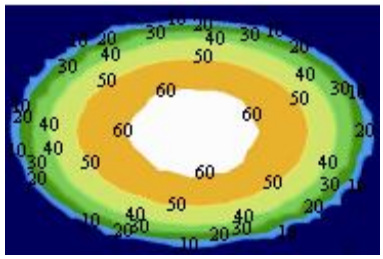
Noting the negative impact of operational factors on the parameters of the contact. For the first wheelset contact area decrease is 9%. In turn, the use of devices to add to the load first wheelset can increase the contact area by 7%.

To increase the vertical load for implementing improved traction finish loading device (fig. 3), which was introduced on shunting locomotive TEM103 PJSC "Luganskteplovoz" [Gorbunov N.I., Kashura A.L., Kravchenko K.A., Popov S.V., Dogadin V.A., Bogopolskii E.M.,Osenin J.J., 2009].

Add to the load device is mounted on the frame 1 trolley locomotive (fig. 3). When moving from the place of the locomotive using the "*Increase clutch*", located on one of the control panels, turned finish loading device. In the cavity of a cylinder 2 with the cover 14 at a pressure of 0.4 MPa, the air is supplied, the piston rod 15 with a 3 move up, release spring 16 is compressed. Lever 5, rotating about an axis 12 through 13 and thrust rollers 8, 9 based on Polozkov 10 welded to the frame 11 of the locomotive. With further movement of the piston rod 15 effort from 3 through the fork 4, lever 5, the axis 12 and the bracket 6 to 7 is transmitted to the suspension crossmember frame 1 trolley, increasing the load on the wheelset is toward the cross beam (fig. 4).

0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 **6 17 20 17 4** 0 0 0 0 0 0
0 0 0 0 0 **21 31 33 34 33 30 17** 0 0 0 0 0
0 0 0 0 **22 33 38 41 43 42 39 34 20** 0 0 0 0
0 0 0 **16 35 42 46 48 49 48 45 41 34 13** 0 0 0
0 0 0 **32 41 47 50 53 54 53 51 46 40 30** 0 0 0
0 0 **17 38 45 51 55 57 58 57 55 51 45 37 14** 0 0
0 0 **28 42 49 54 57 59 60 59 57 54 48 40 25** 0 0
0 0 **34 44 51 57 59 61 62 61 59 56 51 44 33** 0 0
0 **8 37 47 54 59 61 63 64 63 62 58 53 46 37 4** 0
0 **12 38 48 54 59 62 64 65 64 62 59 54 47 38 9** 0
0 **13 39 48 55 60 62 64 65 65 63 59 54 47 39 10** 0
0 **12 38 48 54 59 62 64 65 64 62 59 54 47 38 8** 0
0 **8 38 47 54 59 62 63 64 63 62 58 53 46 37 4** 0
0 0 **34 44 52 57 60 61 62 61 60 56 51 44 33** 0 0
0 0 **28 42 49 54 57 59 60 59 58 54 48 41 25** 0 0
0 0 **17 38 45 51 55 57 58 57 55 51 45 37 14** 0 0
0 0 0 **32 41 47 51 53 54 53 51 46 40 30** 0 0 0
0 0 0 **16 35 42 46 48 49 48 46 41 34 13** 0 0 0
0 0 0 0 **23 34 39 42 43 42 39 34 21** 0 0 0 0
0 0 0 0 0 **20 31 34 35 34 31 18** 0 0 0 0 0
0 0 0 0 0 0 **5 16 19 16 4** 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0

a



b

Fig. 2. The distribution of the contact pressure, 10*N/ mm^2:
a - in a numerical form (based on the results of calculation in the program NZD);
b - in outline form (processing of the results of calculations in the software environment MathCad)

Table 2. Modeling of the contact wheel pair shunting locomotive TEM103

№ of wheelset	The load of the wheels on the rails, kN			Contact area, mm^2			Contact pressure, MPa			Maximum contact pressure, MPa		
	without add to the load device	***given the operational factors***	***with add to the load device***	***without add to the load device***	***given the operational factors***	***with add to the load device***	***without add to the load device***	***given the operational factors***	***with add to the load device***	***without add to the load device***	***given the operational factors***	***with add to the load device***
1	96	88	103	231	211	239	423	426	440	630	620	650
2	110	112	103	249	253	243	449	451	436	660	650	650
3	111	110	116	253	251	262	449	447	450	660	650	670
4	125	132	119	271	281	265	469	478	457	700	680	680

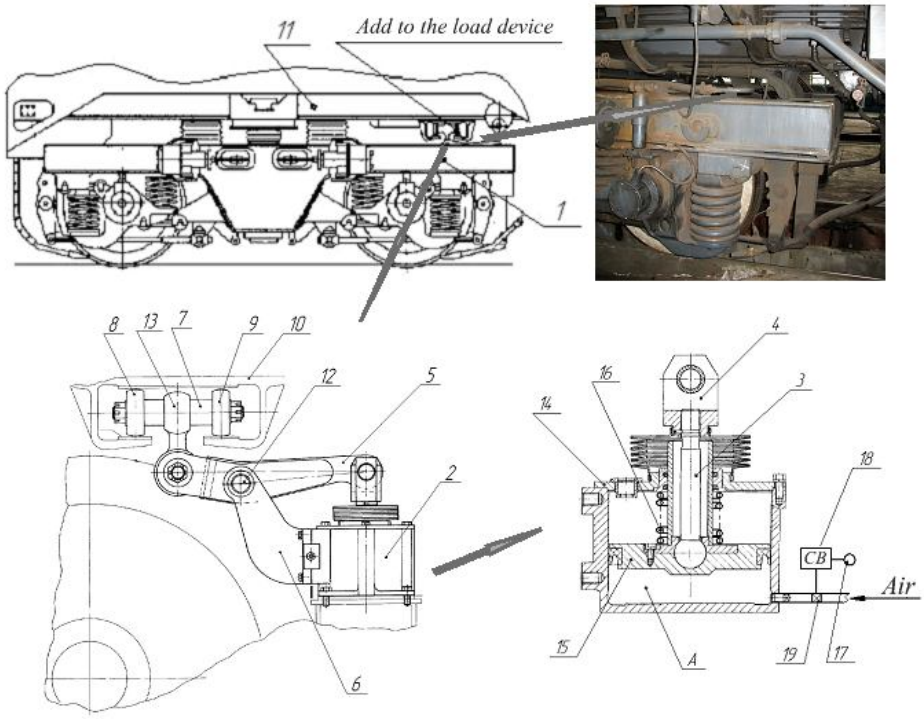


Fig. 3. Installation of the device to add to the load bogie shunting locomotive TEM103

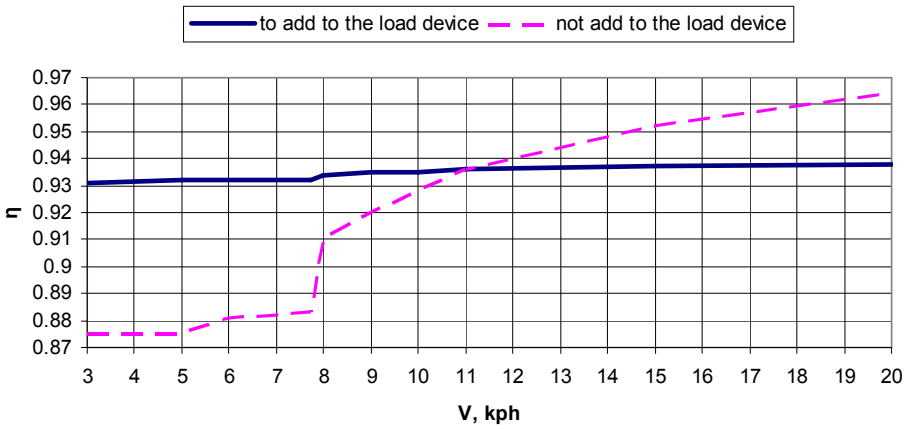


Fig. 4. Change of use of the coupling weights of the first wheel set on the speed

Application add to the load device can increase the coefficient use of coupling weight (η), but when you reach 11 kph its effectiveness decreases (fig. 4). Therefore, at a speed of 11 kph begins operate the control unit 18 connected with a speed indicator 17. From the cavity A of the cylinder 2 through the electromagnetic valve 19 air coming out, and, under the action of letting go spring 16, the piston 15 is returned to its original position.

The difference in the vertical loads on the axles bogie is substantial. To address the phenomenon proposed a complex control system (CCS) redistribution of vertical loads from the wheel pairs on rails [Gorbunov M.I., Kashura O.L., Kravchenki K.O., Popov S.V., Kovtanets M.V., Golembievsky K.V., 2008], which is a system add to the load device on bogie frame and control system. Depending on the driving mode and the operating conditions, the control system changes the functionality of the devices add to the load. In the traction mode in the work included add to the load device two and four axle bogie, herewith loading the first and third axes. To improve braking performance under braking triggered add to the load device first and third axle bogie, herewith loading minimally loaded two and four wheel pairs. On freewheel CCS operates as a shock absorber [Gorbunov N.I., Kravchenko K.O., Popov S.V., Fesenko A.I., Grishchenko S.G., Nesterenko

V.I., Lewandowski V.O., 2009], and redistributes the load curves on the sides of bogie, thus improving traction, braking, dynamic quality shunting locomotive and efficiency blending in a curve track sections.

CONCLUSIONS

The studies found a negative impact of operational factors on the parameters of the contact. For the first wheelset contact area decrease is 9%. In turn, the use of devices to add to the load first wheelset can increase the contact area by 7%. To improve traction and braking qualities proposed design improvement and the location add to the load of devices on bogie of the locomotive, by extending their functionality.

REFERENCES

1. **Belyaev A.I., Bunin B.B., Golubyatnikov S.M., 1984.:** Increasing to reliability crew part diesel locomotive; M., Transport, – 248 p.
2. **Dolganov A.N., 1969.:** Theoretical and experimental study tractive quality diesel locomotive TE10: autoref. dis. c.t.s.: 05.22.07, M. 23 p.
3. **Cherneckaya N., Kolodyazhnaya L., 2010.:** Technical and economic calculations in organization of railway transportations. TEKA Commission of Motorization and Power Industry in AgricultureVX. Poland. – p. 32-37.
4. **Fufryanskiy N.A., Dolganov A.N., Nestrakhov A.S. 1988.:** Development of the locomotive traction/ 2nd edition, revised and enlarged – Moscow: Transport, – 344 p.
5. **Golubenko O.L., 1999.:** Zcheplennya travell about z rod Lugansik: the Publishers VUGU. - 476 p.
6. **Golubenko A.L., Kostyukevich A.I., 1989.:** The Algorithm of the decision of the contact problem under free location wheel pair(vapour)s for rail rut. Konstruirovanie and production transport. the machines. - Harkov, 1989. - drink. 21. - P. 33 – 37.
7. **Gorbunov N.I., 2006.:** Theory and practical realization of the system approach in the construction of the carriage of locomotive. Manuscript of Doctor of Technical Sciences (05.22.07. – railway rolling stock and train traction) Lugansk. – 38 p.
8. **Gorbunov N.I., Kashura A.L., Kravchenko K.A., Popov S.V., Dogadin V.A., Bogopolskii E.M.,Osenin J.J., 2009.:** Patent of Ukraine №87915, кл. B61C 15/00. Additional loading device – 25.08.2009, Newsletter № 16.
9. **Gorbunov N.I., Kravchenko K.O., Popov S.V., Fesenko A.I., Grishchenko S.G., Nesterenko V.I., Lewandowski V.O., 2009.:** Declaration patent on the useful model № 41434, kl. B61C 15/00. Add to the load device – 25.05.2009, Newsletter № 10.
10. **Gorbunov N.I. Kashura A.L., Popov S.V., Kravchenko K.A., Fesenko A.I., 2008.:** Ways to solve problems of locomotive traction qualities increase; International Information Science and Technology Journal "Lokomotivinform" , №5., P. 8-11.
11. **Gorbunov M.I., Kashura O.L., Kravchenko K.O., Popov S.V., Kovtanets M.V. Golembievsky K.V., 2008.:** Declaration patent on the useful model № 37890, kl. B61C 15/00. Truck engine – 10.12.2008, Newsletter № 23.
12. **Gorbunov N.I., Kostyukevich A.I., Kravchenko K.A., Fesenko A.I., 2010.:** Efficiency improvement of the traction rolling stock. Scientific News of Dal's University. Electronic scientific special edition. №1, - http://www.nbuv.gov.ua/e-journals/Nvdu/2010_1 /10gnitps.htm.
13. **Gorbunov N.I., Kravchenko K.A., Popov S.V., 2009.:** Results of yard diesel locomotive traction qualities investigations; Problems and perspectives of transport complex development: education, science, production: works of international scientific and practical conference. – Rostov-na-Donu, P. 42 – 43.
14. **Ivanov V.N., Belyaev A.I., Oganiyan E.S., 1979.:** Increasing utilization ratio coupling weight of the diesel locomotive. The Herald VNIIZHT, N 7. - P. 13 - 17.
15. **Konyaev A.N., Spiryagin I.K., 1971.:** Ways of locomotive 2TE10Л traction qualities perfection compilation « Locomotive building», V. 3, P. 19 – 24.
16. **Kostyukevich A.I., 1991.:** The Numerical and experimental identification of the process of the traction travell about locomotive with rail: autoref. dis. c.t.s.: 05.22.07 - Lugansk – 21 p.
17. **Kravchenko K.A., 2010.:** The grounds of increase backlogs of locomotive hauling qualities and its realization by the management of sliding in the system of wheel with a rail. dis. … c. t. s.: 05.22.07 – Luhansk, 215 p.
18. **Sapronova S., 2010.:** Modeling of locomotive wheel profile form. TEKA Commission of Motorization and Power Industry in AgricultureVX. Poland. – p. 270-278.

ВЛИЯНИЕ ЭКСПЛУАТАЦИОННЫХ ХАРАКТЕРИСТИК ЛОКОМОТИВА НА ПАРАМЕТРЫ КОНТАКТА КОЛЕСА С РЕЛЬСОМ

Екатерина Кравченко, Николай Горбунов, Сергей Сосновенко, Ольга Просвирова, Никита Брагин

Аннотация. В статье рассмотрены основные факторы, от которых зависит реализуемая сила тяги. Представлены результаты исследования параметров пятна контакта колеса с рельсом в зависимости от эксплуатационных факторов и применения догружающих устройств в связи кузова с тележками. Предложено усовершенствование конструкции догружающего устройства, которое позволяет повысить тягово-тормозные качества локомотивов. Представлены результаты изменения коэффициента использования сцепного веса при реализации тягового усилия.

Ключевые слова: сила тяги, коэффициент использования сцепного веса, пятно контакта колеса с рельсом, догружающее устройство, эксплуатационные факторы..

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Cosmic rays muon detectionon the earth surface

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S u m m a r y . The result of experiments on the selection of cosmic ray muons by the amplitude analysis of signals in three different variants of plastic detectors are presented. For this purpose the 512-channel analyzer of gamma spectrometer «RITM-S», attended with a computer, was used. Fig. 7. Ref. 20.

K e y w o r d s : cosmic rays, muon, plastic detector.

INTRODUCTION

Cosmic rays (CR) were discovered in 1912 by austrian scientist V.F. Hess. At getting up on a balloon he find that as far as the increase of height ionization of atoms of air grows above Earth. Such growth of ionization with a height could be caused only the particles of extraterrestrial origin [Berezinsky 1990, Ginsburg 1996, Hayakawa 1973].

Muons are formed mainly due to the decay of pions and kaons produced at the collision of particles of primary cosmic rays with nuclei of the atmosphere atoms. Their inhibition caused only electromagnetic losses in the main ionization [Bugaev 1970, Murzyn 1988]. The average muon energy loss in the material (1).

$$\left\langle \frac{dE}{dx} \right\rangle = A(E) + B(E)E \qquad (1)$$

For example, in the soil of standard composition in MeV/g·cm^2 (2).

$$A(E) = \left(\frac{dE}{dx} \right)_{ion} = 1.888 + 0.0768 \ln \frac{E}{mc^2} \qquad (2)$$

The coefficient B (E) is additively consist of bremsstrahlung losses, losses of electron-positron pairs creation and nuclear loss. For cosmic-ray muons to assume that the energy loss is about 2 MeV in one g/cm^2 matter [Murzyn 1988]. Therefore, the muons flux is the penetrating component of cosmic rays. Even at relatively low energy ~ 10 GeV muon can not just go through the entire atmosphere earth's, but also to penetrate deep into the earth. The maximum depth at which detected the highest energy muons is about 8600 m in terms of water equivalent.

CR intensity observed at the Earth's surface can be affected by both processes on the Sun and in interplanetary space and in the Earth magnetosphere and atmosphere. Therefore study of CR muon flux in different parts of the Earth surface are very important both theoretical and applied investigations [Barabashina 2007, Borog 2005, Ermakov 2003, Filimonov 2007, Khaerdinov 2005, Kudlenko 2010, Lidvansky 2003, Sopin 2011, Voytenko 2008, Yanchukovsky 2006].

CR is very useful to arise the interest of science among students of high schools. Lately the row of projects appeared such as Roland Maze (on the name of one who announced the discovery of extensive air shower) [Feder 2006], CROP (Cosmic Ray Observatory Project) [Hansen 2004], SCROD (School Cosmic Ray Observatory Outreach Detector) [Swain 2005] and other, supposing synchronous work of simple detectors of second CR in many educational establishments in the different points of earthly surface. The principle aim of the projects is education, but there is potential for contribution to cosmic ray physics as well.

The purpose of the paper is the separation by the amplitude analysis of signals from muons in three different detectors based on

polymethylmethacrylate with scintillating additives.

RESULTS AND DISCUSSION

As sensors muon detectors of cosmic radiation is convenient to use plastic scintillators.

The sensing element of the first detector, which is used by the muon telescope [Kudlenko 2009], has an area of approximately 600 cm^2 and 2 cm thickness (fig. 1). Dimensions are in cm, and also marked the point to determine the sensitivity of the detector on the surface.

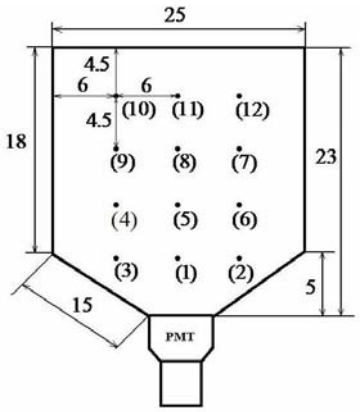

Fig. 1. First type detector

Flashes of light perceived by the photocathode of photomultiplier tube PMT-92 type mounted on the lower of the end faces of the scintillator. Other plates of cintillator painted white based on MgO, which increases the light collection. Photomultiplier with a scintillator placed in light-tight aluminum housing. In the body there are also high-voltage divider and preamplifier. To obtain the amplitude distribution of the pulses from the output of the detector, we used a 512-channel analyzer for gamma spectrometer "RITM-S", paired with the computer [Vorobjov 2010].

The amplitude spectrum of the signals at the output of the first detector from background signals in the laboratory, some of which are caused by cosmic-ray muons, is presented in fig. 2. Signals in the "tail" of the spectrum can be attributed to muons, but the peak of the characteristic muon are not talking.

The measurements were carried out after we were unable to reliably fix the flux of cosmic ray muon by the second type detector . It scintillator of the same thickness, 70·70 cm size through the air gap is viewed by one photomultiplier FEU - 139 types, geometrically located at the top of the right pyramid, which is the basis of the scintillator.

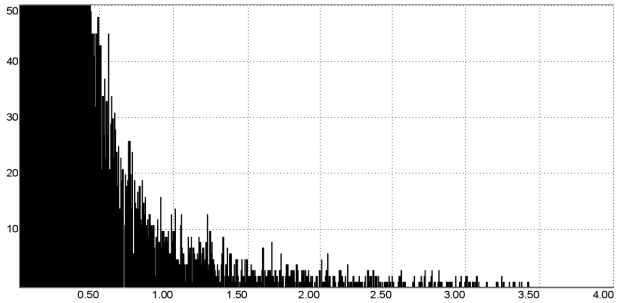

Fig. 2. Amplitude spectrum of signals for the first type detector

In the amplitude spectra of the detector signals, one of which is shown in fig. 3, there is an intense low-energy component.

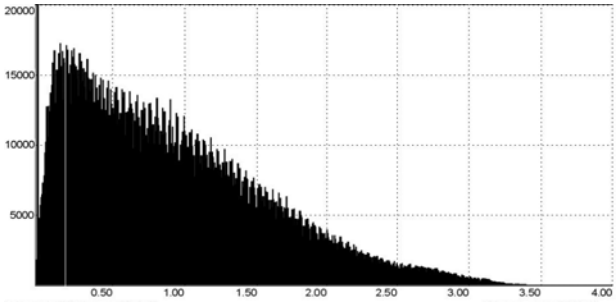

Fig. 3. Amplitude spectrum of signals for the second type detector

To separate the signal from muons discrimination threshold signal amplitude should be chosen so that the count rate was slightly lower than the calculated values, and at the absence of significant variations of the cosmic rays by the Gaussian. In other words, the count rate in these conditions should be constant within the statistical error. Achieve this, we have not succeeded. We plan to improve light collection and use PMT with larger photocathode area.

In the third type of detector, two photomultiplier tubes PMT-110 type with photocathode 63 mm diameter, working on a common load, view, one of the ends of the plastic scintillator with dimensions of 50 x 50 x 10 cm [Voytenko 2008].

The amplitude spectrum of the background signal of this detector is shown in fig. 4.

He has a pronounced peak in the muon energies loss greater than 10 MeV. Continuous recording of the signals in this area was carried out by us during the month. In those days, when the air pressure gradually increases or decreases, we

clearly fixed rate accounts known correlation with atmospheric pressure. [Kudlenko 2010].

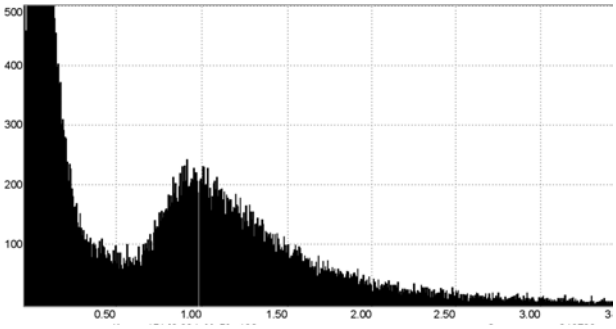

Fig. 4. Amplitude spectrum of signals for the third type detector

It follows from the results that, in the amplitude spectra the signals from the CR-muons can be divided into a third type of detector.

These results, however, do not mean that the use of detectors with a scintillator of 2 cm thickness to detection of cosmic ray muons is very problematic.

For example, creating a telescope (fig. 5) of the detectors of the first type, in which the end of the scintillator is in contact with the photocathode of the photomultiplier, we can fix the vertical flow of cosmic ray muons and follow its variations [Kudlenko 2009].

Fig. 5. Muon telescope view

By varying the distance between the detectors can be detected muons in different solid angles. For example, in fig. 6 presents the counting rate of vertical muon flux, applied to solid angles of 0.5 and 1.5 sr. This constancy is typical of most series of measurements in the absence of magnetic storms and other causes significant variations in the flux.

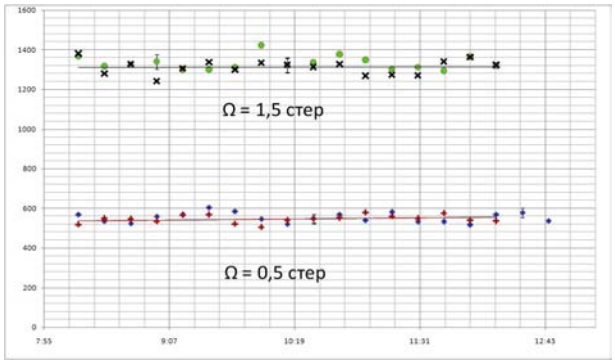

Fig. 6. Muon count rate for vertical flux in solid angles 0,5 and 1,5 sr

Interesting results were obtained in Lugansk (48.6 ° N, 39.3 ° E) by this telescope set at July 13, 2012. In this rainy day with squally wind above the muon telescope were two thunderstorms. They are fixed at 13 hours and 20 minutes, for about 20 min.duration , and at 15 hours 40 min. about 25 minutes duration. Count rate of the vertical muon flux at five minute intervals sharply increased during the storm (fig. 7).

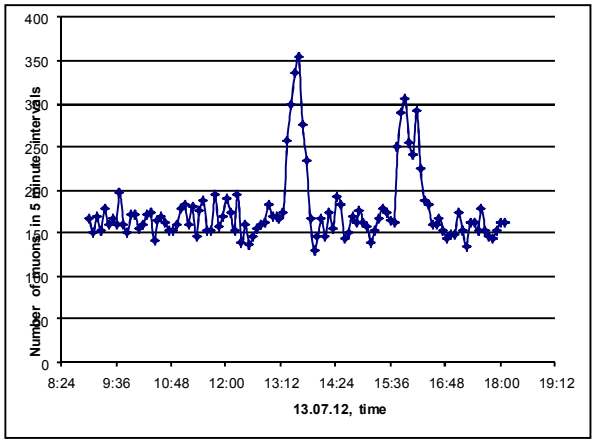

Fig. 7. Response of the muon flux on passing of thunderstorm

This fact has become for us an interesting surprise. To understand the "fine structure" of increase, the software was adapted and improved protection against false coinsides. However, thunderstorms in summer 2012 in Lugansk was not observed after July 13. Therefore, presented the "storm" data we considered preliminary and require further study.

CONCLUSIONS

1. CR muon flux at Earth's surface depends on the atmospheric parameters.

2. A possible cause of these variations may also be anomalies in the Earth's magnetosphere and thunderstorms.

3. For CR- muons is preferable to use detectors of thick plastic scintillators viewed directly PMP.

REFERENCES

1. **Barabashina N.S., Kokoulin R.P., Kompaniets K.G., et al., 2007.:** Acceptance muon detector for the diagnosis of the atmosphere and the Earth's magnetosphere. Izvestiya RAS, physics series, №7, vol.71. pp. 1072 – 1074.
2. **Berezinsky V.S., Bulanov S.V., Dogiel V.A., Ginzburg V.L., Ptuskin V.S., 1990.:** Astrophysics of Cosmic Rays. North-Holland, Elsevier Science Publishers B.V., 357 p.
3. **Borog V.V. et al., 2005.:** Study of Atmospheric Temperature at Different Altitudes Using Muon Angular Distribution at Sea Level. Proc. 29th International Cosmic Ray Conference. Pune (India), vol.2., pp. 381-384.
4. **Bugaev E.V., Kotov J.D., Rosenthal I.L., 1970.:** Cosmic muons and neutrinos. M. Atomizdat, 320 p.
5. **Ermakov V.I., Stozhkov Y.I., 2003.:** The role of cosmic rays in the formation of lightning. Brief reports on physics. LPI, №9, pp. 43 – 50.
6. **Feder J. et al., 2006.:** The Roland Maze Project – school-based extensive air shower network – Nucl Phys B – Proc. Suppl., N1, V.151, pp. 430-433.
7. **Filimonov G.Y., Hasamov R.Z., Yanchukovsky V.L., 2007.:** Atmospheric muon intensity variations for different zenith angles registration. Izvestiya RAS, physics series, №7, vol.71, pp. 1066 – 1068.
8. **Ginzburg V.L., 1996.:** Cosmic Ray Astrophysics (History And General Review). Physics-Uspekhi, № 2, vol. 66, pp. 169–183.
9. **Hansen S. et al., 2004.:** Low –Cost Date Acquisition Card for School-Network cosmic Ray Detectors – IEEE Trans. Nucl.Sci., V.51, pp. 926-930.
10. **Hayakawa C., 1973.:** Cosmic-ray physics. Part I. Nuclear-physical aspect. M.: "MIR", 504 p.
11. **Khaerdinov N.S., Lidvansky A.S., Petkov V.B., 2005.:** Electric Field of Thunderclouds and Cosmic Rays: Evidence for Acceleration of Particles (Runaway Electrons). Atmospheric Research, vol. 76, issues 1-4, July-August 2005, pp. 346-354.
12. **Kudlenko V.G., Devyatkin D.S., Devyatkin Y.S., 2009.:** Cosmic ray muons flux at the sea level at highest solar activity. VNU named of V. Dalya Edition, № 8 (138), 2, pp. 89 – 93.
13. **Kudlenko V., Dmitriy D., Devyatkin Y., 2010.:** Cosmic rays muon flux at the sea level by highest solar activity. TEKA Kom Mat i Energ, Roln. – OLPAN, 2010, 10A, 339-344.
14. **Lidvansky A.S., 2003.:** The Effect of the Electric Field of the Atmosphere on Cosmic Rays. J. Phys. G: Nucl. Part. Phys., v.29, pp. 925-937.
15. **Murzyn V.S., 1988.:** Introduction to the cosmic rays physics. M: MSU, 319 p.
16. **Sopin A.A., Yampolsky Y.M., 2011.:** Determenation of a cold front parameters "Kyrill" storm in simultaneous measurements of pressure and muons flux. Radio Physics and Radio Astronomy, № 1, vol. 16, pp. 62 – 69.
17. **Swain J. et al., 2005.:** SCROD: A new approach to large school based cosmic ray experiments – 29 ICRC, 2005, V.9, 323-326.
18. **Vorobjov S., Kredencer S., Kudlenko V., 2010.:** Radiation background of the damps of some donbass coal mines. TEKA Kom Mat i Energ, Roln. – OL PAN, 2010, 10D, 31-35.
19. **Voytenko V.A., Kudlenko V.G., Matsevich S.V., 2008.:** Muon detector to monitoring of atmospheric processes. VNU named of V. Dalya Edition, №1(59), 2, pp. 191 – 196.
20. **Yanchukovsky V.L., 2006.:** Cosmic ray telescope. Solar-terrestrial physics. Novosibirsk: Publisher RAS, №.9, pp. 41 - 43.

РЕГИСТРАЦИЯ МЮОНОВ КОСМИЧЕСКОГО ИЗЛУЧЕНИЯ НА ПОВЕРХНОСТИ ЗЕМЛИ

Василий Кудленко, Сергей Воробьев

Аннотация. Представлены результаты экспериментов по выделению мюонов путем амплитудного анализа сигналов в трех различных вариантах пластиковых детекторов. Для этого использовался 512-канальный анализатор гамма-спектрометра «Ритм-С», сопряженного с компьютером. Рис.7. Ист.20

Ключевые слова: космические лучи, мюон, пластиковый детектор.

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Determination the dynamic parameters of the controlled technological processes of coal preparation by using the semi graphical method

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Summary. Presented a graphic-analytical method for determining the dynamic parameters of the regulated coal preparation processes using the experimental data. The algorithm of the proposed method stems from graph-analytical analysis of the transition function, built for the aperiodic link second order. The proposed method allows determining the dynamic parameters of the controlled system with a minimum amount of experimental data.

Key words. Coal preparation, graphic-analytical method, dynamic parameters of characteristic equation

INTRODUCTION

The events in Ukraine over the last decade suggest that there has been a strengthening of scientific research in the field of mining and mineral processing, and, in particular, mining and processing of coal. This fact is confirmed by the appearance of a number of new scientific publications, the development of new technological tools and systems, new proposals for the use of innovative methods of analysis and synthesis of automatic control system (ACS), ensuring optimum economic process.

In this context, the definition of the dynamic parameters of the regulated objects is particularly important because the positive effect of the use of innovative methods of synthesis of ACS may be offset by significant errors in determining the parameters of the controlled system.

Much of the fact, noted above, refers to the analysis and synthesis of the major ACS process coal (flotation, jigging, and preparing coal in severe environments) for coal preparation plants.

The latter is due to the following circumstances.

Input and (or) output parameters of the regulated objects are mainly the parameters that characterized the quality indicators of enriched coal and products of its enrichment. Today industrial equipment for automatic analysis of coal quality and product enrichment are not mounted yet at coal-preparing plant (CPP). That is why the required information can be obtained only by sampling and analysis. Researcher is forced to develop the plans of experiment taking in account high labor and cost of testing process but not the data that he got from statistical analysis.

In addition, the researcher, as a rule, tends to make all measurements to determine the dynamic characteristics of the object under the same conditions. From this point of view, the ideal conditions of the experiment would be constant quality and quantity of enriched material that is raw coal. CPP equipped by special averaging device to stabilize the fractional composition and particle size of raw coal. However, the statistical analysis of the qualitative and quantitative characteristics of the raw coal shows that these devices are not solving completely the problem of instability in the separated coal. That is why the qualitative and quantitative characteristics of the raw coal are not permanent. The maximum frequency of the qualitative and quantitative characteristics of the raw coal is on average $8*10^{-4}$ s^{-1}. This frequency corresponds to the oscillation period equal to 2.2 hours (about 130 seconds).

Provided suggestions for determining the dynamic parameters of the coal preparation processes using the least possible amount of experimental data in light of this information are important and their realization is an urgent task.

THE RELEVANCE OF THE STUDY

Plan of experimental studies of controlled object in the conditions of the action of disturbance should be developed taking in account matching the value magnitude of the first harmonic of disturbance and the time constant of the object. The results of the comparison of these parameters will allow to choose a strategy of measurement that ensures the reliability of the results.

It is believed that the time constant to the channel input - output for the machine which receive and process a continuous stream of technological resources is close in meaning to the value K. The value K is equal to the ratio of the volume of the material is in the machine to the performance of this device on the processed raw materials [Tikhonov O. 1973].

Let's take as example of an object of regulation the hydraulic jig for coal preparation. Let's choose the jig VBP (MO) with the volume of material 5-6 m^3 and average performance of the raw coal 180-320 t/h (about 180-320 m^3/h). In this case, the time constant will be equal to 40 - 100 s. Let's write the model of this jig as aperiodic link of second order by the channel "raw coal capacity - coal concentrate quality" [Lehtsier O. 2005]. Then the transfer function of the object $W(p)$ can be written as

$$W(p) = \frac{k}{T^2 p^2 + 2\rho T p + 1} = \frac{k}{(T_1 p + 1)(T_2 p + 1)},$$

where k, T, T_1 and T_2, ρ - the gain coefficient (k), time constants of the object (T, T_1 and T_2) and the damping factor (ρ).

Taking in account the above numerical parameters, the transfer function of the object can be of the form

$$W(p) = \frac{k}{20^2 p^2 + 2*1.5*20 p + 1} = \frac{k}{(52_1 p + 1)(7.6_2 p + 1)}.$$

Frequency function for this expression is:

$$W(j\omega) = \frac{k}{20^2 (j\omega)^2 + 60 j\omega + 1}.$$

The graph of frequency function in the frequency range [0 - 0.5 1/s] is presented in figure 1.

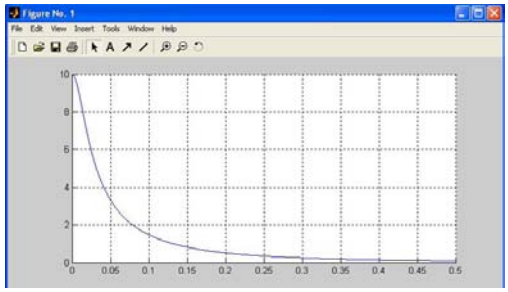
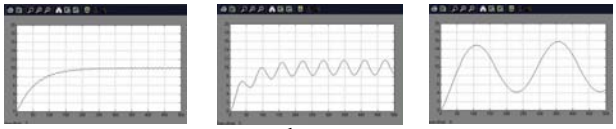


Fig.1. Graph of frequency function with the k = 10

Analysis of the graph given in fig. 1, shows that value of harmonic signal is virtually absent when the value of the oscillation period is less than 60 seconds. More clearly this fact illustrated by three separate graphs, (look fig.2) obtained by computer simulation for the frequencies ω 0.5, 0,1 and 0.025 1/s.



a b c

Fig. 2. Graphs of the transition functions with k = 10; x (t) = 1 + sin ωt, ω - frequency of the periodic component of the input signal; a) ω = 0.5 1/c (~4,8 cycles per minute), b) ω= 0.1 1/c (~1 cycles per minute), c) ω= 0.025 1/c (~0,24 cycles per minute)

From these graphs, it follows that a periodic signal of disturbance which has a frequency less than

ω = 0.1 1/s significantly distorts the output signal of the controlled system. And only when the frequency of the disturbance ω ≥ 0.5 1/s, we may assume that the disturbance has almost no effect on the output signal.

In connection with the above, the intervals between the steps of the experiment should be selected taking in account fluctuations of the parameters of the initial coal.

In addition, we note that the fixed fact impairs the quality of regulation in the existing ACS. To improve the quality of control by coal preparation processes necessary to equip ACS not only by control loops in the deviation, but by feedforward control loop also.

MATERIALS AND RESEARCH RESULTS

Graphic-analytical method of data processing assumed to provide sufficient representative of data for initial and final phases of the experiment. This provides two reliable stages: point in which time t = 0 (start of the experiment)

and the ordinate of the asymptote, which gives (approximately) point for t = ∞, ie point at which the transition designedly is over.

In addition to this information, need several points, which will submit the curvature of the transient.

Let's review the use of this method with the following example. Let's agree to identify our control object by aperiodic link of the second order. Differential equation of such object has the form

$$T_2^2 \frac{d^2 y(t)}{dt^2} + T_1 \frac{dy(t)}{dt} + y(t) = k\,x(t) \qquad (1)$$

Transfer function

$$W(p) = Y(p)/X(p) = k/(T_2^2\,p^2 + T_1\,p + 1).$$

Let $k = 1$. The characteristic equation of the link will be

$$T_2^2\,p^2 + T_1\,p + 1 = 0.$$

The roots of the characteristic equation:

$$p_{1,2} = (-T_1 \pm \sqrt{T_1^2 - 4T_2^2})/2T_2^2.$$

The general solution of (1) which defining the free movement:

$$y(t) = C_1 e^{p_1 t} + C_2 e^{p_2 t}.$$

A particular solution we'll obtain taking into consideration the zero initial conditions

$$y(0) = 0; \quad y'(0) = 0.$$

Let's agree that in our case $T_1 \geq 2T_2$, then both roots are real

The transition function of the object with k = 1 is:

$$y(t) = 1 - \frac{-T_1}{T_1 - T_2} * e^{\frac{-t}{T_1}} + \frac{T_2}{T_1 - T_2} * e^{\frac{-t}{T_2}}.$$

Suppose, for example, the transfer function of our object is equal:

$$W(p) = \frac{1}{20^2\,p^2 + 60\,p + 1}.$$

The characteristic equation of this link is equal

$$20^2\,p^2 + 60\,p + 1 = 0.$$

The roots of the characteristic equation are:

$$p_1 = -0.0191,$$
$$p_2 = -0.1309.$$

Let's denote

$$p_1 = -\frac{1}{T_3}, \quad T_3 = -\frac{1}{p_1} = 52.356;$$
$$p_2 = -\frac{1}{T_4}, \quad T_4 = -\frac{1}{p_2} = 7.639.$$

The transition function for these values is

$$y(t) = 1 - \frac{T_3}{T_3 - T_4} * e^{\frac{-t}{T_3}} + \frac{T_4}{T_3 - T_4} * e^{\frac{-t}{T_4}} \qquad (2)$$

Graph of the transition function of our object is shown in fig. 3.

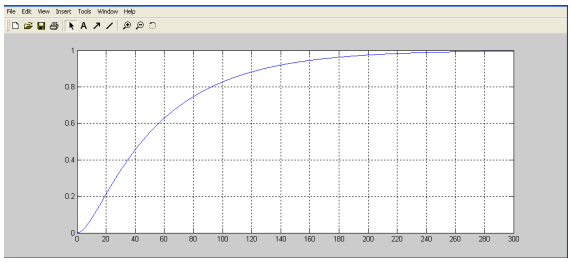


Fig. 3. Graph of the transition function

The shape of the curve of the transition function schematically shown in figure 4.

It can be seen that the argument t increases when derivative of this function (which is tangent to the curve) also increases at the beginning.

At point M the derivative reaches a maximum and then, after a point M, the value of the derivative begins to decrease.

Thus, at M tangent line is tangent simultaneously to the ascending and descending branches of the curve of the transition process. And the second derivative at the point M equal zero. With that said, we have:

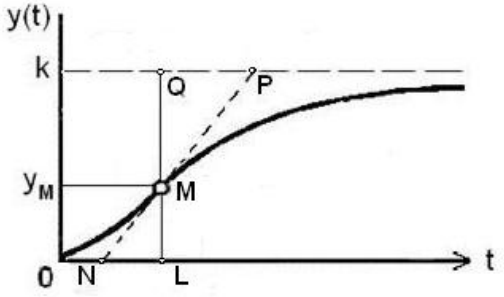


Fig. 4. Schematic picture of the curve of transition function

Let's define the value of the second derivative of the transfer function (2) to determine the abscissa of the point M:

$$y' = \frac{1}{T_3 - T_4} * e^{\frac{-t}{T_3}} - \frac{1}{T_3 - T_4} 1 * e^{\frac{-t}{T_4}} \qquad (3)$$

$$y'' = -\frac{1}{(T_3 - T_4) * T_3} * e^{\frac{-t}{T_3}} + \frac{1}{(T_3 - T_4) * T_4} * e^{\frac{-t}{T_4}}$$

For a point M is true $y''=0$. Then

$$\frac{e^{\frac{-t}{T_3}}}{e^{\frac{-t}{T_3}}}=\frac{T_3}{T_4},\quad \ln\frac{T_3}{T_4}=-\frac{t}{T_3}+\frac{t}{T_4};$$

$$t=\frac{T_3T_4}{T_3-T_4}\ln\frac{T_3}{T_4} \qquad (4)$$

We'll obtain the value of the segment 0L substituting in equation (4) the values T3 and T4: $t_M=17.21\ c$.

Ordinate of the point M can be obtained from equation (2) with a value of t = 17.21. The tangent of the slope in point for which $y''=0$. can be calculated from the equation (3) for first derivative using the obtained coordinates of point M.

We can now find a point P of intersection line NM and line k=const, indicated in fig. 5. This can be done by jointly solving the equation of the tangent with the value of the abscissa (in our case k = 1)

Now, we can determine the sum of the time constants (T3+T4 graphically, by measuring segment QP.

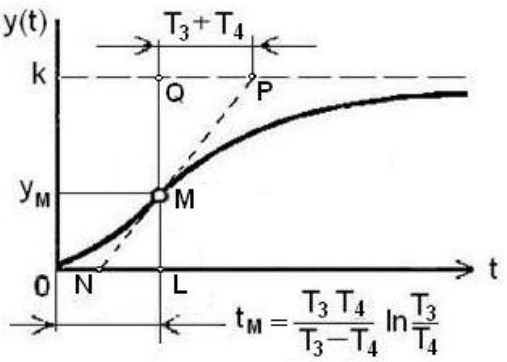


Fig. 5. Determination the time constants T3 and T4 using graphic measurement

Figure 6 shows the transfer function (2) constructed by computer simulation. Above mentioned points of the graph are indicated in the figure.

The sum of the time constants of T3 and T4, that was determined from the graph, is not very different from the calculated value. This difference depends on the scale of the chart. Graphical way to solve the individual values of T3 and T4 by given T3+T4 is predisposed to make bigger errors caused by inaccurate graphs. For this reason, sometimes researchers prefer to use an analytical way. Algorithm of analytical method for determining the separate values T3 and T4 can contain also a subroutine that takes into account the degree of approximation curve to the experimental data.

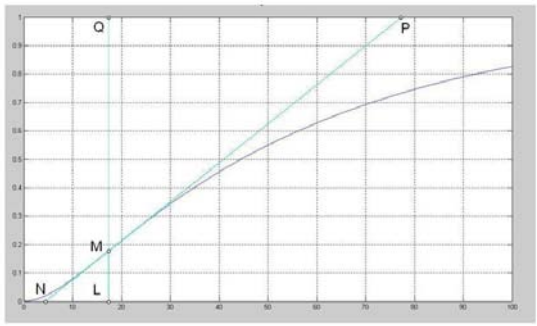


Fig. 6. The transition function for the assumed values of T3 and T4

Block diagram of the program calculate the time constants of T3 and T4 using the graphic data of measurement segments QP and 0L is shown in fig. 7.

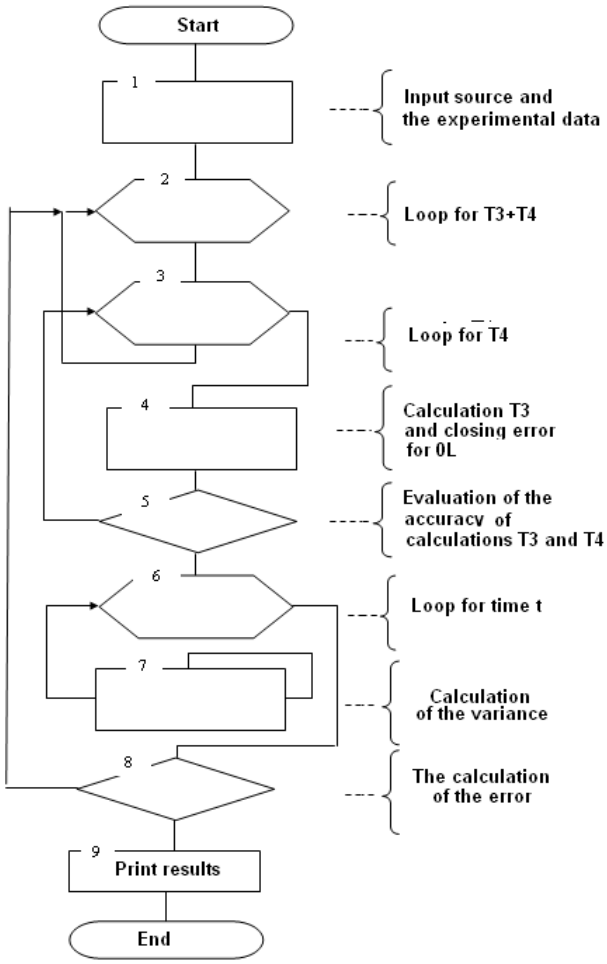


Fig. 7. A block diagram of the program calculate the time constants of T3 and T4

Calculation of time constants with this program gave the following results: T3 = 52.32 (relative error was 0.1%), T4 = 7.68 (relative error is 0.5%).

As the initial data were taken these values:

0L = 17.28 s. and QP = 60.1 s.

In conclusion let's summarize the main steps in determining the parameters of the characteristic equation. The next stages of the work have to be done

1. Perform statistical analysis of experimental data of transfer function. Remove mistakes and errors in the experimental data.

2. Construct the graph with experimental data taking in account the statistical correction.

3. Define the point M (Fig. 6). From point M draw a tangent to this curve. Find segments OL, ML and QP by graphic way.

4. Determine the parameters of the characteristic equation of the object for which there is minimal deviation of the transition process relative to the experimental data (using given algorithm).

CONCLUSIONS

Application of the algorithm to determine the dynamic parameters of the control object which represented by the aperiodic link of second order gives capability for using a smaller amount of experimental data

REFERENCES

1. **Alekseev A., Korablev Y., Shestopalov M. 2009.:** Identification and diagnosis of systems: for stud. in institutions /- M.: Publishing Center "Academy",– 352p.
2. **Bakshi V., Bakshi U. 2009.:** Automatic Control System. Technical Publications, 884p.
3. **Balakirev V., Dudnikov E., Tsirlin A. 1967.**: Experimental determination of the dynamic characteristics of the industrial plants of control. - Moscow: Energiya. 232p.
4. **Borovikov V., Borovikov I. 1997.:** STATISTICA - Statistical analysis and data processing inWindows environment. M.: Information and Publishing House "Filin",. - 608 p.
5. **Cui D., Meyer A. 1972.:** The modern theory of automatic control and its application. Translation from English Bochkova V. and others.. -M.,: Mechanical Engineering,
6. **Deitch A. 1979.:** Methods of identification of dynamic objects. - Moscow: Energiya..-240p.
7. **Diligenskaya A. 2009.:** Identification of control objekts. Samara University SSTU.– 136p.
8. **Dorf R., Bishop R. 2002.:** Modern control systems. Tr. from English. Kopylova B. - Moscow: Laboratory of Basic knowledge S_Pb, -832 p.
9. **Gnoevsky L., Kamensky, G., Èlsgolts L. 1969**.: Mathematical foundations of control systems. - Moscow: Nauka. - 512 p.
10. **Golnaraghi F., Benjamin C. 2009.:** Automatic Control Systems, 9 Edition 800p.
11. **Kalman R., Falb P., Arbib M. 2004.:** Essays on mathematical systems theory: Tr. from English. / 2nd ed. - Moscow: Editorial URSS, - 400 p.
12. **Kim D. 2004.:** The theory of automatic control. V.2. Multi-dimensional, nonlinear, optimal and adaptive systems: Manual. - Moscow: FIZMATLIT, - 464p.
13. **Kim D. 2008.:** Collection of problems in the theory of automatic control. Multi-dimensional, nonlinear, optimal and adaptive systems. - Moscow: Fizmatlit, - 328 p.
14. **Lehtsier O. 2005.:** Dynamic simulation model of jigging machine / / Scientific journal. № 3 (85). - SNU named by V.Dahl, Lugansk. -. - 130-140p.
15. **Lehtsier O. 2008.:** Modeling of the coal preparation and synthesis of automatic control jig- Lugansk: SNU. - 102 p.
16. **Lucas V. 2002.:** Control theory of technical systems. Compact course for universities. - 3rd edition, revised. and enlarged. - Ekaterinburg. Publ UGGA, - 675 p.
17. **Malkov V. and others. 2011.:** Method of the dynamic analysis of the mechanism. ..- Lublin, "Teka", Vol. XIa, p. 145-150.
18. **Nalimov V. 1971.**: The theory of the experiment. - Moscow: Nauka,– 208p.
19. **Nalimov V., Chernov N. 1965.:** Statistical methods for planning of extreme experiments. - Moscow: Nauka.– 340p.
20. **Petrov B., Solodovnikov V., Topchiev Y. 1969.:** Modern methods of designing control systems. Analysis and Synthesis / -M.: Mechanical Engineering, - 704 p.
21. **Poliakov A., Lachinov V. 1983.:** Some methodologies for developing control systems. - – NIIEFA– 32 p.
22. **Preygerzon G. 1969.:** Coal preparation. Second edition. -M.: Nedra,– 472p.
23. **Shubladze A, and others. 2011.:** Identification of the parameters of aperiodic objects dynamic models, Probl. Upr.- no. 6, 14-20p.
24. **Tikhonov O. 1973. :** Introduction to the dynamics of mass transfer processes of enrichment technology. - Nedra,. - 239 p.
25. **Ulshin V., Smoliy V., 2011**.: Automated management by designer preparation of production of electronic vehicles..- Lublin, "Teka", Vol. XIa, p. 276-281.
26. **Vlasov K. 1985.:** Fundamentals of automatic process control in coal. - Moscow: Nedra, - 188 p.
27. **Vlasov K. 1985**.: Fundamentals of automatic control of the coal preparation process. - Nedra, 192p.

ОПРЕДЕЛЕНИЕ ДИНАМИЧЕСКИХ ПАРАМЕТРОВ КОНТРОЛИРУЕМЫХ ТЕХНОЛОГИЧЕСКИХ ПРОЦЕССОВ ОБОГАЩЕНИЯ УГЛЯ С ПОМОЩЬЮ ГРАФОАНАЛИТИЧЕСКОГО МЕТОДА

Олег Лехциер, Виталий Ульшин,
Олег Килымник, Алексей Писменский

Аннотация. Представлен графоаналитический метод определения динамических параметров процессов обогащения угля с использованием экспериментальных данных. Алгоритм предлагаемого метода основан на графоаналитическим анализом переходной функции объекта, аппроксимированного апериодическим звеном второго порядка. Предлагаемый метод позволяет определить динамические параметры объекта управления при минимальном объеме экспериментальных данных.
Ключевые слова. Обогащение угля, графоаналитический метод, динамические параметры характеристического уравнения

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RAIL VEHICLE WHEELS COMMON FAULTS CHARACTERISIC

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S u m m a r y . The article focuses on the issue of rail vehicle common faults characteristic with the purpose of choosing optimal method of their diagnosis in service.
K e y w o r d s . Wheelsets, undercarriage, wheelset faults, rim, profile, flange.

INTRODUCTION

At the present stage of railway transport development it is necessary to pay special attention to the issue of passenger and goods transportation safety.

Wheelsets are the major element of undercarriage because traffic safety depends on their condition in the first place. They receive the weight of the body and wagons with all the equipment (sprung mass) as well as their own weight with details that are mounted directly on the wheelsets (unsprung weight) and convey it to the rails. In addition, the wheelset transmitts the torque of the traction motor; tractive and braking forces are realized at the place of wheels and rails contact. As the locomotive moves each wheelset takes hits from the track irregularity and guiding forces, and in turn, strongly affects the upper track structure and assembly of articulated wheelsets with a cart itself. Therefore, monitoring the wheelset assembly state is an actual task.

There is an analysis of wheelset details faults in works [1, 2, 4, 10, 11, 13]. However, each author considers faults that are specific to the individual assemblies of the wheelset.

OBJECTS AND PROBLEMS

Wheelset construction has not changed since the emergence of rail transport, and is mainly determined by the way of torque transfer from the traction motor, traction motor suspension method and the type of wheel centers.

Wheelset consists of an axle and two wheels. In order to transfer torque one or two tooth gears should be pressed on the axle, or there could be mounted the hollow shaft which is attached to the wheels with the help of elastic fingers. Traction gears are in their turn pressed on the shaft [12, 13, 16, 20].

Most domestic locomotives are operated with the axle load of up to 225 kN and can have wheelsets with wheels of 870-1050 mm in diameter. Wheels on new passenger locomotives DEL70 (diesel-electric locomotive) and DEL75 have a diameter of 1220 mm; wheel diameter of 1250 mm is accepted for freight locomotives with the load of axle on the rails up to 245 kN. [4, 5, 6].

Figure 1 shows profile of standard diesel wheelset rim according to State Standard 11018-87 [6]. The outer surface (roll surface) has a special profile which consists of the flange (ledge), main surface with the conical shape of 1:10 and lateral surface with the conical shape of 1:3,5. Flange directs the movement of the wheel on the rail track and prevents the wheelset of derailment. The main conical surface allows centering wheel pair in fixed tracks and facilitates the passage curves sections of track without slipping and excessive wear. The main conical surface allows centering of the wheelset in tracks and facilitates the passage of

the curved sections of track without slipping and excessive wear. The lateral conical surface and chamfer facilitate the passage of switches [17-19].

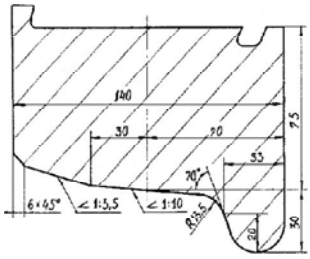

Fig. 1. Flange profile according to State Standard 11018-87

Flange is the most wearing part of the wheelset. Wear in the time of rolling circle is called clearance under flange; wear of the flange's lateral side is called flange worn sharp. Wheelsets in proportion to their wear come to tyre returning at which their original profile is restored. Marginal rate of wear and flange thickness are set according to the rules for technical operation.

In the operation of wheelsets there happen their natural wear and damage [5, 9].

The analysis of the wheelsets classification shows that the main faults of wheelset axles are the following [3, 6, 7, 8]:

- cracks in the wheel seat (on the inside of the wheel hub and rarely in the centre piece).
- scuff marks of the wheelset axle in the centre piece.
- weakening and shift of the wheel on the axle.
- modification of the axle journal (which occurred because of roller bearings usage in car boxes).

Possible causes of wheelset axles faults emergence and faults themselves are shown in table 1.

Wheels in turn can have the following faults[4,10, 14, 15, 17 - 19]:

- cracks;
- splitting of rim, disc and hub of solid-rolled wheels;
- fractures;
- uneven wheel rolling;
- even rim rolling;
- flange wear;
- flange undercut;
- sliders (dents);
- chips (local depressions on the surface of the wheel rim of wheelset, appearing due to peeling or chipping of metal);
- blisters in the wheels.

- In addition to the above-mentioned faults of the wheels, there are often found circular gallings on the roll surface (fig. 2), metal displacement and sharp worn in the area where the undercut part of flange joins its top (fig. 3).

Table 1 Wheelset axles faults

Fault	Possible causes of their emergence	Geometrical characteristics of the faults
Cracks in the wheel seat	Strikes experienced by wheelset under the condition of the poor quality of wheelset formation, while loading and unloading of wheelsets	Hidden defects and transverse cracks of≤2-4 mm in depth, inclined cracks of≤ 2 - 8 mm.
Scuff marks of the wheelset axle in the centre piece	It is caused by incorrect assembly and adjustment of the brake linkage	The depth of scuff is 2 -2,5 mm.
Scuff marks in the before-hub part	Friction of the walls of box with the axle because of incorrect assembly of axle unit and other reasons	No more than 2 mm.
Weakening and shift of the wheel on the axle	Among the signs of attachment hub weakening there is appearance of rust or oil at the hub of the wheel on the inside, crack of paint around the perimeter of the connection to the hub	The deviation from the nominal size according to State Standard 30237-96
Modification of the axle journal	The use of roller bearings in the car box	Conicity is ≤ 0,1 mm, ellipticity is ≤ 0,05 mm, waviness is ≤ 0,02 мм.

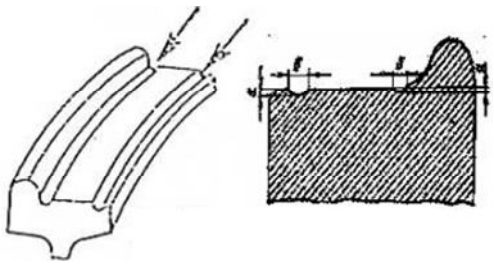

Fig. 2. Circular gallings on the roll surface

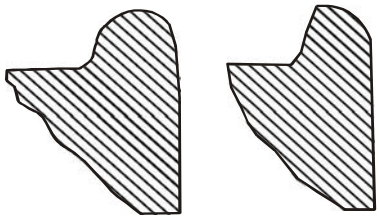

Fig. 3. Example of flange worn sharp

Circular galling is allowed at the base of flange with the depth of no more than 1mm and at the inclination of 1:7 it should be 2 mm at most or no more than 15 мм broad. Metal displacement (gain) may be at a height of wheelsets of passenger cars no more than 0,5 mm.

Possible causes of wheel faults emergence and faults themselves are shown in table 2.

Circular crack in the drive wheels can appear due to the tight fitting of drive axle. Wheelsets with cracks in the rim and solid-rolled wheels drives are not allowed to operate.

All of these defects of wheelset parts lead to quick wheelset breakdown, and also serve as the source of additional dynamic loads that cause vibrations in the frequency range close to resonance.

Taking into account the results of this study, in order to ensure reliable operation of the rolling stock it is necessary to create a system for wheelsets defects identifying. The basis of this system is the detection of wheelset defects by methods and techniques of vibro-acoustic signal.

Table 2. Wheel faults

Fault	Possible causes of their emergence	Geometrical characteristics of the faults
Cracks; splitting of rim, disc and hub of solid-rolled wheels; fractures	Shock interaction of wheel and rail	It is not allowed to operate wheel sets if they have a surface spalling on the outer rim edge, including local split circular roll, with depth (radial tires) exceeding 10 mm, or if the width of the remainder of the rim in spalling is less than 120 mm, or in a damaged place, regardless of the size of spalling, there is a crack extending into the metal
Uneven wheel rolling	It occurs mainly due to the stiffness of the way, high speed, and formation of defects of the brake origin on the roll surface	Uneven wheel rolling is standardized only for passenger cars: ≤ 2 mm (for wheelset with gear from the front axle it is ≤ 1 mm)
Even rim rolling	Its friction on the rails	≤ 4 mm for wheelsets with gear drive from the end of the axle and ≤ 5 mm for other wheelsets of passenger cars with speed from 121 to 160 km/h; ≤ 7 mm for long-distance passenger with speed up to km/h; ≤ 8 mm for cars of local and commuter passenger train; more than 9 mm for freight and refrigerator cars used in the trains at speed up to 120 km/h; for empty cars, used for loading or included to deadhead routes the wheel rolling of ≤ 8,5 mm is not allowed
Flange wear	Contact with the rail due to the winding movement of wheelset on straight way and car passing on curves	At speed of ≤ 120 km/h the flange thickness is more than 33 mm or less than 28 mm at the locomotive when measured at a distance of 20 mm from the top of the flange at a height of 30 mm, while the rolling stock with flange height of 28 mm measured at a distance of 18 mm from top of the flange
Flange undercut (especially often appears in eight-wheel cars)	Larger difference of lateral bogie frames bases; large difference between the diameters of wheels mounted on a single axle; and if there is a large gap between the axle boxes and jaws, as well as the warp of a bogie frame; wheels which were forced on the axle irregularly	It is not allowed to use cars, which have wheelsets with vertical undercut of the flange on a height of more than 18 mm from wheel rolling circle or flange worn sharp
Sliders (dents)	They are formed on the roll surface when sliding on rails in case of jamming of wheelsets	Having roller bearing axle boxes with depth of ≤ 1 mm; plain bearings with depth of ≤ 2 mm.
Chips	Flaking or pitting of the metal. They occur most often in the place of sliders and are located symmetrically on one line of both wheels	Depth is ≤ 10 mm, length is ≤ 25 mm for passenger cars, thickness of the wheel rim in the place of chip is: ≤ 31 mm. for passenger trains with speed of up to 120km/h; it is ≤34 mm., if speed is up to 140 km/h; and it is ≤ 40 mm. if speed is up to 160 km/h
Blisters in the wheels	Non-metallic inclusions in the metal, which are found on the roll surface after its abrasion or peeling	Not standardized
Circular gallings on the roll surface	Interaction with the surface of the pad, large axial and lateral loads	Depth at the base of flange is ≤ 1 mm, at the inclination 1:7 is ≤ 2 mm, width is ≤15 mm, metal displacement (gain) is ≤ 0,5 mm
Circumferential crack in the disk of wheel	Tight fitting of drive axle	≤ 2 - 4 mm

CONCLUSIONS

Proposed classification is of great importance for the analysis of defects causes and development of their elimination measures. It establishes link between the characteristics of wear, wheelset damage and operating conditions.

Therefore, for safety movement of rolling stock it is necessary:

- to develop a systematic approach when predicting running gear faults;
- to implement monitoring and diagnostics based on methods of vibroacoustics natural frequencies vibroacoustics, acoustic emission, electromagnetic acoustics, multi-angle acoustogalographics;
- to develop a new generation of diagnostic systems, which give three-dimensional image of defects with predictable operation life;
- to introduce fixed and on-board diagnostic of the rolling stock state assessment.

REFERENCES

1. **Kamaev A.A., Apanovich N.G. and others, ed. by A.A. Kamaev., 1981.:** Construction, calculation and design of locomotives: Textbook. Moscow: Engineering, - 351 p.
2. **Poyda A.A., Khutoryansky N.M., Kononov V.E., 1986.:** Locomotives. Mechanical equipment. Organization and repair: Textbook. Moscow: Transport, - 328 p.
3. **Airapetov E.P., Balitsky F.Y., Ivanova M.A. and others. 1982.:** Vibration diagnostics of incipient gear mechanisms defects. – In book: Theses of reports of the 5 national conference on technical diagnosis. Suzdal, pp. 11-13.
4. **Alekseev V.D., Sorokin G.E., 1987.:** Cars repairment. Moscow: Transport, - 280p.
5. **Kireev A., 2010.:** Analysis of the ultrasonic control system at making of elements and knots of rolling stock of railways. TEKA Com. Mot. i Energ. Roln. – OL PAN, 2010, X, pp. 110 - 115.
6. **Dobrynin S.A., Feldman M.S., Firsov G.I., 1987.:** Methods of automated machinery vibration studies. - Engineering, – 224 p.
7. **Haushild G., 2001.:** Automatic diagnostics of wheelsets with the help of ARGUS. Railways of the world. - № 12, pp. 36-42;
8. **Genkin, M.D., Sokolova A.G. and others. 1987.:** Vibroacoustic diagnostics of machines. - Engineerinf, – 288 p.
9. **Basov G., Kireev A., Lysak D., 2010.:** Improvement of testing operations during diagnosing tyres of railway vehicles. TEKA Com. Mot. i Energ. Roln. – OL PAN, 2010, X, pp. 12-18.
10. **Gerasimov V.S., Skiba I.F., Kernich B.M., 1988.:** Technology of carriage engineering and cars repairment. Moscow: Transport, -381p. 2
11. **Gridyushko V.I., Bugaev V.P., Krivoruchko N.Z., 1988.:** Carload economy. Moscow: Transport, - 295p.
12. **Gutman B.A., 1979.:** Diagnosis of mechanical systems by joint use of spectral and bispectral methods. – In book: Accuracy and reliability of mechanical systems: Intercollege scientific-technological collection. Riga Riga Polytech. Inst, pp.84-92.
13. **Biryukov I.V., Savoskin A.A.,. Burchak G.P, etc.: Under. ed. of I.V. Biryukov., 1992.:** The mechanical part of traction electrical equipment: Textbook. Moscow: Transport, – 440 p.
14. **Weimer J., 2000.:** New generation of devices detecting basking boxwood and jammed wheels. Railways of the world. - № 1. pp. 54-57.
15. **Kolchin A.V., 1984.:** Sensors for diagnostics of machines. - Engineering, – 120 p.
16. **Makhortova N.V., 2006.:** To the problem of identifying typical traction drive units faults based on their classification. Volodymyr Dahl East-Ukrainian National University. Lugansc, №3, - pp. 78-83.
17. **Mamshand S. , Bahuguna, 2000.:** Floor detection of vehicle faults. Railways of the world. -№ 7. p. 56-62;
18. **State Standard 16353-79** Nondesctructing control. Types and methods classification, – 23p.
19. **Tsikin I.A., 1982.:** Discrete-analog signal processing. - M.: Radio and communication, - 160 p.
20. **Vivdenko Y.G., Makhortova N.V., Spiryagin M.I., 2004.:** Analysis of axle box and recommendations for their technical diagnostics. Problems and prospects of transport systems development: engineering, technology, economics and management: Theses of the second scientific conference. - K.: Couette, - pp. 18-19.

ХАРАКТЕРИСТИКА РАСПРОСТРАНЕННЫХ НЕИСПРАВНОСТЕЙ КОЛЕС РЕЛЬСОВЫХ ЭКИПАЖЕЙ

Надежда Махортова, Юрий Вивденко

Аннотация. Статья посвящена вопросу характеристики распространенных неисправностей колес рельсовых экипажей для выбора оптимального метода их диагностирования в процессе эксплуатации.

Ключевые слова. Колесные пары, экипажная часть, неисправности колесной пары, бандаж, профиль, гребень

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Dangerous radiation when using your computer

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Summary. It is established that such monitors are the source of soft X-ray, ultra-violet, infra-red, electromagnetic radiation has been done in this article.
Key words: human vital activity, monitor, X-ray, ultra-violet, infra-red, electromagnetic radiation.

INTRODUCTION

Scientific and technological progress characteristic for modern century is impossible without the application of personal computers in all spheres of human vital activity: at private enterprises, organizations, industrial sites, in education, medicine and so on. Computer technologies play more and more decisive role both in professional and everyday person's activity even from the first years of his studies at school. Lately a constant and gradual diminishing the overall dimensions of a great variety of personal computers simultaneously with the growth of their productivity has been observed. Using personal computers and mobile devices of information representation – notebooks, Desktop replacements, Ultra – Mobile PCs, Subnotebooks, ultraptables, Handleheld PCs, desktop PCs) is one of the factors, having negative influence on a person's health. The application of personal computers is accompanied by PC user's creative thinking activity, visual analyser effort of a person, the considerable concentration of attention against a background of a nervous – emotional effort, and also the influence of PC radiation on the person's organism.

RESEARCH OBJECT

The analysis of the factors, influencing human vital activity.

RESULTS OF EXPERIMENTAL RESEARCH

The analysis of the latest publications, devoted to the influence of PCs on a person's health has revealed some essential factors. They are the following.

While working with the computers more than 6 hours a day and having industrial experience more than 2 years we can observe different changes in functioning such organs as a spleen, a pancreas, cerebrum vessels, reproductive disorders, the formation of tumors in a thyroid gland. The authors point out the association of these factors with the influence of electromagnetic radiation emitting from the monitors on the basis of cathode – ray tube [Piskunova L.E., Prilipko V.A., Zubok T.O., 2012., Grachyov N.N., 2005., Gordiyenko V.A., 2006., Avraamov U.S., 2002., Kechiyev L.N., 1997., Kasianov M.A., Gunchenko O.M., Medianic V.O. [and others]., 2008., Valeriy Maletkin, Lydmila Maletkina, Oleg Druz., 2010.].

It is established that such monitors are the source of soft X-ray, ultra-violet, infra-red, electromagnetic radiation (EMR) [Myhailyuk V.O., 2008.]. According to the information of the Russian Electromagnetic Safety Centre, the level of electromagnetic radiation (EMR) in the zone of PC operation exceeds a biologically dangerous level which must be decreased [Myhailyuk V.O., 2008., Druz O.N., Maletkin V.N., 2009].

In the period of Sun's activity and magnetic storms even during a weakly perturbed magnetosphere (with the index of geomagnetic activity Kp from 3 to 4) 80% of users observe the reduction of their working efficiency already in 50 – 60 minutes of a strenuous visual work, there appear a headache and tiredness [Shandala M.G.,

Zuyev V.G., Ushakov I.V., Popov V.I., 1998., Bannikov U.A., 1988.].

THE UNSOLVED PROBLEMS

When using your computer the levels of electromagnetic radiation (EMR) are regulated by the following normative documents [Kechiyev L.N., 1997., Shandala M.G., Zuyev V.G., Ushakov I.V., Popov V.I., 1998., Bannikov U.A., 1988., . Meltser A. V., Nikitina V.N., Naumova T.M. and others., 2001., . Afanasiev A.I., Dolotko V.I. and others., 1998., . DSanPiN 2.2.2/2.4.1240-03, Tarasova L.A., Muhina G.N., Lagutina G.N., Matyuhina V.V., 1995., Dubrov A. P., 1992., Pol Brouder., 1990., Kirikova O. V., 1992., Litvak I.I., 1999., Miagchenko O.P., 2010.]: GOST 12.1.006-84, GOST 12.3.002-75, GOST 12.2.003-74, GOST 12.1.045-84, MPR I, MPR II, TCO'92, TCO'95, TCO'99, TCO'O3, TCO'05, DSanPiN 3.3.2.007-98, DSanPiN 2.2.2.542-96. Certainly, the transition from electronic-radial monitors to liquid-crystal ones makes it possible for PC users to get rid of electrostatic fields and electromagnetic radiation, but the problem of electromagnetic radiation (EMR) has not been solved yet. In spite of the existence of the above mentioned normative documents which restrict the levels of electromagnetic radiation (EMR), they aren't able to take into account the whole variety of information display technologies, the peculiarities of their application, the rates of computer technologies development.

STATEMENT OF THE PROBLEM IN GENERAL

The main task of this article is the elucidation of dangerous factors when using mobile devices of information representation (notebooks, liquid – crystal monitors); the substantiation of the directions of EMR influence on the users of PCs with liquid – crystal monitors (LCM).

PRESENTATION OF THE BASIC RESEARCH MATTER

While using portable PCs they are mostly accommodated as nearer to the user as possible, in most cases – on his knees or on a palm (laptop), therefore, the sources of radiation with greater intensity have an influence on the area of person's vitally important organs. Furthermore, modern portable PCs have wireless modules which are also the sources of emanation. For example, the level of electromagnetic radiation (EMR) from Wi-Fi is equal to 50 mWt, and from Bluetooth – 1 mWt, hereto the time of action of these sources may be equal to 6 hours a day that causes harm for a person's health.

Two modes of power supply (from a built – in accumulator or from a network) are peculiar to PCs with liquid – crystal monitors (LCM). In the case with an accumulator, as the measurements showed [Piskunova L.E., Prilipko V.A., Zubok T.O., 2012.], the levels of electromagnetic radiation are lower. In the mode of power supply from a network, a portable PC emits an electric constituent of an alternating electromagnetic field which, in its intensity, is slightly different from PCs with electronic – radial monitors. Fig.1 shows the electric field tensity of the Notebook Epson at two distances of 30 cm (a real distance when using a liquid – crystal monitor) and 50 cm (according to MPR II methods) from the centre of a keyboard. As fig.1 shows, the emissions considerably exceed the standards both in the first and in the second diapasons.

In the mode of power supply from an accumulator in the majority of portable PCs the electric field tensity in the first diapason appreciably exceeds the standards and in the second diapason the exceeding is observed only on the right and behind the screen. The pictures of the notebook Samsung field in two modes of power supply are given as an example on fig. 2. The levels of electromagnetic radiation of portable PCs exceed the normative standards for the majority of PCs with electronic-radial monitors.

PROSPECTS OF FURTHER INVESTIGATIONS

The dangerous and harmful factors that occur when using modern means of information representation require further investigations, studies and working out additional normative documents with their regulation. A number of factors have not been explored up to now. They are:

- the influence of portable PCs on the person's organs of sight;
- the diseases of vertebral column and joints;
- the subjective and objective user's health;
- overheating internal tissues which have no heat receptors in a person's organism;
- mental and psycho-physiological processes;
- industrial productivity;
- a working posture.

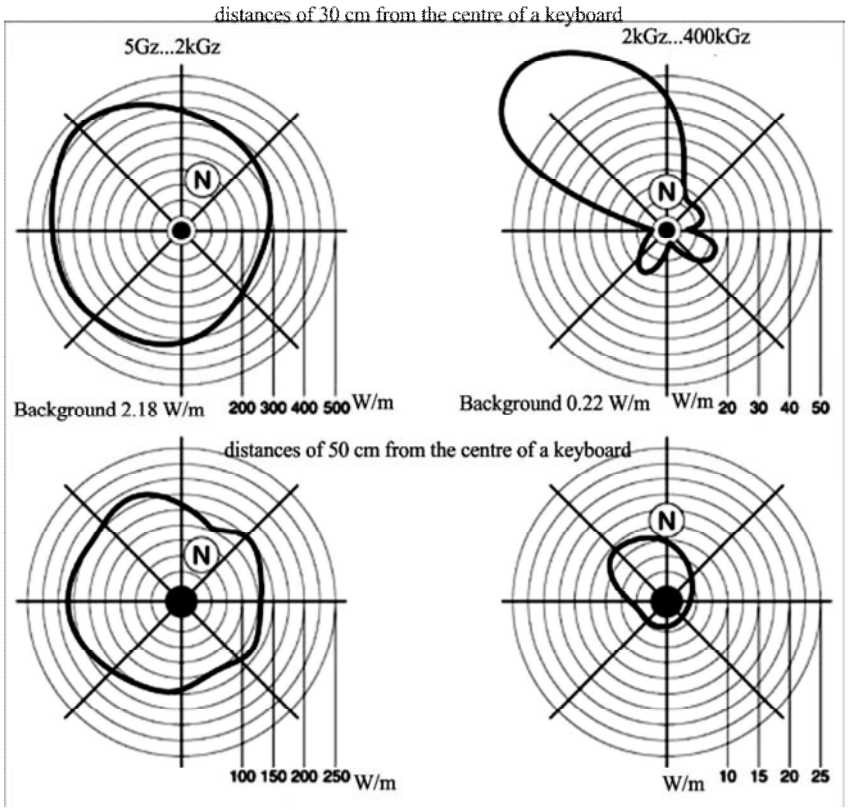

Fig. 1. The emissions considerably exceed the standards both in the first and in the second diapasons [Piskunova L.E., Prilipko V.A., Zubok T.O., 2012.]

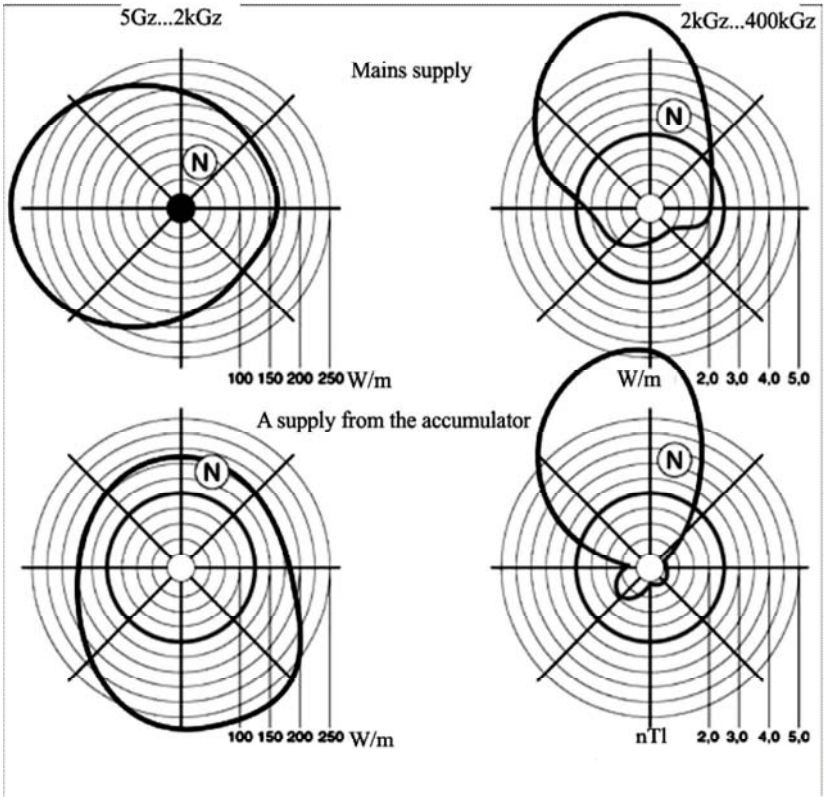

Fig. 2. The levels of electromagnetic radiation of portable PCs exceed the normative standards for the majority of PCs with electronic-radial monitors [Piskunova L.E., Prilipko V.A., Zubok T.O., 2012.]

CONCLUSIONS

1. The investigations of many scientists are indicative of the danger of non – regulatory application of portable PCs (notebooks) and liquid – crystal monitors.

2. The rates of computer technologies development leave behind working out normative documents that regulate dangerous and harmful factors when using PCs.

3. It is necessary to work out a normative basis being able to make producers of PCs take into consideration all possible dangerous factors as early as on the stage of designing and development. It goes without saying that it should be done on the international level.

4. The investigations of dangerous factors when using the latest computer technologies should be necessarily continued.

REFERENCES

1. **Piskunova L.E., Prilipko V.A., Zubok T.O., 2012.:** Safety of human vital activity. Textbook – K., Academy, – 221 pp.
2. **Grachyov N.N., 2005.:** The protection of a person from dangerous emanations [text]: Textbook for higher and secondary educational establishments. / Grachyov N.N., Myrova L.O. – M.: Binom. Laboratory of knowledge, – 317 pp.
3. **Gordiyenko V.A., 2006.:** Physical fields. Problems of ecology, health and life on the Earth [text] – V.A. Gordiyenko. – M.: Astrel. AST. Prof.publish.house, – 316 pp.
4. **Avraamov U.S., 2002.:** The protection of a person from electromagnetic influence [text]: Textbook / Avraamov U.S., Grachyov N.N., Shlyapin A.D. – M.: MGIU, – 432 pp.
5. **Kechiyev L.N., 1997.:** Elements of ergonomic safety work with computers [text]: / Kechiyev L.N., Litvak I.I. – M.: MGIEM, – 176 pp.
6. **Kasianov M.A., Gunchenko O.M., Medianic V.O. [and others]., 2008.:** The protection of PC users' job [text]: Textbook for higher students. – Luhansk.: East Ukrainian V. Dahl National University, – 124pp. – ISBN 978-966-590-683-4.
7. **Myhailyuk V.O., 2008.:** Safety of human vital activity – education, science, practice: scientific works of the conference, 20-21, March, 2008, Mykolaiv. / Editor-in-chief V.O. Myhailyuk. – Mykolaiv: NUK, 2008. – 292pp. – ISBN 978-966-321-092-6.
8. **Druz O.N., Maletkin V.N., 2009.:** The influence of electromagnetic radiation when using your notebook. Materials of the international scientific and practical conference. 17.12. 2009. The problems of labour and social technologies in the industrial region. Theory and practice. Lugansk – 334 pp.
9. **Shandala M.G., Zuyev V.G., Ushakov I.V., Popov V.I., 1998.:** Reference book on electromagnetic safety of working people and population. – Voronezh: Istoki – 244 pp.
10. **Bannikov U.A., 1988.:** Radiation. Doses, effects, risk: Translation from English. U.A. Bannikov – M.: Mir, – 112 pp.
11. **Meltser A. V., Nikitina V.N., Naumova T.M. and others., 2001.:** A safe computer in office and at home. — SPb: Prof. publish. house by Sizov M.P., – 82 pp.
12. **Afanasiev A.I., Dolotko V.I. and others., 1998.:** Methods of measurements and evaluations of ergonomic and safety parameters. – M.:GNPP «Cyclone-Test», – 28 pp.
13. DSanPiN 2.2.2/2.4.1240-03 «Hygienic requirements to videodisplay terminals, personal computer and job organization». Ministry of Health, Russia, 2003.
14. **Tarasova L.A., Muhina G.N., Lagutina G.N., Matyuhina V.V., 1995.:** The influence of nervous-strenuous work on the development of mental disorders inherent to operators. // Labour medicine and industrial ecology. 1995, №1, pp.11-13.
15. The problems of safety of modern PCs monitors // PC Week. 2000. № 4 (226).
16. **Dubrov A. P., 1992.:** Earth radiation and person's health. // Arguments and facts. – M.
17. **Pol Brouder., 1990.:** Magnetic fields – a threat to a person's health. // World of PCs. 1990, №5.
18. **Kirikova O. V., 1992.:** Protection from electromagnetic radiation. – M.: Radio and communication, 1992. – 42 pp.
19. **Litvak I.I., 1999.:** Computers at school. 1999. №6,7.
20. **Miagchenko O.P., 2010.:** Safety of human and society vital activity. Textbook – K., Centre of educational literature, – 384 pp.
21. **Valeriy Maletkin, Lydmila Maletkina, Oleg Druz., 2010.:** Planetary safety of life activity as the way of spiritual integration of mankind // TEKA Com. Mot. Energ. Roln. – Lublin, 2010. – Vol. XB. – P. 23 – 27.
22. **Valeriy Maletkin, Lydmila Maletkina, Oleg Druz., 2010.:** Research of effect of physical fields on ability to live of a person. // TEKA Com. Mot. i Energ. Roln. – OL PAN, 2010. – Vol. XD. – P. 196 – 200.

ОПАСНЫЕ ИЗЛУЧЕНИЯ ПРИ ИСПОЛЬЗОВАНИИ КОМПЬЮТЕРА

Валерий Малеткин, Олег Друзь, Людмила Малеткина

Аннотация. В данной статье установлено, что электронно-лучевые мониторы являются источником мягкого рентгеновского излучения, ультрафиолетового, инфракрасного, радиочастотного и электромагнитного излучений.

Ключевые слова: безопасность жизнедеятельности, рентгеновское излучение, ультрафиолет, инфракрасное излучение, электромагнитное излучение.

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The analysis of adhesion effect on properties of the modified polymeric nano composites

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Summary. The analysis of the adhesion effect on the structure and properties of nano-modified composites is given in the article. Existing theories of adhesion were considered. The analysis results showed that the introduction of nano modifiers into the epoxy matrix leads to improvement of the physical and mechanical properties of polymer composites [6].
Key words: epoxy matrix, nano modifiers, physical and mechanical properties, polymeric composite materials.

INTRODUCTION

Replacement of metal structural components in the aerospace technology of polymeric materials produces a significant gain in the weight of an aircraft. Consequently, it also gives the technical and economic advantages.

However, polymeric composite materials (PCM) must have strictly regulated physical and mechanical characteristics. These include: high impact strength, low water permeability, electrical conductivity etc [18].

Obtaining the PCM with specified characteristics is a priority technology of the XXI century. According to the forecasts of the European Union, the amount of funding in development in the field of nano technology in the world will reach 1 trillion euros by 2015 [1].

The study of information of international conferences NANO-2008 (Minsk), NANO-2010 (Kiev), NANO-2011 (Moscow), the annual conferences "Composite Materials in Industry" at Yalta and Moscow International Conference "Theory and Practice of manufacturing technology of products made from composite materials and new metal alloys, "2006-2011, was conducted. Sources points to the wide interest to the nano modified PCM with carbon-modifiers.

However, there is an insignificant number of the papers about creation, study of the effect on adhesion properties of PCM and the use of thin films as the structural materials and the coatings for special purposes.

Proceeding from above, the study of the adhesion effect on the properties of polymer composite materials is an important task.

The purpose of article is the analysis of the adhesion effect on the structure and properties of nano-modified composites.

OBJECTS AND PROBLEMS

At present time there are a number of theories of adhesion.

Adsorption theory of adhesion assumes that the adhesion is caused by the secondary valent bond force [12] between the molecules of the padding (substrate) and adhesive on the minimum range of 5 Å. Van der Waals forces, dipole-induced and dipole molecular interaction and hydrogen bonding may be involved here. To obtain stable adhesion the polar surfaces should be agreed [16].

Diffusion theory assumes that the adhesion of polymers is the result of diffusion of the substrate of molecules or their entities. Interdiffusion but with different mobility occurs when both layers are polymers. For example, glass (glass fiber) is recommended to be covered with

the silane, which is capable for mutual diffusion of the resin.

The theory of surface energy states that good adhesion can be obtained by any polymer and the surface of any material. This is possible if the surface tension of the substrate material is higher. In this case, the polymer which is in a liquid state will have a minimal contact angle with the surface and spread out well on it.

Reactionary theory of adhesion is applicable in cases where the covalent bond can occur between the binder and the substrate. Adhesive compound becomes like a part of the massive block of the copolymer.

There is a semi-empirical theory of adhesion of macromolecular compounds (MMC) [2]. Most of polymeric adhesives are solutions MMC. Adhesion processes involving polymeric adhesives play a key role in the creation of various types of adhesives and composite materials.

Existing theories consider the specific mechanisms of adhesion at the interphase boundary "adhesive - substrate" in dilute solutions mainly. Therefore it is important to solve the problem of interfacial solid connection at the "polymer - adhesive - substrate" boundary. Semi-empirical model does not analyze the intermolecular forces at the interphase boundary.

Theory prerequisites are the following ones: non-ideality of adhesives solutions is expected; various forces in the interaction of the polymer adhesive with the substrate are considered - van der Waals, chemical, electrostatic (however, details of every interaction is not conducted); set of polymer globules forms a cluster; adhesive forces are determined by the interaction of clusters with the substrate; expansion of the polymer particles and clusters into the structural defects and pores of the substrate occurs under the influence of the field of molecular interaction; concentration dependence of the adhesion forces obeys the law of non-ideal solutions. Each type of clusters is making its contribution to the "expansion".

In contrast to the perfectly smooth surface of the substrate which is assumed in [2], the adhesive forces have not superficial but the volume nature. Hence the dimension of force is evaluated in N/m^2, and the work of the adhesion forces - in J/m^3.

The work of these forces according to the first law of thermodynamics is determined by the formula:

$$\delta Q = dU + \delta A + \pi dV, \qquad (1)$$

where: δQ - amount of heat released (absorbed) by the system; A - work which was being done over the system; U - internal system energy; dV - volume change of the considered system [19].

As it is shown by the theory of adhesion (classical and semi-empirical) and the results of their practical confirmation, glass fiber plastics strength increases with adhesion strength increasing [17-18].

Therefore, to increase the strength of fiberglass products the different ways of modifying the surface of the filler and the binder is required to be used. It will lead to increasing of adhesion strength [20].

Adhesion strength depends on many factors related not only to the nature of the contacting materials but also particularly technological interface preparation; these include the surface area and roughness, the polarity of the molecules, the interphase tension etc [15].

There is a relation between the surface and material bulk properties. Consideration of the processes which are occurring at the interface from a molecular point of view helps to explain the relations of physical and mechanical properties of the structure of the PCM [3-5].

The difference in the coefficients of thermal expansion in composite materials may create the additional effect at the rigid inclusion point [17]. Thus, in the "epoxy resin-fiberglass" there is an additional pressure on the surface of the glass up to 7 MPa in the polymerization process. Factors that affect the adhesion strength are shown in fig. [1].

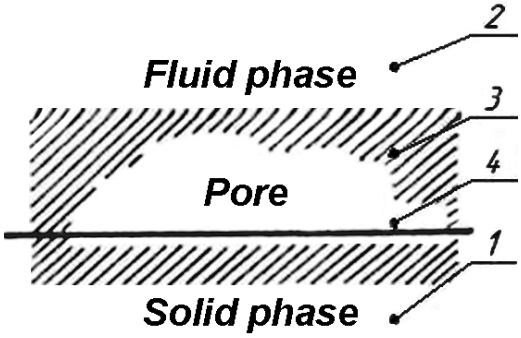

Fig. Factors that affect the adhesion strength: 1-solid body; 2-fluid phase; 3- pores; 4- surface separation

Analysis of the literature on the acquisition polymeric composite materials with regulated characteristics showed that nanotechnology is an interdisciplinary science. To solve any technical problem the whole complex of the physicochemical investigations is required [11].

Particularly for obtaining composite materials with specific characteristics it is

necessary to consider the following processes: to justify the choice of nanomodifiers, to establish mechanism of interaction of nanomodifiers with the matrix; to determine the optimum ratio "nanomodifiers - matrix" [6].

One of the problems in modern aviation and space technology is to reduce the weight of the aerial vehicles through the use of structural elements made of polymer composite materials. Applied to this polymer composites must combine high strength, resistance to dynamic loads and exploitation in various climatic conditions.

The basic material as a binder in obtaining the adhesives, glues, protective coatings are the thermosetting epoxy resins [13].

The progress in science and technology causes the creation of new materials with a set of required properties. Important factors in the ensuring of operational reliability are: the adhesive strength, strength characteristics resistance for use in a variety of environments [14].

Influence of processing of thin composite coatings on steel was studied by the authors. It showed that the injection of the filler of various nature into the epoxy matrix increased the strength of the "coating-base" [7].

The mechanism of interfacial interaction in the epoxy resin filled with dispersed particles was explained by the methods of structural and spectral analysis. It was found that the molecular mobility of the epoxy oligomer near the surface of the filler decreases independently on the chemical activity of the filler.

The change in the infrared spectra (IR), that is the shift of the band of the hydroxyl group (3760 cm-1) at 20 cm-1 and a decrease in the intensity of the absorption band of the C = O demonstrates the chemical interaction at the phase boundary [7-9].

Layer structure was studied on a microscope with an increase in 104 times. The processed results allowed us to calculate the value of the area of the layers around the particles. They showed that not only the first but the second layer is affected by the active filler particles. Physical relations are being formed during the interaction.

Particle size of fillers (zinc oxide, carbon black, technical graphite, electrocorundum) was about 40-60 microns. Although the nanodimensional (50-500 nm) particles are used in our experiments, the study of adhesive strength of the modified epoxy resin represents statistical interest (table).

Table. Adhesive strength of the protective coatings

Properties	Modifier material			
	Cuprous oxide	Carbon black	Electrocorundum	Technical graphite
Adhesive strength σ_{max}, MPa	56,95	52,6	67	69

CONCLUSIONS

The conducted analysis of the influence of adhesion on the properties of polymer nano-modified composite materials leads to the following conclusions:

1. Tensile stress is considerably increased (in 2,5-3 times).

2. Optical properties of thin films of polymer composites vary.

3. The extent of water absorption decreases with the introduction of nanomodifiers of 30%. This allows to use them as a sealing layer.

4. Adhesive strength of nano-modified composites increases.

REFERENCES

1. **Piatti J. 1978.:** «Achievements in Composite Materials.» Collection of scientific papers. International Symposium. Ispra, Italy. p. 304.
2. **Dolmatov M.Y., Timofeeva M.Y. 2006.:** Semiempirical theory of adhesion of macromolecular compositions compounds // Proceedings of the 26th International Conference "Composite Materials in Industry".- Yalta. pp. 391-394.
3. **Malkov I.V., Bondar L.P., Sirovoy G.V. 2008.:** Physico-chemical basis of nano modification of polymers // Bulletin of Kremenchutskiy sovereign politechnical universitetu named by Mikhail Ostrogradskiy.- Kremenchuk: 2008.- 5/ (52) part 1. pp. 70-71.
4. **Malkov I.V., Bondar L.P., Tarasov Y.I., Voskoboynikov V.I., Sirovoy G.V. 2006.:** The mechanism of interaction of carbon nanomodifiers with the epoxy matrix // Proceedings of the 4th Moscow International Conference «Theory and practice of manufacturing technology of products from composite materials and new metal alloys».-M.: Znaniye. pp. 662-665.
5. **Gunyaev G.M., Kablov E.N., Ilchenko S.I., Ponomarev A.N. 2006.:** Structural modification of polymer and composite materials with carbon nanoparticles. // Proceedings of the 4th Moscow International Conference «Theory and practice of manufacturing technology of products from composite materials and new metal alloys».-M.: Znaniye. pp. 82-89.
6. **Malkov I.V., Bondar L.P., Makukhin A.G., Sirovoy G.V. 2010.:** Perspectives of nano-modified polymers application in aviation and space technology // Resource-saving technology of production and forming

of materials in engineering. Collection of scientific papers.- Lugansk: edited by EUNU named after V.Dahl. pp. 137-141.
7. **Buketov A. A. 2007.:** Regularities of the influence of processing energy fields binder and filler on the properties of epoxy composite materials for protective coatings. Thesis abstract.
8. **Laricheva V.P. 2006.:** Radiation-chemical transformations in epoxy oligomers of different structure and perspectives for their use in the radiation technology for new composite materials // Proceedings of the 4th Moscow International Conference «Theory and practice of manufacturing technology of products from composite materials and new metal alloys».-M.: Znaniye. pp. 129-135
9. **Malkov I.V., Bondar L.P. 2008.:** About the destruction of nano-modified epoxy composite materials // Proceedings of the 5th Moscow International Conference «Theory and practice of manufacturing technology of products from composite materials and new metal alloys ».- M.: Znaniye. pp. 229-235
10. **Malkov I.V., Bondar L.P., Makukhin A.G., Syrovoy G.V., 2010.:** Properties of epoxy materials with diferent nano-modifiers. TEKA Commission of Motorization and Power Industry in Agriculture, OL RAN, IOB. 28-32.
11. **Ponomarev A., Nikitin V., Shakhmatov B., 2006.:** Astroleny is carbon nano-modifier of fylleren type. Proceeding to the 4-th International conference «Corporate nano and GALS-technologies». «Znanie», Moscow, pp. 642-653.
12. **Nosko P., Breshev V., Fil P., Boyko G., 2010.:** Structural synthesis and design variants for non-contact machine drives. TEKA Commission of Motorization and Power Industry in Agriculture, OL RAN, IOB. 77-86.
13. **Sytar V.I., Burya A.I., Stowpnyk O.V., Ransky A.P., Panasyuk A.G., 2006.:** The Development of antifriction coatings based on aromatic polyamide phenilon modified with the complex heterocyclic compounds of thioamides. Energy and environmental aspects of tribology. Insycont´06. Cracow, Poland, pp. 371-376.
14. **Sviridenok A.I., Sirotina T.K., Pisanova E.V., 1991.:** Effect of biochemical treatment on the adhesion of pol-p-amiddenzimidazole fibre. J. Adhesion Sci. Techn., V. 5. № 3, pp. 229-237.
15. **Sviridenok A.I., Meshkov V.V., Pisanova E.V., 1997.:** Effect of biochemical treatment on the adhesion of poly-p-amidobenzimidazole fibre. Adhesion Science and Technology. Tokyo, p. 839-849.
16. **Trofimov B. A., Nedolya N. A., 1993.:** A new strategy in the synthesis of epoxy resins. Reviews on heteroatom Cheam. Japan. Vol. 9., pp. 205-209.
17. **Smokal V., Krupka O., Wilczek M., Kostrzewa M., Kolendo A. J., 2008.:** Nanomaterials and Biostructures. V.3(1), pp.41-47.
18. **Masatoshi M., Masataka O., Yasunori O., 2009.:** Numerical Simulation of Temperature and Torque Curve of Multidisk Wet Clutch with Radial and Circumferential Grooves. Tribology Online. Vol. 4. № 1, pp. 17-21.
19. **Xiaohui Lio, Qiuju Wu, Lars A., 2002.:** Xiaohui Lio Polymerphism in polyamide clay nanocomosites. Polymer, t. 43, pp. 4967-4972.
20. **Brantseva T.V., Gorbatkina Y.A., Mader E., Dutschk V., Kerber M.L., 2004.:** Mechanical characteristics of unidirectional glass-plastics J. Adhesion Sci. Technology. Vol. 18, №11, pp.1293-1308.

АНАЛИЗ ВЛИЯНИЯ АДГЕЗИИ НА СВОЙСТВА ПОЛИМЕРНЫХ НАНОМОДИФИЦИРОВАННЫХ КОМПОЗИТОВ

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Аннотация. В статье дан анализ влияния адгезии на структуру и свойства полимерных наномодифицированных композитов. Рассмотрены существующие теории адгезии. Результаты анализа показали, что введение наномодификаторов в эпоксидную матрицу приводит к улучшению физико-механических характеристик полимерных композитных материалов.

Ключевые слова: эпоксидная матрица, наномодификаторы, физико-механические свойства, полимерные композиционные материалы.

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Investigation of the kinetics of the development of the distribution

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Summary. The article presents an analytical solution of the equations of Kolmogorov-Fokker-Planck, as well as the analysis of dynamics of development of cracks on the basis of the model of diffusion of defects.
Key words: stochastic process, diffusion of defects, the intensity of wear.

PROBLEM DEFINITION

The task of improving the efficiency of complex technical systems is directly connected with optimal for the design of the load conditions of materials, structural state of which optimized for the conditions of service, for which it is necessary the knowledge of the mechanism and of the evolution of damage accumulation of the material in the course of his service. Solution of the problem requires an interdisciplinary approach on the basis of the physics of strength and fracture mechanics and material science.

ANALYSIS OF THE PROBLEM

New approaches have arisen as a result of the development of non-equilibrium thermodynamics and information theory. Classical thermodynamics, as it is known, explores the irreversible processes, leading to an increase in energy, meaning the increase in the chaos and the destruction of the interior structural relations [Thursdays V.A., 2003]. On the contrary, nonequilibrium thermodynamics studies irreversible processes, leading to a decrease in entropy by self-organization ordered or dissipative structures, flows in open systems, the exchange of energy with the environment [Reshetov D.N., 1988]. Conclusions of non-equilibrium thermodynamics do not contradict the classical, as the assertion of a reduction in entropy refers to the local system, which is compensated by the increase in the entropy of the external environment, interacting with the system [Pakhomov E.A., 1985]. Nonequilibrium systems are inherent in bifurcation.

To Prigozhin, worked out the mathematical apparatus, describing the behavior of the system near the bifurcation points, the system due to random fluctuations selects one of several options for the future, both near these points fluctuations become strong. Reaching the stage of bifurcation, the system loses its stability. The alternation of stability and instability - a common phenomenon in the evolution of any open system, and the process is irreversible [Ostreikovskaya V.A., 2005]. This means that the system after the passage of the bifurcation cannot be returned to its original state [Terentyev V.F., 2003].

In the process of operation of any system is exposed to various influences, which eventually lead to the destruction of the system as a whole or any of its parts, which can also be regarded as a violation of the system, as it removes it from the system. However, begins the process of destruction with the appearance of defects in the system response to perturbations of the impact, its attempts to move to a stable state. For a description of this process, consider the parameter that defines the status of the defect [Marchenko D., Vetrov A., 2003]. For example, it may be the size of fatigue cracks [Klyuyev V.V,. 2003].

In some cases, the rate of change of the determining parameter can be described by the stochastic differential equation of the type:

$$dy = mdt + \sigma d\xi(t) \qquad (1)$$

where: m – mathematical expectation of rate of formation of cracks; σ – the average quadratic deviation of the rate of formation of cracks; $\xi(t)$ – normal white noise with zero mathematical expectation and variance [Ivanova V.S., 1979]. Model (1) change of the determining parameter leads to the diffusion distribution of uptime, whose form is determined by the relevant provisions of the decisions of the equations of Kolmogorov-Fokker-Planck. The last equation is determined by the probability density of transition $p(t_0, y_0, t, y)$ of the Markov diffusion process from one state to another parts [Barenblatt G.I., 2003]. The equation of the Kolmogorov-Fokker-Planck has the form:

$$\frac{\partial p}{\partial t} + m\frac{\partial p}{\partial y} - \frac{\sigma^2}{2}\frac{\partial^2 p}{\partial y^2} = 0. \qquad (2)$$

View the solution of this equation is determined by the boundary conditions, which in the simplest case, you can establish, on the basis of the physical essence of the considered processes power [Gnedenko B.V., Belyaev Yu.K., Soloview A.D., 1965, Gadasin V.A., Ushakov I.A., 1975, Bortsova A.T., 1983, Barzilovich E.Yu., Kashtanov V.A., 1971]. In particular, if the implementation of the process (1) have the monotonous character, in the capacity of boundary conditions are accepted by the following:

$$p(y,t)\big|_{y=-\infty} = p(y,t)\big|_{y=\infty} = 0 \qquad (3)$$

$$p(y,t)\big|_{y=0} = \delta(y), \qquad (4)$$

where: $\delta(y)$ is a Delta - function.

The solution of equation (2) with the conditions (3), (4) is known as the fundamental solution and has the following form:

$$p = \frac{1}{\sigma\sqrt{2\pi t}} e^{\left(\frac{(y-mt^2)}{2\sigma^2 t}\right)}. \qquad (5)$$

You can, however, show that the equation of the Kolmogorov-Fokker-Planck under certain boundary conditions has an analytical solution.

The solution of diffusion equation allows us to offer analytical modeling of the process of education and development of cracks and methodology of the location of the uncertain parameters of the model [Baldin K.V., 2004]. To change the concentration of cracks in the process of operation of the system depending on the boundary conditions for an equation of the Kolmogorov-Fokker-Planck allows to receive the parametric solution either in an explicit form, or with the help of the numerical algorithm [Ayzinbud S.Y., 1990]..

THE AIM OF THE RESEARCH

Analytically find the General solution of the equations of Kolmogorov-Fokker-Planck, as well as the distribution functions of the time of the first achievements of the defining parameter of the defect a set limit, which will allow to determine the function of the intensity of wear and tear $r(t)$.

THE RESULTS OF THE STUDY

Let us consider the General case equation a random walk on the vertical axis, recorded in the form of the equation of the Kolmogorov-Fokker-Planck relatively concentrations

$$\frac{\partial p}{\partial t} = \frac{\sigma^2}{2}\frac{\partial^2 p}{\partial y^2} + m\frac{\partial p}{\partial y}. \qquad (6)$$

Here $p = p(t,y)$ is the fraction of defects (cracks) to the moment of time t in point y. Axis Oy believe aimed up; m – mathematical expectation of the rate of formation of cracks, м/с; σ – average quadratic deviation of the rate of formation of cracks, м^2/с. In the General case, m and σ are not constant and change over time. However, these changes for a small period of time is insignificant. Defects (cracks) are not homogeneous in their properties .) [Dodonov A.G,. 1988, Golubenko A., 2008]. For each class of defects [Khaitun S.D., 1996] you can write the equation of a random walk in the working volume with their conditions of development of the defect y. Reaching the value $y = 0$, the defect with a probability $1 - P$ is maintained, i.e., returns to the process of wandering, and continues to generate new defects, or with probability P disappears, i.e. exits process wandering. Thus, in the General case, the value y - is the value of the approximation to the point of the possible implementation phase transition, i.e. the restoration of the damaged defect of the surface area or the other phase transition associated with the achievement of the size of the

defect some limiting value a. In the second case there is a break in the relations, which leads to a catastrophic failure of the system, or to its transition to a new state of equilibrium.

Reflection, return to the process of wandering, occurs with a probability $1-P=1-P(x)$. Therefore, the condition of full reflection can be written as equality to zero of a stream of particles (defects) through the screen. It has the form: $\frac{\sigma^2}{2}\frac{\partial p}{\partial y}+mp=0$. The condition of full recovery (disappearance of defect) corresponds to $p=0$. This event occurs with a probability P. With the probability of the particle (defect) enters a new phase state, becomes an attachment to the environment. It will not be further discussed in the process of wandering.

Therefore a weighted sum of these two equations gives the boundary condition for the differential equation (6) in partial derivatives provided $y=0$:

$$(1-P)\left(\frac{\sigma^2}{2}\frac{\partial p}{\partial y}+mp\right)-\mu mPp=0, \qquad (7)$$

where $\mu>0$ is the dimensionless ratio.

The solution of equation (6) is in the form of the product of two functions $H(y)$, $G(t)$:

$$p(t,y)=H(y)\cdot G(t). \qquad (8)$$

They have the form

$$G=G_0\cdot e^{-\lambda t},\ \lambda>0.$$
$$H=C_1e^{k_1y}+C_2e^{k_2y}$$

Where

$$k_1=\frac{-m-\sqrt{m^2-2\lambda\sigma^2}}{\sigma^2}$$
$$k_2=\frac{-m+\sqrt{m^2-2\lambda\sigma^2}}{\sigma^2}$$

So C_1, C_2 as two arbitrary constants, are to be determined, and the General solution is obtained by the substitution in (8) the obtained expressions for $H(y)$ and $G(t)$, then there is no need to introduce a third of the constant G_0. You can put $G_0=1$.

Therefore, the General solution of the equation (6) not taking into account the boundary conditions, we obtain the form of:

$$p(t,y)=\left(C_1e^{k_1y}+C_2e^{k_2y}\right)e^{-\lambda t}. \qquad (9)$$

Two of undefined constant C_1 and C_2 is found from the following considerations. In addition to the boundary condition (7), which will give one equation, it is necessary to use the initial condition $t=0$, the sum of all concentrations, that is, the integral $\int_0^\infty p(0,y)dy$ is equal to the derivative of the density of defects $\gamma(x)$. Proceeding from this,

$$C_1=\frac{\lambda\gamma}{\mu mP\sqrt{m^2-2\lambda\sigma^2}}\left[(1-P)\frac{m+\sqrt{m^2-2\lambda\sigma^2}}{2}-\mu mP\right],$$
$$C_2=-\frac{\lambda\gamma}{\mu mP\sqrt{m^2-2\lambda\sigma^2}}\left[(1-P)\frac{m-\sqrt{m^2-2\lambda\sigma^2}}{2}-\mu mP\right]$$

The equation of the Kolmogorov-Fokker-Planck allows you to determine the density of the distribution $f(t)$ of the time of the first achievements of the defining parameter of the defect a set limit. It has the look of

$$f(t)=\int_0^a\frac{\partial p}{\partial t}dy. \qquad (10)$$

With regard to (9) it will take the form of:

$$f(t)=\int_0^a\frac{\partial\left(C_1e^{k_1y}+C_2e^{k_2y}\right)e^{-\lambda t}}{\partial t}dy,$$

where:

$$k_1=\frac{-m-\sqrt{m^2-2\lambda\sigma^2}}{\sigma^2},$$

$$k_2=\frac{-m+\sqrt{m^2-2\lambda\sigma^2}}{\sigma^2},$$

$$C_1=\frac{\lambda\gamma}{\mu mP\sqrt{m^2-2\lambda\sigma^2}}\left[(1-P)\frac{m+\sqrt{m^2-2\lambda\sigma^2}}{2}-\mu mP\right]$$
$$C_2=-\frac{\lambda\gamma}{\mu mP\sqrt{m^2-2\lambda\sigma^2}}\left[(1-P)\frac{m-\sqrt{m^2-2\lambda\sigma^2}}{2}-\mu mP\right].$$

Продифференцировав the integrand the variable t, we obtain

$$\frac{\partial p(t,y)}{\partial t}=\frac{\partial\left(C_1e^{k_1y}+C_2e^{k_2y}\right)e^{-\lambda t}}{\partial t}=-\lambda\left(C_1e^{k_1y}+C_2e^{k_2y}\right)e^{-\lambda t}.$$

Than we obtain

$$f(t)=-\lambda\int_0^a\left(C_1e^{k_1y}+C_2e^{k_2y}\right)e^{-\lambda t}dy.$$

Thus, we finally obtain the

$$f(t)=-\lambda e^{-\lambda t}\int_0^a\left(C_1e^{k_1y}+C_2e^{k_2y}\right)dy=-\lambda e^{-\lambda t}\left(k_1C_1e^{k_1y}+k_2C_2e^{k_2y}\right)\Big|_0^a=$$
$$=-\lambda e^{-\lambda t}\left(\frac{C_1}{k_1}e^{ak_1}+\frac{C_2}{k_2}e^{ak_2}\right)+\lambda e^{-\lambda t}\left(\frac{C_1}{k_1}+\frac{C_2}{k_2}\right)=$$

$$= -\lambda e^{-\lambda t}\left(\frac{C_1}{k_1}e^{ak_1} + \frac{C_2}{k_2}e^{ak_2} - \frac{C_1}{k_1} - \frac{C_2}{k_2}\right) =$$

$$= -\lambda e^{-\lambda t}\left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right) =$$

$$= -\lambda\left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t} = f(t,a), \quad (11)$$

Having found it $f(t,a)$, you can find the distribution functions of the time of the first achievements of the defining parameter of the defect a set limit. It is enough to integrate (12) :

$$\int_0^t f(t,a)dt = \int_0^t\left(-\lambda\left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t}\right)dt =$$

$$= -\lambda\left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)\int_0^t e^{-\lambda t}dt =$$

$$= \left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t}\Big|_0^t = \left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t} = F(t,a)$$

Knowing $F(t,a)$, you can define the intensity of wear of the system as:

$$r = \frac{F'}{1-F} = r(t), \quad (12)$$

or, substituting F' and F :

$$r = \frac{-\lambda\left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t}}{1 - \left(\frac{C_1}{k_1}\left(e^{ak_1} - 1\right) + \frac{C_2}{k_2}\left(e^{ak_2} - 1\right)\right)e^{-\lambda t}},$$

where:

$$k_1 = \frac{-m - \sqrt{m^2 - 2\lambda\sigma^2}}{\sigma^2},$$

$$k_2 = \frac{-m + \sqrt{m^2 - 2\lambda\sigma^2}}{\sigma^2},$$

$$C_1 = \frac{\lambda\gamma}{\mu m P\sqrt{m^2 - 2\lambda\sigma^2}}\left[(1-P)\frac{m + \sqrt{m^2 - 2\lambda\sigma^2}}{2} - \mu m P\right]$$

$$C_2 = -\frac{\lambda\gamma}{\mu m P\sqrt{m^2 - 2\lambda\sigma^2}}\left[(1-P)\frac{m - \sqrt{m^2 - 2\lambda\sigma^2}}{2} - \mu m P\right]$$

CONCLUSIONS

Thus, analytically found the General solution of the equations of Kolmogorov-Fokker-Planck, as well as the distribution function of the time the first achievements of the defining parameter of the defect a set limit, which allowed to determine the function of the intensity of wear and tear $r(t)$.

The obtained dependences can be used for forecasting the processes of defect formation and choice of optimal design parameters tribosystems that will allow for a much more efficient use of complex technical systems. In practice, of interest is the determination of the time of trouble-free operation of the system. The reduction of formation of defects in the scheme of random walks allows you to easily implement the numerical solution of differential equations at any given boundary conditions. The possible implementation of the appropriate mathematical model on the computer.

REFERENCE

1. **Ayzinbud S.Y., 1990.:** Operation of locomotives. Transport. M., 261 p.
2. **Baldin K.V., 2004.:** Management Decisions: Theory and technology adoption. Design. M., 304 p.
3. **Barenblatt G.I., 2003.:** Nonlocal model of damage accumulation. Phys. Mesomech. 4, 6, 85-92.
4. **Barzilovich E.Yu., Kashtanov V.A., 1971.:** Some mathematical problems of the theory of service of complex systems. Sovetskoye radio. M., 180 p.
5. **Bortsova A.T., 1983.:** Electrorolling composition. Operation. Reliability. Repair. Transport. M., 350 p.
6. **Dodonov A.G,. 1988.:** Computing systems to solve problems quickly and organizational management. Naukova Dumka. Kiev, 213 p.
7. **Gadasin V.A., Ushakov I.A., 1975.:** Reliability of complex information-control system. Sovetskoye radio. M., 345 p.
8. **Gnedenko B.V., 1978.:** Mathematics and check of the production quality. Znanie. M., 265 p.
9. **Gnedenko B.V., Belyaev Yu.K., Soloview A.D., 1965.:** Mathematical methods in the theory of reliability. Nauka. M., 478 p.
10. **Golubenko A., 2008.:** Features of diagrams of phases and anomaly of structures of dynamic systems during degradation of their properties. TEKA. Commission of motorization and power industry in agriculture. Vol. VIII., 77-81.
11. **Ivanova V.S., 1979.:** Failure of metals. Metallurgy. M., 168 p.
12. **Khaitun S.D., 1996.:** Mechanics and irreversibility. Janus. M., 263 p.
13. **Klyuyev V.V,. 2003.:** Nondestructive testing and diagnostics. Mashinostroenie. M., 656 p.
14. **Koks D.R., Smith V.Z.,1967.:** The theory of restoration. Sovetskoye radio. M., 637 p.
15. **Marchenko D., Vetrov A., 2003.:** The increasing of wheejsets longevity Railway wheelsets. Silesian University of Technology. 59, 61-70.
16. **Nagovitsyn V.S., 2004.:** Diagnostic systems of rolling stock on the basis of information. VINITI. Moscow, 248 p.

17. **Ostreikovskaya V.A., 2005.:** Reliability Theory. High School. M., 463 p.
18. **Pakhomov E.A., 1974.:** Methods of diagnosis in the operation of locomotives. Transport. M., 40 p.
19. **Pakhomov E.A., 1985.:** Monitoring and evaluation of the technical condition of locomotives. Transport. M., 254 p.
20. **Panin V.E., 1985.:** Structural levels of deformation of solids. Nauka. M., 226 p.
21. **Reshetov D.N., 1988.:** Reliability of machines. High School. M., 235 p.
22. **Terentyev V.F., 2003.:** Fatigue of metallic materials. Nauka. M., 354 p.
23. **Thursdays V.A., 2003.:** Reliability of locomotives. Moscow route, 415 p.

ИССЛЕДОВАНИЕ КИНЕТИКИ РАЗВИТИЯ ПОВРЕЖДАЕМОСТИ

Дмитрий Марченко

Аннотация. Представлено аналитическое решение уравнения Колмогорова-Фоккера-Планка, а также анализ динамики развития трещин на основе модели диффузии дефектов.

Ключевые слова: случайный процесс, диффузия дефектов, интенсивность износа.

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Strategic controlling of innovation activities of enterprises in the changing technological structure of economy

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Summary. The article deals with the theoretical and methodical statements as regards organization of strategic controlling of innovation activities of enterprises as well as with controlling expediency in the management of the enterprises, with prerequisites in forming the concept of controlling in the company innovation activity management.
Key words. Innovation activity, structure, management, controlling.

INTRODUCTION

Modern trends in management of enterprises are related to weak predictability of changes in the aggressive environment and to continuous development of innovations in all spheres of society. Focus on innovative type of development becomes one of the main conditions of sustainable operation and maintenance of the necessary level of competitiveness of individual enterprises, industries and region as a whole. To achieve this goal, knowledge of the flow of separate innovation processes is required.

Relevance of research of theories, methodologies and concepts of strategic controlling of innovation activities is growing in the course of forming information economy which changes the nature of accounting processes. Dominance of horizontal management, separation of information flows from physical flows, fragmentation of the value chain and multilevel processing and the use of information is characteristic for it. Systematic, comprehensive approach to the management of innovation activity of the enterprise arises out from the need to create and analyze certain information base of innovation processes and environment, to use the appropriate paradigm of innovation management and to create on this basis the system of strategic controlling of innovation activity of industrial enterprises adequate to modern requirements. It is necessary to develop the concept of strategic controlling of innovation activity of industrial enterprises. The need for the formation of approaches to strategic controlling of innovation activity of industrial enterprises leads to relevance of publication.

OBJECTS AND PROBLEMS

The basis of success in today's business is the development, implementation and commercialization of innovations, their forecasting, organization and management of strategic financial accounting, control, audit and analysis of innovation processes effectiveness to ensure the growth of the national product and the increase of competitiveness of domestic enterprises. In modern conditions strategic management requires modifying the existing organization and methodology of financial and strategic accounting, analysis, control and audit of innovation. Strategic management provides decision-making for a long term. Strategic controlling of innovation activity is paramount because the enterprise strategy is primarily associated with innovative solutions. Traditional accounting records the facts and phenomena of economic activity that occurred in previous periods, moreover, standards and accounting rules do not allow to take into account the processes of discounted cash flows and to use different kinds of

prices, etc. Consequently, using traditional accounting, it is impossible to give the accurate forecast of events that can occur in the future.

ANALYSIS OF PUBLICATIONS IN RELATION TO RESEARCH OBJECT

A lot of different questions about creating of marketing [Maksimova, Shapran 2010., Zhdanova 2010], crisis management [Nadyon, Dyachenko 2010, Ramazanov 2010], national [Tretyak, Kurilov 2010, Voronkova 2010], dynamic [Voronkov 2010], intellectual [Voronkova 2010] and financial [Zhytnyy 2010] conditions for enterprises functioning and development have been considered lately in scientific publications. The research of development problems of microeconomics and regional production systems on the basis of the innovative determinants activization found its reflection in the works of many Ukrainian scientists [O.I. Amosh, V.P. Babych, V.M. Geets, S.M. Illyashenko, L.I. Fedulov, O.V. Knyaz]. But the information and organizational-economic aspects of innovative development support problem have been left unsolved. The development management must be aimed on the dynamic aggregate of interdependent administrative processes directed above all things at the search of the internal and external reserves of economical growing and development. As known from the classics of the economic cycle theories, one of the basic principles that provides microsystem development, is providing of possibility of transition from the stage of higher level of development within the framework of one period of cycle (maturity phase) to the phase of establishment with high-quality new parameters of the next level, passing the phase of recession and crisis. Providing of effective management of enterprise development must be accompanied by the permanent strategic diagnostics of activity that allows us to define possibilities of enterprise in external surroundings. Exactly on the basis of strategic diagnostics an enterprise can elaborate or correct the external activity strategy that will determine its development. For enterprise development it is necessary to create terms for adoption of innovative, organizational, economic measures that allow us to pass the phase of the next level becoming.

Recently many different issues related to creation of marketing, anti-crisis, national, dynamic, intellectual and financial conditions for the operation and development of enterprises have been considered in the latest publications. The problem of development of microeconomic and regional production systems based on activation of innovative factors have been reflected in the works of local scientists such as O.I. Amosha, V.P. Babych, V.M. Geyets, S.M. Illyashenko, L.I. Fedulova, O.V. Knyaz. Scientific works give variety of views, approaches, methods and concepts of financial management, financial control issues in the enterprise. This is also much discussed in many papers and chapters in the audit of financial and economical activity of enterprises. But today sufficient attention is not paid to the issue of organization of controlling of innovation activity in enterprises. In the studies mentioned above the nature, functions, tasks, stages of development, instrumental and information aspects of controlling, as well as functions and tasks of controllers that are functions of controlling service have been considered in details. However, the methodological and conceptual foundations of modern Controlling is not widely represented in the national literature. It is represented one-sided in our opinion.

RESULTS OF RESEARCH

Formation of the controlling concept in the enterprise innovation activity management takes place in terms of transition of Ukrainian economy to the new technological structure. The technological structure of the economy consists of technological sets that have got different functions and levels of processing resources. "Groups of technological sets related to each other with single-type technological chains which reproduce integrity" are called "technological structures" [Glazyev, 1993]. Technological structure is characterized by a single technical level of its production components coupled with vertical and horizontal flows of single-type resources based on the total resources of skilled labor, on the overall scientific and technical potential etc. The core of the technological structure forms a complex of basis sets of technologically interrelated industries. Components of technological structure are technological chains which cover technological sets of all processing resources levels, and close on the appropriate type of nonproductive consumption. This type, closing reproductive contour of technological structure, serves at the same time as a major source of its expansion that ensure recreation of labor resources as appropriate. Technological structure is developed within the

frames of the technological system that covers all the processing resources stages and the appropriate type of nonproductive consumption; all this forms macroeconomic reproduction system. That is to say that each technological structure is a self-replicating integrity. As a result the technical development of the economy can not develop otherwise than by succession of technological structure changes. The life cycle of each technological structure forms the content of the corresponding stage of technical and economic development.

Each technological structure is consistent with its dominant industry (in which great number of components, the core of the structure of totality of technologically related industries are concentrated). Their dynamics determines the development of appropriate technological structure. The field of "chemical and petrochemical industry" is the fourth technological structure. Although a significant part of the "core" of this structure remains outside these industries, through the synchronous development of the components the technological structure of productions, the activities of development of the chemical and petrochemical industry allow us to get a rough idea of the dynamic of resources reallocation in favor of the fourth technological structure. Currently, despite the relative immaturity of the fourth technological structure, the outflow of resources from its reproduction circuit begins. This might happen because of the problems of material and technical supply resulting from the increase of economic expenditures because of the technological mixed economy and formation of the fifth technological structure. At the same time production of the fifth technological structure constitutes a small part in the technological structure of the economy. But as the further development of the fifth structure occurs, each percentage of its increase will be achieved only through more intensive redistribution of resources taken from the fourth and the third technological structures. Consequently, modern businesses operate in the environment that changes dynamically. The external environment becomes a constant source of new opportunities and risks that create complex situation. Business needs to find new theories that define the principles of management.

Enterprise innovative development is based on the set of interconnected elements, which facilitate the generation of new knowledge, manage their streams, distribute them. The efficiency of enterprise innovative activity is determined by cooperation of basic acting persons of innovative process as element of the collective system of knowledge creation and use. The substantiation of direction of enterprise innovative development consists in elaboration and use of optimum economic criteria and choosing on their basis from the great number of alternative decisions. In that time, enterprise innovative development is the organizational, administrative and strategic question not only economic. As the factors of innovations management have a different nature (social, economic, technical, organizational, strategic), it is necessary to define the proper mechanisms of innovative development that is the forming basis of the complex mechanism of innovative development management. The specialized action mechanisms on the concrete constituents of productive forces and production relations must be a part of the complex mechanism of enterprise innovative development management.

The economic mechanism of innovative development includes the following elements: preparation and substantiation of plans of assortment and volume of output taking into account the existing limitations on material, financial, labour resources, sales volume, location of enterprise capacities, that provide production development; elaboration of enterprise development plans and substantiation of economic efficiency of innovative and investment projects of enterprise reconstruction, equipment modernizations and products renewal, distribution of profit to the funds of accumulation and consumption; choosing the most advantageous level of specialization and cooperation; systematic economic analysis of enterprise, forming of indices, that characterize enterprise activity, and determination of their quantitative size. The economic mechanism of enterprise operates under market influence at the expense of the competitive forming of price and demand for products of enterprise. Duration of productive forces reproductive cycle depends on speed of innovations distribution, also determined competition and situation at the markets of financial resources.

Enterprise management system must improve when technological structure of the economy changes. Today management problems in Ukraine are associated with marketing, organization of supply, scientific organization of production and labor. The modern economy management requires a mechanism that would help to modernize the organizational and information structure of the company. Definition of appropriate

stable activities not only nowadays but also in the future becomes urgent for enterprises. Constant monitoring of financial ratio and its analysis is a mandatory requirement while performing the management process in the company.

To implement basic management functions (planning, accounting, monitoring, analysis) the search of more effective ways is required, as methods, tools, prevailing classical management concepts do not give answers to all the questions concerning industrial enterprise management according to the nowadays requirements. The enterprise management system requires the mechanism that is able to evaluate management techniques that are in use, their relevance to the changing economic environment of the enterprise. Formation of information and analytical support of management decision making processes should be put into specially created units. Referring to the above mentioned researches the scientific term called "controlling" was made.

Taking into consideration terminology, "controlling" should be defined as a system of the enterprise economic management based on the achievement of the ultimate goal and planned performance. The basis of the given concept of the managed company system is the desire to ensure the effective functioning in the long term. In domestic conditions controlling increasingly acts as a system that ensures effective functioning of the enterprise aimed at profit optimization and harmonious relationship support with the environment.

Strategic controlling of innovation activity of industrial enterprises is considered as a set of tools aimed at reorientation of the management system from traditional to innovation approaches as well as creation of the information system of management decision support related to the planning and control of innovation activity on the basis of control data.

The enterprise management process is impossible without clear organization which forms the basis of management activity. Usually neither plans nor programs work without it. The totality of controlling functions has been specified by us by adding innovative function to its main functions; it consists in informational, organizational and economic maintenance of innovation activities using planned, regulatory, actual data; the data on the change of impact of innovative factors with the help of systems of planning, regulation, accounting and control.

The result of the made adjustments was implementation of specific developments and improvements in the activities of industrial enterprises in Lugansk region. The following was improved:

organizational and economic interrelationship of strategic and operational controlling of innovation activity of the industrial enterprises by means of identifying the main characteristics; summarization of theoretical and methodological bases, organization of functioning, creation of graphics structural model, formation of the effective interconnection model and the main ways of the increase of effectiveness of interconnection of strategic and operative controlling of innovation activity of industrial enterprises;

the method of graphic interpretation of the results of controlling of innovation activity of industrial enterprises by means of detection a mechanism of change of effectiveness of the industrial enterprises functioning in strategic perspective as a result of controlling and discovering the gap between the desired and expected performance;

the sequence of development and implementation of the balance sheets strategic derivatives in controlling innovation activity of industrial enterprises by means of implementation of the phase of correction, transformation, strategic phase and the phase of hypothetical asset sales and meeting requirements that ensures improvement of analytical support of strategic innovation management;

the method of scenarios in strategic controlling of innovation activity of industrial enterprises which allowed to define the stages of making scenario of innovation activity of industrial enterprises and build the scenario of the enterprise innovation activity, the use of which has improved the process of innovation development forecasting.

CONCLUSIONS

The research results have been received; offered approaches, methods and models allow to use them in practice in industrial enterprises management to improve the results of their innovation activities.

REFERENCES

1. **Bezchasmyj L.K, 2000.:** Innovative element of economic development: [monograph] / [editor-in-chief L.K. Bezchasnyj]. - Kiev, 2000. - 262 p.

2. **Buz'ko I, Yefremov O., 2010.:** Pre-conditions of forming of information-innovative development paradigm of Ukrainian industrial enterprises / TEKA. KOM. MOT. I ENERG. ROIN. – OL PAN, 2010. V XB. – P. 214–219.
3. **Demsenko M.P, 2008.:** Investment and innovation activity: theory, practice and experience [monograph] / [edited by M.P. Demsenko, L.I. Mikhayjlovoy]. - Sumi: Umversitetsjka kmga, 2008. - 1050 p.
4. **Gerasymchuk V.G., 2000.:** Strategic management of enterprise: graphic modeling. – K.: KNEU. – 457 p.
5. **Glaziev S., 1993.:** Theory of long-term technical and economical development. - M.: VlaDar, 1993. - 310 p.
6. **Grynov V.M., Kozyreva O.V., 2006.:** Socio-economic problems of enterprises innovative development. – KH.:INZEK. – 192 p.
7. **Illyashenko S.M, 2003.:** Innovation development management: problems, concepts, methods. - Sumi: VTD Universitetsjka kniga, 2003. - 278 p.
8. **Illyashenko S.M., 2005.:** innovation development management. - Sumi: Umversitetsjkakniga, 2005. - 324 p.
9. **Ivanov Y.B, Pihpenko A.A, 2006.:** Concept and ontology of the object domain of management of integrated company development / / Ekonomika promislovosti. - 2006. - № 1. - P. 162-171.
10. **Maksimova T., Shapran E., 2010.:** Approach to diagnostics of marketing complex of industrial enterprise / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 5-11
11. **Nadyon G, Dyachenko Y., 2010.:** Anticrisis management of industrial enterprises staff / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 56-59.
12. **Ramazanov S., 2010.:** Innovative technologies of anticrisis management for production-transport complex / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 120-124.
13. **Stadmk V., Rudmchenko K.M, Tomalya T.S, Nepogodma N.I, 2008.:** Innovation and investment strategies in the management of the market value of the enterprise: [monograph] / [V.V Stadmk, K.M. Rudmchenko, T.S. Tomalya, N.I. Nepogodma]. - Khmeljmcjkiyj: KhNU, 2008. - 302 p
14. **Tretyak V., Kurilov M., 2010.:** National innovation system as the basis of innovation-type economy / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 5-11.
15. **Volkov O.I, Demsenko M.P, Grechan A.P, 2006.:** Innovative development of industry in Ukraine. - K.: KNT, 2006. - 648 p.
16. **Voronkov D, Korolevska N., 2010.:** Model of potential changes in the enterprise / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 253-259.
17. **Voronkova A. E., 2000.:** Strategic management of enterprise competitive potential: diagnostics and organization. Monograph. – Lugansk: East-Ukrainian National University. – 315 p.
18. **Voronkova A., Sushchenko O., Chasovskyi S., 2010.:** International competitiveness of the region as the background of forming geoeconomic directions of foreign economic activity of its industrial enterprises / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 304-309.
19. **Voronkova A., Grynov A., 2010.:** Model of human capital company / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 310-315.
20. **Zhdanova O., 2010.:** Features of industrial enterprises market positioning on the basis of marketing policy / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 345-350.
21. **Zhytnyy P., Kulikova O., 2010.:** Problems and prospects of the development banking system on Ukraine in the conditions of globalization / TEKA KOM. MOT. I ENERG. ROIN. – OL PAN, 2010, 10 B, V XB. – LUBLIN, 2010. – P. 351-356.

СТРАТЕГИЧЕСКИЙ КОНТРОЛЛИНГ ИННОВАЦИОННОЙ ДЕЯТЕЛЬНОСТИ ПРЕДПРИЯТИЙ В УСЛОВИЯХ ИЗМЕНЕНИЯ ТЕХНОЛОГИЧЕСКОГО УКЛАДА ЭКОНОМИКИ

Виталий Максимов, Светлана Фирсова, Ирина Литвинова

Аннотация. В статье обоснованы теоретические и методические положения относительно организации стратегического контроллинга инновационной деятельности предприятий, обоснована целесообразность контроллинга в управлении деятельностью предприятия, определены предпосылки формирования концепции контроллинга в управлении инновационной деятельностью предприятия.

Ключевые слова. Инновация, деятельность, уклад, управление, контроллинг.

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Research of trajectory design error of coil piling of geodesic winding

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S u m m a r y . In the article research of a geodesic trajectory design error of reinforcing material piling is considered. For the estimation of error the comparison of analytical data of different trajectories on the cylinder and cone surfaces with the data got in a mathematical model for the corresponding surfaces.is made. The analysis of reasons and character of error is done, the criterion of breaking up is offered.
K e y w o r d s : geodesic winding, research of error, Ansys, setting trajectory.

INTRODUCTION

In many industries technological process of winding perfectly proved as an effective method of a morphogenesis of the shell constructions made with compositional materials (CM). Winding of the CM reinforced by fibers, allows to make not only large products practically any sizes, but also to implement the maximum indexes of physicomechanical properties of polymeric aggregates. Industrial manufacturing of products by winding is also characterized by good productivity, high automatisation and low waste.

The first operations on process modeling of winding and development of systems of controlling programs (CP) automated preparation began with modeling of a mandrel surface on an internal theoretical circuit of the product, one round on a mandrel surface, being the geodesic line, i.e., the line of the equal deviation. These issues where studied in the works of A. F. Parnyakov [1-3], M. V. Orlov [4, 5], A. K. Dobrovolsky, V. I. Kostrov [6], G. B. Evgenev, V. M. Morozov, A. N. Petukhov, J. M. Pidgayny, V. A. Dudko, D. Struve [7-8], Y. Isakov [9], Y. Y. Chikildin, V. E. Shukshunov, J. M. Alpatov [10], V. I. Zborzhevskiy [11], V. A. Grechishkin [12].

The works dealt mainly with shell-shaped body of revolution. Despite the fact that such shells are fairly common in industry, they do not exhaust the whole variety of shell elements of modern constructions.

Trajectory modeling of reinforcement material (RM) spiral winding is one of the main objectives of the preparation manufacturing of products made by winding the RM [13]. Issues of forming surface models and setting the curves for them are considered in the work of the following authors: I. Kotov [13,14], H. H. Ryzhov [15,16], Aushev [17] and others. Currently, there are software packages that allow to calculate the trajectory of the winding of complex shape products: Composite Software from the world leader MC Laren Anderson, CADWIND from company MATERIAL [18,19], as well as the software systems allowing to model the strength properties of composite products, for example Ansys Composite Prepost from company Ansys [20, 22-23]. However, the problem of modelling and research of the winding process during technical preparation of manufacturing products made of CM is relevant because of the lack of the complex approach which allows to combine the tasks of building separate RM winding turns, products' thickness design and their strength determination.

Geodesic winding - one of the most efficient and technologically advanced ways to create simple simulated products of CM by the method of winding. Geodesic winding suggest laying RM

path without friction, i.e., the wind is in the position of equilibrium on the entire trajectory. One method of representation of complex bodies surfaces is the method of partitioning into finite elements (FE), which is widely used in CAD/CAM/CAE systems. In the work [Mogilniy G.A. 2012] a mathematical RM laying model on the surface of the complex bodies divided into triangular finite elements with software implementation in the package Ansys was developed. An important component of wind laying trajectory modeling is to obtain the results of calculation with the accuracy which is sufficient to implement the process of winding. The purpose of this work is to investigate the error of the mathematical model of the RM wind on the surface of the complex bodies divided into triangular finite elements.

RESEARCH OBJECT

The research of the error is suggested to be held on the example of a cylindrical body and a conical body by comparing the output of the models exit data implemented in APDL (system Ansys) with analytical calculations for the selected bodies.

To set the parameters in the model [Mogilniy G.A. 2012], the following assumptions are suggested: the mandrel is divided into the triangular FE, RM is inextensible and has infinitely small width. Any smooth body is a polyhedron. Base point for the calculation is the point belonging to wind placement in which it is convenient to specify the angle of reinforcement. The basic point is one of the key points of some arbitrary finite element, which belongs to wound surfaces.

It is known that for determining the angle of reinforcement RM wind laying on the cylinder surface the theoretical identity is true:

$$\lambda = const . \quad (1)$$

For conical bodies in any basic point it can be written as:

$$R \sin \lambda = const , \quad (2)$$

where: R – radius of the cone by a plane perpendicular to the axis of rotation at some point;

λ – the angle of reinforcement.

We assume that the angle of deviation from the theoretical reinforcement at a given point is an error of mathematical model of wind laying δ for that body.

An important stage of the study is to determine the accuracy of modelling conditions affecting its value. Therefore, besides "the fineness of the partition" (parameter of Ansys) bodies in the FE, it is necessary to study the influence of the number of partition elements, to explore the possibility of error accumulation in the modeling process of winding RM on the surface of the wound body.

Firstly, let us consider the cause of accumulated error δ.

It is known that on a cylinder the angle of reinforcement (i.e. the angle between the projection of the rotation axis and the direction which is calculated in the tangent plane) has a constant value.

However, even for a cylindrical surface for random arbitrary partitions there will be normal fluctuations in the FE, and, therefore, there will be projection axis swing. Consequently, the rotation axis projections on the FE plane will not be parallel. This will cause the oscillation of the reinforcement angle and the error of the mathematical model. Similar effects will be observed on all the surfaces of complex shape.

Secondly. There is a difference of areas of the polyhedron and the real surface, therefore, the difference of the lengths of the geodesic curve, and the broken line built on the corresponding surfaces. For example, let us consider a circular cross-section (fig. 1).

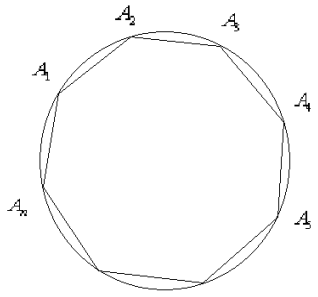

Fig.1. Section of the RM wind trajectory
$\{A_1, A_2, ..., A_n\}$ – Nodal points of finite elements.

We suggest the same distance between FE nodal points. Then, the ratio of the geodesic curve to the broken line will be as follows:

$$\frac{P}{C} = \frac{n \sin(\frac{180^\circ}{n})}{\pi} , \quad (3)$$

here: C - the length of a geodesic curve
P - the length of a broken line
n - the number of broken links.

The modeling process of winding includes several stages. Phase trajectory modeling is the first. Therefore, at this stage, the error should be less than 0.5%. At 36 polyhedron, the dihedral angle between the normals of two adjacent FE is 10 degrees and the length error should be less than 0.2%, which satisfies the accuracy of modelling stage.

Thirdly, we examine the nature of the error δ.

Let us consider two pairs of adjacent finite elements {(ABC); (ADB)} and {(ABC); (ACE)}, through which the wind is going (fig. 2). Element (ADB) is rotated clockwise relating the (ABC), therefore, it introduces an error with the "+" and the element (ACE) is rotated counter-clockwise relating to the (ABC), therefore, if introduces an error with the sign "-".

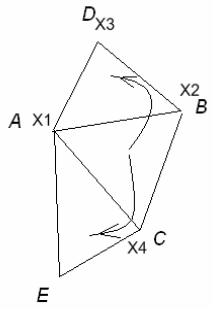

Fig. 2. Adjacent finite elements

Since the wind has a cyclic trajectory, we can assume that the wind laying error δ passing i-th element has equally probable, both the rising and descending characters. Probability of changing the angle is determined by the direction of reinforcement wind and design of finite-element partitioning. Hence, during the change of the mathematical model error δ has alternating character in case of winding the surface of complex bodies.

RESULTS OF RESEARCH

To test this model (in the Ansys) numerical experiment was performed. Cylinders with diameters of 10, 20 cm and a length of 36 cm and 180 cm were selected as the wound surfaces. The starting points are arbitrary points on the left edge of the cylinder, the end points are the points at the right edge of the cylinder. Figure 3 shows the example of one of the wind's modelling.

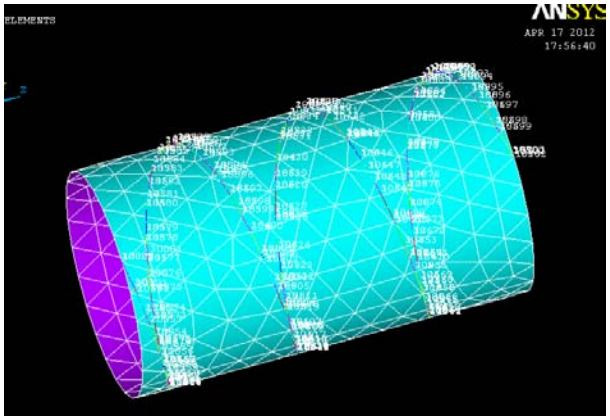

Fig. 3. RM wind laying modeling on the cylinder in Ansys

Each wind is modelled with reinforcement angles at the starting point of 30, 45, 70, 85 degrees. Large initial reinforcement angles experimentally demonstrated the greatest error of the mathematical model of wind laying δ.

For each cylinder different models of FE partitioning provided by the package Ansys were chosen. Among the main characteristics of the partition we can identify "fineness of the partition" and "partition type." Experiment was conducted on the "fineness of the partition" in the range from 0.6 cm to 0.05 cm, and various types of partitions: Smart-sized, Mapped, Sized. The lower boundary of fineness partitioning is caused by its unreasonable calculating resource taking. At each point of the wind the program stores the data on the value of the angle of reinforcement, which are compared with the theoretical ones.

Based on the data the graphs of the error of the mathematical model of the δ fineness partitioning are obtained. For example, for the fineness of the partition of the cylinder 0.3 cm long and 36cm radius of 10 cm, the starting point of 24 will get the chart in figure 4.

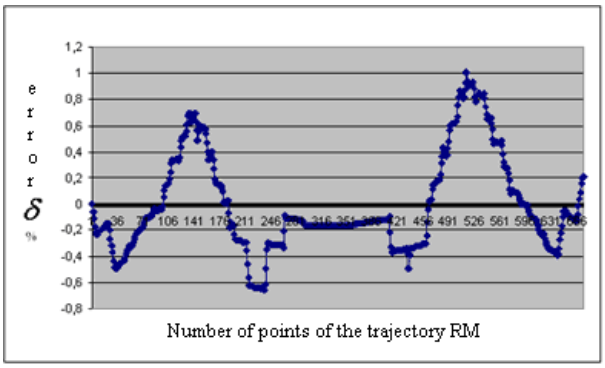

Fig. 4. Graph of error size dependence on the point RM wind trajectory on the cylinder (for δ error percentage of the reinforcement angle is taken).

The main parameter that affects the accuracy of the mathematical model is the angle between the normal's of adjacent finite elements. Therefore, for different products and partitioning models the average angles between the normals of neighboring finite elements are obtained and the values of the standard deviations of angles relating to their average values.

On the basis of all the results we get the graph of the mathematical model error of the average angle between the FE normals - figure 5.

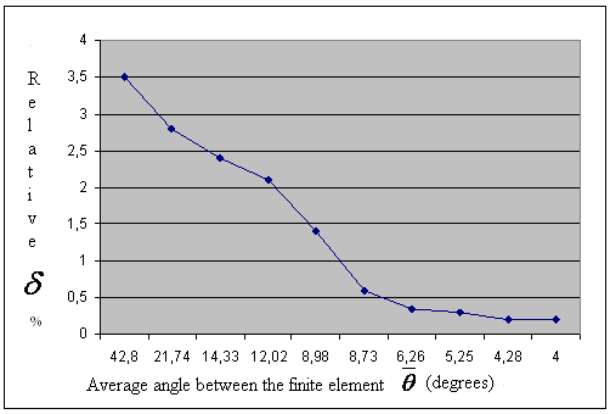

Fig. 5. Error as a function of the average angle of the finite element partitioning of the cylinder (for δ it is accepted percentage error of the angle of reinforcement).

Figure 5 shows that in order to achieve a relative error of the mathematical model of no more than 0.25% it is necessary to split cylindrical body with an average angle between the normals to FE of no more than 4 degrees. As experimental conical bodies, turned one to one cones with an apex angle of 32 degrees, a height of 35 cm and a cone with an apex angle of 67 degrees, a height of 35 cm were chosen (figure 6).

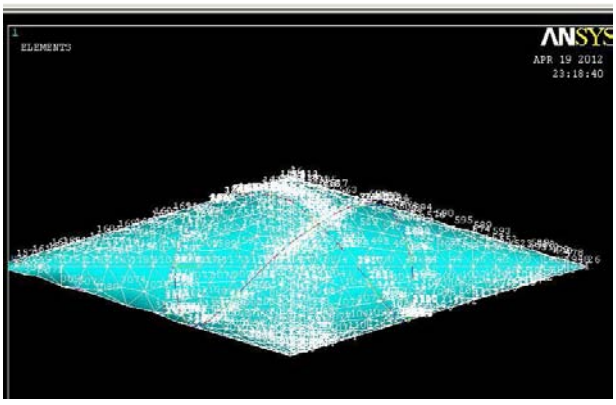

Fig. 6. Modeling of RM wind laying on the cone in Ansys

Similarly, for these conical bodies different starting points with the angle of 90 degrees of reinforcement are chosen. As a result we get the graphs of mathematical model's error δ. For example, for the "fineness partitions" 0.03 cm to 35 cm and the height of the cone apex angle of 32 degrees, the starting point of 14 will receive the chart in Figure 6. Also, for different products and models of decomposition average angle between the normals of neighboring FE and the values of the standard deviation are obtained.

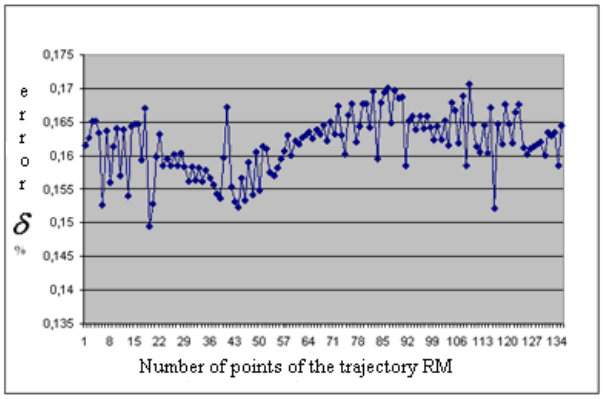

Fig. 7. Graph of dependence the error size on the wind track points of the cone (for δ it is accepted a percentage error of the angle of reinforcement).

On the basis of the received data we get the graph of dependence the mathematical model error of wind laying on the average angle between the normals of finite elements - figure 7.

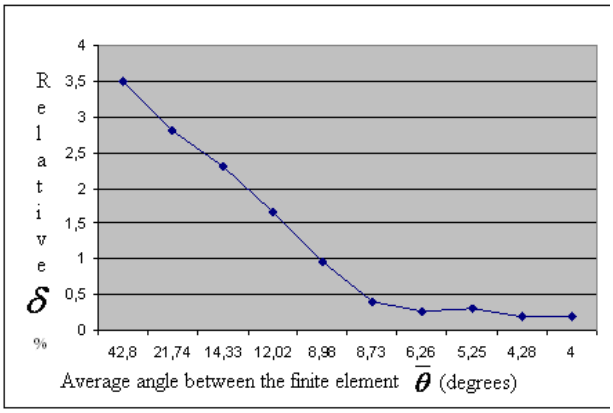

Fig. 8. Error as a function of the mean angle of the finite element partition of the cone (for δ it is accepted percentage error of the angle of reinforcement).

Figure 8 shows that, to achieve a relative error of the mathematical model of no more than 0.25% it is necessary to split conical body with an average angle between the normals of finite elements no more than 4 degrees, which corresponds to the data for the cylinder.

The data of figures 5 and 8, for the bodies of the conical and cylindrical shape are identical, they prove our theoretical assumptions and give numerical error meanings of the finite element model of the trajectory of laying RM. General view of the relationships suggests that the error of the finite element model does not depend on the shape of the simulated body. In addition, the nature of the dependences obtained suggests that a further decrease in the angle between the normals FE would increase processing power without significantly increasing the accuracy of the model.

CONCLUSIONS

Based on the experiment it is suggested regardless the form of the product for partitioning the criterion for FE (in the Ansys) on surfaces of any bodies - the angle between any two adjacent elements of the partition: $(\vec{N}_1 \hat{;} \vec{N}_2) \le 4^\circ$, where $\vec{N}_1, \vec{N}_2$ - normal corresponding elements.

Let two adjacent finite elements ABC and DBC be presented by the points A (x_1, y_1, z_1), B (x_2, y_2, z_2), C (x_3, y_3, z_3), D (x_4, y_4, z_4), then:

$$\arccos\left(\frac{\left|E_1E_2 + K_1K_2 + F_1F_2\right|}{\sqrt{E_1^2 + K_1^2 + F_1^2} * \sqrt{E_2^2 + K_2^2 + F_2^2}}\right) \le 4^\circ, \quad (8)$$

Where are $E_1, E_2, K_1, K_2, F_1, F_2$ calculated on formulas:

$$E_1 = (y_2 - y_1) * (z_3 - z_1) - (y_3 - y_1) * (z_2 - z_1)$$
$$K_1 = (x_3 - x_1) * (z_2 - z_1) - (x_2 - x_1) * (z_3 - z_1)$$
$$F_1 = (x_2 - x_1) * (y_3 - y_1) - (x_3 - x_1) * (y_2 - y_1)$$
$$E_2 = (y_2 - y_1) * (z_4 - z_1) - (y_4 - y_1) * (z_2 - z_1)$$
$$K_2 = (x_4 - x_1) * (z_2 - z_1) - (x_2 - x_1) * (z_4 - z_1)$$
$$F_2 = (x_2 - x_1) * (y_4 - y_1) - (x_4 - x_1) * (y_2 - y_1)$$

With this partitioning it is possible to simulate geodesic RM wind laying with accuracy sufficient for practical implementation of the winding process.

REFERENCES

1. **Parnyakov A.F. 1969.:** Geometric problems in manufacturing technology surfaces by coils // Cybernetics and applied graphics geometry of surfaces: SAT. Scientific. MP. Moscow: Moscow Aviation Institute. VYP.Z. p. 18-21.
2. **Parnyakov A.F. 1969.:** Building Dense Geodetic framework for coaxial compartments combined surfaces of revolution // cybernetics and applied graphics geometry of surfaces: sat. scientific. MP. Moscow: Moscow Aviation Institute Vyp.3.-p. 103-106.
3. **Parnyakov A.F. 1969.:** With constructing a dense geodetic frames: Author. diss. Candidate. Tech. Science. -M.
4. **Orlov M.V. 1970.:** Determination of the surface additional technological compartment serving for continuous winding along a geodesic // Proceedings of the MAI. Moscow, NO. 205. - p. 51-52.
5. **Orlov M.V. 1972.:** Some questions forming multilayer shells geodetic // Author. Diss. . Candidate. Tech. Science. Moscow, p.17
6. **Dobrovolsky A.K., Kostrov V.I. 1970.:** A note on the calculation of the characteristics of the geodesic winding fiberglass shells of revolution // Mechanics of Polymers. - № 6. - p. 934-936.
7. **Evgenov G.B., Morozova V.M., A. Petukhov, Struve D. 1971.:** Programming winding glass fiber membranes such as bodies of five-axis machine tool rotation on the cpu / / Production-tech. Experience. № 6.-p. 13-16.
8. **Morozov V., Evgeny G.B. 1973.:** The method of calculation programs of winding products with different axial holes // Production-Tech. Experience. № 11.p. 62-64.
9. **Pidgayny M. Morozov, V.A Dudko 1967.:** Method for calculating the characteristics of geodesic winding shells rotating bodies // Mechanics of polymers. - № 6. p. 1096-1104.
10. **Chikildin J.J, Alpatov Y.M, Shukshunov V.E. 1968.:** Algorithm for optimal placement during winding glass fiber products for products with controlled // Proceedings novocherkas. Polytech, inst. Ordzhonikidze. Novocherkassk. t. 182. p. 59-63.
11. **Zborzhevsky V.I, SvitycH A.I., V.M. Mazur, Bilenko L.D. 1977.:** On the calculation of the orbital parameters of winding rotating bodies of arbitrary shape on the curve is the deviation // Production-tech. Experience. № 1. p. 10-11
12. **Grechishkin V.A. 1967.:** Methods Of spiral wound and their advantages // Aviation Industry. - Appendix № 2, 3. p. 64-67.
13. **Kotov I.I. 1971.:** Applied Geometry and automated playback surfaces // Cybernetics And Applied Graphics Geometry Of Surfaces: Cb.Tr. - Moscow: Publishing house of the Moscow Aviation Institute, Vol. 8. p.3-5
14. **Kotov I.I. 1977.:** Algorithms for computer graphics / I. Kotov, V.S., Whip Snakes, L. Shirokov. – Mashinostroenie, p. 231.
15. **N.N. Ryzhov 1967.:** Frame set theory and design of surfaces // Proc. UDN. - V.26. Mathematics. - VYP.3.- P.128-138.
16. **Ryzhov N.N. 1971.:** The determinant of the surface and its application // Proc. UDN.-T.53. Applied Geometriya.-VYP.5., p.3-16.
17. **Ausheev T.V. 2006.:** Methods For three-dimensional modeling and control of manufacturing processes of parts made of composite materials means of winding: avtor.dis. Dr. Phys. Math. Science 05/01/01 [Buryat scientific] - Ulan-Ude.
18. Mcclear anderson composite designer [Electronic resource]. - Mode of access: http://www.mccleananderson.com/

19. Process simulation software for element winding technology [Electronic resource].- Mode of access: http://www.material.be/filement-winding-software.html
20. Ansys Composite Prepost [Electronic resource].- Access mode: http://ansys.soften.com.ua/the-decisions/103-ansys-composite-preppost.html
21. **Mogilniy G.A., Zhukov M.S. 2012.:** Trajectory modeling stacking spiral reinforcement by finite element method [Text] // News of Volodymyr Dahl East Ukrainian National University.
22. **Lehtsier L. 2010.:** An algorithm for reconstitution of geometrical 3D body's form that are represented in orthogonal projections. TEKA Commission of Motorization and Power Industry in Agriculture. V. XC, Poland, Lublin, Lublin university of Technology, p.171-177.
23. **Malesa W. 2011.:** Modelling tire-soil interaction with the fem application. TEKA Commission of Motorization and Power Industry in Agriculture. V. XI, Poland, Lublin, Lublin university of Technology, p.236-244.

ИССЛЕДОВАНИЕ ПОГРЕШНОСТИ МОДЕЛИРОВАНИЯ ТРАЕКТОРИИ УКЛАДКИ ВИТКА ГЕОДЕЗИЧЕСКОЙ НАМОТКИ

Геннадий Могильный, Владимир Донченко

Аннотация. В статье рассматривается исследование погрешности моделирования траектории намотки армирующего материала по геодезической траектории. Выполняется сравнение аналитических данных различных траекторий на поверхности цилиндра и конуса с данными полученными в математической модели для соответствующих поверхностей. Проводится анализ причин и характера погрешности, вырабатывается критерий точности.

Ключевые слова: геодезическая намотка, исследование погрешности, Ansys, траектория укладки.

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To the methodology of experimental research of the continuous-running fodder mixer

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S u m m a r y. A construction of an effective continuous-running fodder mixer is suggested. The research technique of the level of homogeneity of three-component feed mixture, obtained as a result of the work of continuous-running fodder mixer is improved.

K e y w o r d s. Technical process of mixing, a degree of homogeneit, technique of experimental investigation.

INTRODUCTION

At the present time a large variety of mixers of feed materials was worked out, the most effective of which are continuous-running mixers. A large variety of designs of continuous-running mixers points to the absence of not only a unified theory of their design, but also the general methodology of their experimental study.

ANALYSIS OF THE LATEST RESEARCH AND PUBLICATIONS.

The results of the study of the theoretical foundations of design and experimental investigation of continuous-running fodder mixers are set out in the works of S.V. Mielnikov, A. A. Lapshin, A.M. Grigoriev, R.L. Zienkov, P.K. Zhevlakov, G.M. Kukty, F.K. Novobrantsev, O.V. Tsurkan, V.I. Sementsov, V.F Pershin and others [1-11, 23, 24]. The works of the above-mentioned scientists prove the following:

– the mixing or shaking is such process of moving particles of the material, at the result of which given quantity of its components will be contained in any volume of the mixture;

– devices, in which the process of mixing happens, are called mixers;

– mixers are made in the form of vertically and horizontally located continuous- and periodic-running working tools;

– working tools of mixers are called agitators;

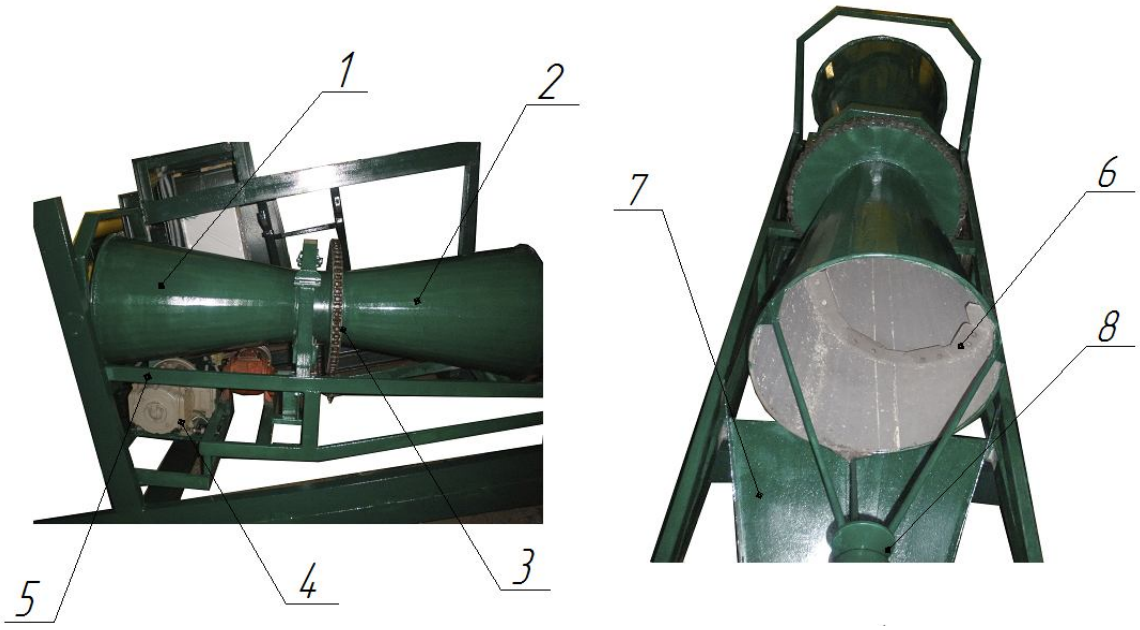
– depending on the components of feed mixtures the working tools of the following types: screw, vaned, propeller, turbine, drum etc. are taken.

– the mixing process is characterized by the degree of homogeneity.

The purpose of research is the development of the adequate technique of experimental study of effective continuous-running fodder mixers.

Research results. The scientists of Lugansk NAU have developed a new continuous-running fodder mixer (fig.). The technical novelty of this mixer is certified by the patent of Ukraine № 70668.

The mixer works in the following way. The components of the feed mixture (crushed grain, succulent and roughage fodder) are fed into the mixer with a help of proportioning devices. The front cone 1 with a help of the winding 6, situated on its inner surface catches components and sets them moving along a spiral path. The winding is equipped with L-shaped beaters with a length 100 mm, the beaters are fixed with an interval of 75 mm from one another. This allows lifting a part of the layer of the feed mixture at a height, greater than the slope of repose of its components. This effect prevents the formation of the center of the



a b

Fig. Continuous-running fodder mixer: *a* – side view;
b – view from the side of unloading of the final product; 1, 2 – front and back cone, accordingly; 3, 4 – mechanism of the mixer's drive; 5 – the movable frame; 6 – the screw winding with L-shaped beaters; 7 – the discharge chute; 8 – the supporting block.

circulation of the mixture's components and mixing is provided by the alternate change of the layers' position. Furthermore, the shape of the mixer, consisting of two truncated cones connected by a smaller base, provides a varying value of the components' angular velocity, which also has a positive effect on the efficiency of the mixing process. The winding provides two complete rotations of the material. The length of the each cone is 750 mm. The cones are connected by a cylindrical spacer plate of the length of 250 mm. The diameter of the larger base of the cones is 500 mm and of the smaller base is 250 mm.

After passing the first cone feeding stuff is additionally mixed in the symmetrically-situated second cone. The installation angle of the mixer is changed by a screw mechanism of the movable frame 5 from 0 to 25 degrees. The rotational speed of the mixer is changed with the help of the direct current motor in the range of 0 to 1500 min^{-1}. The design of the mixer allows to change the quantity and shape of the beaters of the winding, and the scheme of their installation. The ready feed mixture is unloaded through the tray 7.

The basic qualitative characteristic of efficiency of the work of any mixing aggregate, including the proposed mixer, is the homogeneity of the final product. A mixture is considered to be homogeneous if the contents of components in any part of its volume corresponds to a nominal mix proportions. The mixing efficiency, thus, the quality of the final mixture depends not only on the physical characteristics of the components (granulometric texture, shape and type of the surface of the particles, moisture, density, etc.) and arrangement of the mixer, but also on the parameters of the process itself (the mixing period, mixer's tool-point velocity, the filling degree, etc.) [1-14].

Based on the data received by leading scientists, who are studying the mixing process, we can come to a conclusion that if any component is distributed in the mixture uniformly, than other components will be distributed uniformly.

For small cattle (SC) the following composition of crumbled feed mixtures is used most often [5, p. 35]:

– 20 – 40% - straw;
– 12 – 26% – hay;
– 40 – 60% – silage and roots;
– 7 – 17% – concentrated feed.

The most hard-mixable component is concentrated feed, because it can stick to the crushed roots or spill through dry roughage fodder. Therefore, it makes sense to evaluate the efficiency of mixing in terms of the criteria of uniformity of distribution of namely concentrated feed in the mixture.

The efficiency of mixing is determined on the basis of the statistical characteristics of the

mixture. Usually a coefficient of variation (relative measure of dispersion, expressed as a percentage) of the distribution of the "key" component in the mixture serves as such characteristics.

$$V = \frac{\sigma}{x} \cdot 100\%, \quad (1)$$

where: σ - standard deviation;

x - arithmetic mean of the measurable value.

$$\sigma = \sqrt{\frac{1}{n} \cdot \sum_{i-1}^{n} (x_i - x)^2}, \quad (2)$$

where: x_i - the value obtained as a result of the measurement;

n - number of experiments.

In addition, the mixing efficiency is estimated via degree of homogeneity. The degree of homogeneity of the mixture is determined by the empirical relationships of A.A. Lapshin [1, p. 259]:

$$C_0 = \frac{1}{n} \sum \frac{B_t}{B_0} \text{ at } B_t < B_0, \quad (3)$$

$$C_0 = \frac{1}{n} \sum \frac{2B_0 - B_t}{B_0} \text{ at } B_t > B_0, \quad (4)$$

where: C_0 – degree of homogeneity ;

n – number of samples;

B_t – part of the smaller component in the mixture, in sample;

B_0 – part of the smaller component in the nominal mixture.

The received experimental data should provide an error in percent of the mean value not more than 5%.

The error in percent of the measurements [15-21]:

$$a = m / x, \%, \quad (5)$$

where: m - absolute error of the measurements;

The absolute error of the measurements [16-21]:

$$m = x_i - x, \%. \quad (6)$$

The degree of homogeneity of the mixture is determined by the following method.

The feed mixture, consisting of three components of different mass M_1, M_2 and $M_к$ is loaded in the mixer. And the component of smaller mass $M_к$ is controlling (concentrated feed). The mixer is put into use (at a constant frequency of rotation of the working tool) and at least 5 samples from different parts of the mixer's tankage with a mass $m_П$ of 100 g each, are taken in regular intervals. Then the samples are separated into the components. The mass of the control component $m_к$ in each sample is weighed and then is written into the table 1.

Table. Results of experiments

№ of the experiment	Time of the experiment, minutes	M_1, g	M_2, g	$M_к$, g	B_o	$m_П$	$m_к$	B_t	$\frac{B_t}{B_o}$	$\frac{2B_o - B_t}{B_o}$

In the table the values B_o and B_t are determined from the formula[1, p. 259]:

$$B_o = \frac{M_к}{M_1 + M_2 + M_к}, \quad B_t = \frac{m_к}{m_П}, \quad (7)$$

where: $m_к$ – mass of the control component in the sample, kg;

$m_П$ – mass of all fodder in the sample, kg.

The results of the experiments are substituted into the formula (3) or (4) and the degree of homogeneity of the mixture is calculated. The rational values of the degree of homogeneity of the mixture are within the limits 0,85 – 1,15. The characteristic curve is made on the basis of the received data.

CONCLUSIONS

1. The qualitative characteristic of the efficiency of the feed mixer's work is homogeneity of the feed mixture, regardless of the number of its components.

2. Continuous-running feed mixers are the most promising. The working tool of the continuous-running mixer should consist of two truncated cones connected by a smaller base. This provides a varying value of the components' angular velocity, which also has a positive effect on the efficiency of the mixing process.

3. The winding, located on the inner surface of the cones should be equipped with L-shaped beaters fixed in a spaced position to each other, which will create the effect of preventing formation of the center of circulation of the mixture's components and mixing will be provided by alternate changing the layers' position.

REFERENCES

1. **Mielnikov S.V., 1978.:** Mechanization and automation of cattle farms. L.: Kolos.
2. **Koba V.G., Braginets N.V., Murusidze D.N., Niekrashevich V.F. and others, 1999.**: Mechanization and technology of manufacture of products of cattle breeding. M. Kolos.
3. **Zavrazhnov A.I., 1990.:** Mechanization of preparing and storage of feeding-stuff / A.I. Zavrazhnov, D.I. Nikolaiev. - M.: Agropromizdat.
4. **Aleshkin V.R., 1985.:** Mechanization of cattle breeding / V.R. Aleshkin, P.M. Roshchin. - M.: Agropromizdat, 336 p.
5. **Tsurkan O.V., 2004.:** Development and research of energy-saving vibrational mixer for application of premixes in feed-stuff : dissertation of the candidate of engineering sciences: 05.05.11 / Tsurkan Oleg Vasylyovych. – Vinnytsia, 155 p.
6. **Sementsov V.I., 2008.:** Ground of the parameters of the enrichment process of feed stuff with biologically active feed supplements by a centrifugal mixer: dissertation of the candidate of the engineering sciences: 05.05.11 / Sementsov Volodymyr Illich. Kharkiv, 186 p.
7. **Gvozdiev V.O., 2008.:** Ground of the production process and design parameters of quick-running screw mixer of feeding-stuff: dissertation of the candidate of engineering sciences: 05.05.11 / Gvozdiev Viktor Oleksandrovych, Melitopol, 193 p.
8. **Pershin V.F., 2009.:** Processing of bulky materials in the drum-type machines / V.F. Pershin, V.G. Odnolko, S.V Pershina. M.: Mashinostroienie,. 220 p.
9. **Revenko I.I., Rogovyi V.D., Kravchuk V.I. and others, 1999.:** Design of mechanized production processes of cattle-breeding enterprises; under the editorship of I.I. Revenko – K.: Urozhai.
10. **Belianchikov N.N., 1989.:** Mechanization of cattle breeding / N.N. Belianchikov, A.I. Smirnov. - M.: Agropromizdat,.
11. **Mzhelskii N.N., 1984.:** Handbook in mechanization of cattle farms and complexes / N.I. Mzhelskii, A.I. Smirnov. - M.: Kolos,.
12. **Diemchenko V.N., Alatoom Mohammad, 2011.:** Improvement of the process of preparing multicomponent fodder for small cattle // Scientific reporter of Tavriiskyi state agrotechnological university [Electronic resource]. - Melitopol: TDATU. Issue 1. – Book 3. - P. 35-42.
13. **Braginets N.V., Bakhariev D.N., Alatoom Mohammad, 2011.:** Requirements to preparing of feeding stuffs for small cattle // Collection of thesis reports of the international conference «Modern problems of agricultural mechanics» in memory of the academician P.M. Vasylenko October 17-18, 2011. Lugansk: JINAU, - P. 7-8.
14. **Braginets N.V., Bakhariev D.N., Alatoom Mohammad, 2012.:** Ground of the constructive and technological scheme of the fodder chopper-mixer for small cattle // Collection of thesis reports of the scientific-practical conference of Lugansk national agricultural university of January 19-25, 2012. Lugansk: LNAU, - P. 12-13.
15. **Zavalishin F.S., 1982.:** Methods of research in mechanization of agricultural industry / F.S. Zavalishin, M.G. Matsniev. - M.: Kolos,.- 231 p.
16. **Mielnikov S.V., 1980.:** Planning of the experiment in investigations of agricultural processes / S.V. Mielnikov, V.P. Aleshkin, P.M. Roshchin.- L.: Kolos. Leningradskoie department, 168 p.
17. **Nalimov V.V., 1965.:** Statistic methods of planning extreme experiments / V.V. Nalimov, N.A. Chernova.- M.: Nauka, 365 p.
18. **Adlier Yu.I., 1976.:** Planning the experiment in the search for optimal conditions / Yu.I. Adlier, Ye.V. Markova, Yu.V. Granovskii. M.: Nauka, 279 p.
19. **Vinarskii M.S., 1975.:** Planning the experiment in technological research / M.S. Vinarskii, M.V. Lurie. - K.: Tekhnika, 168 p.
20. **A.A. Spiridonov, N.G. Vasiliev., 1975.:** Planning the experiment at the research and optimization of technological processes. Sverdlovsk, publishing office UPI named after S.M.Kirov,. - 140 p.
21. **Borovikov V., 2003.:** STATISTICA. Art of data analysis on the computer. For professionals / V. Borovikov, the 2-nd issue – SPb.: Piter, 688 p.
22. **Mohammad Alatoom, 2011.:** Improvement of the preparation process of multicomponent fodder for small cattle. TEKA Commission of motorization and power industry in agriculture and the VOLODYMIR DAHL and East-Ukrainian national university of Lugansk. Volume XI B. – Lublin, p. 213-219.
23. **Victor Shapovalov, Yakov Nezhinskiy, 2010.:** The development and applying of flexible technical facilities is effective way of agricultural production mechanization in industry. TEKA Commission of motorization and power industry in agriculture, volume XB.
24. **Victor Belodedov, Pavel Nosko, Pavel Fil, Marina Mazneva, Grogoriy Boyko, 2010.:** Selection of batcher with horizontal disk parameters while maize sowing. TEKA Commission of motorization and power industry in agriculture, Volume XA.

К МЕТОДИКЕ ЭКСПЕРИМЕНТАЛЬНОГО ИССЛЕДОВАНИЯ СМЕСИТЕЛЯ КОРМОВ НЕПРЕРЫВНОГО ДЕЙСТВИЯ

Мохаммад Аль-Атум.

Аннотация. Предложена конструкция эффективного смесителя кормов непрерывного действия. Усовершенствована методика исследования степени однородности трехкомпонентной кормовой смеси полученной в результате работы смесителя непрерывного действия.

Ключевые слова. Технологический процесс смешивания, степень однородности, методика экспериментального исследования.

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The algorithms for improvement regulatory provision of light industry

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S u m m a r y . Number and level of regulatory action in the production of light industry is still intuitively assign actions. The scientifically article are based matrix algorithm dynamics influence elements process with stages of normalization on quality products. Determined by the weight of the elements by using the peer reviews. With solving the matrix model is identified the necessary steps to ensure the weight of regulatory quality. Identified shortcomings of the current system of regulatory support.
K e y w o r d s : light industry, quality, regulatory support, the algorithm, the elements of the production process.

INTRODUCTION

The light industry is manufactures products which is specifically designed to meet needs of people. Therefore, the main requirement for it is the quality and competitiveness. Unfortunately, the quality in this industry so far are largely subjective and not always provided normative documents. Number and level of regulatory action in the production of light industry is still intuitively assign actions. Justification of such actions can increase the objectivity of the process to ensure quality and competitiveness of products.

OBJECTS AND PROBLEMS

The object of this study are process, the stages and elements of the manufacturing process of light industry. We are consider the industry related to the production of clothing and related industries, the manufacture of products from genuine leather. The subject of study is the impact of the regulatory elements of each process to ensure quality of each stage of production and the process in general. The problem is consist in the absence of scientifically requirements to the level of regulatory providing each stage of production.

RESEARCH ANALYSIS

The quality of light industry in a lot of cases is the determining factor, the level of which depends on the competitiveness of [3.20].

Production of light industry is a multi-stage process, each stage of which, to some extent affect the final quality of products. So, for the industry related to the of clothing, such steps, there are: pre-production process, the process of cutting, the connection process, the process of wet-heat treatment. For the preparation of each process to identify quality or semi finished materials [18, 21], which, in turn, need to know the methods to determine these parameters [2, 4, 5]. Final product quality is monitored at every stage and standards which are controlled [9.15]. It should be noted that the overall algorithm to ensure quality at every stage of a single, four stages (methods for determining the performance, quality of raw materials or semi-finished products, process, quality performance after the process). At the same time struck by the coincidence of the number of production steps to control the number of steps that can be implemented in building efficient symmetric algorithms [19], but so far this has not been done.

Each analysis can be performed for one more light industry is a production of genuine leather. It is desirable to distinguish five stages of production (process of choosing, process of cutting, process of seeing, process of correcting, process of drying) [22,23]: At each stage of quality control is ensured by five stages (material control methods, material parameter determination before process, Technical process, material control methods after process, material parameter determination). As we can see, in this case also suggests potential for the use of symmetric algorithms [17], which is not reflected in any publication.

Each review stage, or in the production method provided by the system of normative documents, which largely determine the level of production and quality. The main regulatory documents providing process manufacturing clothes, include a number of publications [11, 14], similar to the problems associated with natural leather industry are given in [10, 12]. Increasing quality requirements, the emergence of new processes, improving existing necessitate improvement of regulatory support of all of these processes. To systematize data on regulatory environment and justify the creation of new regulatory requirements of scientific support.

In this case, the extreme complexity of the problem, its novelty, lack of available information, the difficulty of mathematical formalization process solutions necessary to address the recommendations of competent professionals, well knowing the problem, they are experts. Their solution of the problem, the arguments, the formation of quantitative assessments, treatment last formal methods are called method of expert estimates. Method, as reflected in a number of publications, but not used until now in the problems of finding the weight of the stages of production and control process to ensure product quality.

Purpose is to scientifically substantiate the structure of regulatory quality of light industry products on the basis of the weight of expert evaluation stages of production, the introduction of matrix methods and symmetric algorithms.

MAIN RESULTS OF THE RESEARCH

Processes in light industry, as noted above, may be reduced to a linear algorithm of production, an example of which is shown in (fig. 1).

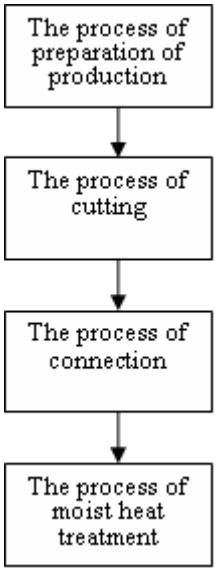

Fig.1. A linear algorithm in light industry

Preparation of garment production is one of the main functions of the enterprise [1, 16]. This is due to the steady increase in the rate and extent of renovation products in annual nomenclature clothing companies new product is more than 80%. Under market economic conditions there is an urgent need to develop methods to ensure comprehensive training organization garment production, to reconcile the interests of the company with the ever changing demands of the market, competitive products, improve garment production. For the methodological organization support of a comprehensive pre-production to quickly determine the properties of materials, to determine the rational technological and organizational modes of the production process.

In the process of training, in particular to determine the optimal combination of materials, angles and positions with the cutting of parts of the lower and upper limit of the size of the lot of garments manufacturing term party garments, depending on organizational and technological characteristics of the production process.

Of cutting materials stage [8, 13] is solving important issues of quality and resource conservation. It is known that the clothing industry is a material-production, where it is at the stage of preparation of materials for cutting and cutting laid such basic parameters of the product quality, competitiveness, cost. In the process of cutting address issues of system approach for computer-aided design process, issues of resource conservation for multi layouts, energy conservation.

Connection process takes one of the greatest places in the process. Quality of the process due to both hardware requirements and the properties of materials, as well as the organization of the process.

Step humid heat treatment plays an important role in ensuring the appearance of products. It is the most energy-intensive process, requiring the consideration of the material properties.

To ensure quality at every stage of production requires a set of quality control methods.

Quality problem in the modern world is universal. Analysis of the quality of garments by three methods: organoleptic, measuring and sociological. Unfortunately, the dominant is the organoleptic method with often subjective. Thus, the quality of the product landing on a figure or a mannequin is determined visually. This product is wear on a person or mannequin is fastened to the neck and is known belt (if applicable). Evaluated the product meets the size and shape of the human body, fashion, product integrity composition, the presence of structural defects (horizontal folds, vertical folds, inclined folds, corner creases and balance disorders, and ease of use small details (pockets, belts, valves, fasteners and other .) and convenience in static and dynamic). Quality technology garment determined visually on the table. Product is placed on the table wrong side up, assessed the quality of the product from the wrong side, then from the front. Determined is measuring the size of defects, and the symmetry of paired parts.

In general, the generalized process control, production control can be represented as a linear algorithm (fig. 2).

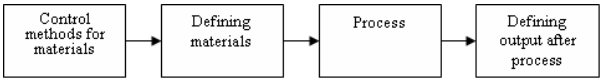

Fig. 2. Linear control algorithm

We pay an attention on the similarity of processes with the production stage. We note that despite the fact the physical nature of the processes are different, the formal sequence uniform. When you combine the stages of production in one model can be a rectangular structure that shows a symmetric algorithm garment production (fig. 3). The result of any production must act with its products of quality, competitiveness, energy, etc.

Obviously, each step of system elements can be associated with some measure of weight, which contributes to the overall effect of production denote the weight of a single element of the symbol E_{ij}, where i - number of the stage production, j - number of the quality assurance process. We also denote R_i - the weight indicator of quality.

We come back for the issue of ensuring the individual elements of the system shown in (fig. 3). Despite these shortcomings in the regulatory process ensuring each element provides a certain system of standards, specifications, test methods and production monitoring.

The hypothesis of our study consist is is a link between the achievement of each element of the system and the effectiveness of regulatory support. For each stage, we denote this performance X_i. In this case, a formalized model for quality in the light industry can be demonstrated by (fig. 4).

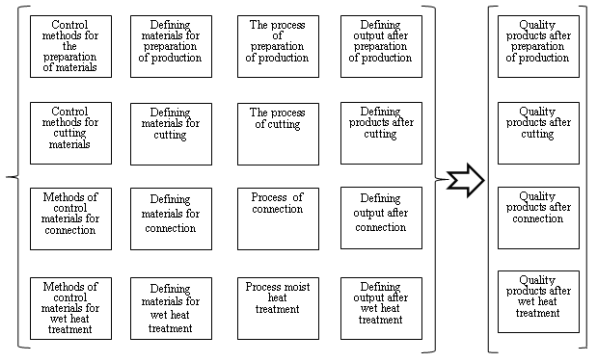

Fig. 3. The rectangular structure of the stages of production in the apparel industry

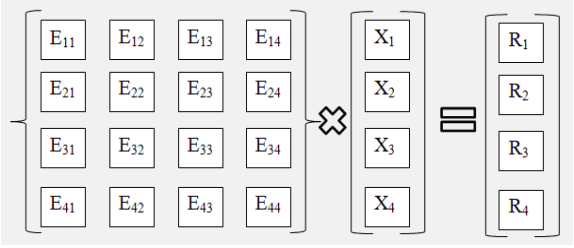

Fig. 4. A formalized model of quality

The similar analysis for the light industries consist with production of products from natural leather provides a more complex result, which is implemented in a square system of five cells horizontally and vertically, shown in (fig. 5).

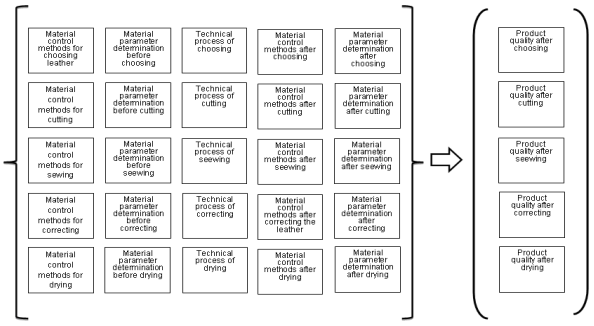

Fig. 5. The rectangular structure of the stages of production in the manufacturing of natural leather

Described of matrix of the fourth order for the garment industry mathematical model in this case would look as

$$\begin{Bmatrix} E_{11} & E_{12} & E_{13} & E_{14} & E_{15} \\ E_{21} & E_{22} & E_{23} & E_{24} & E_{25} \\ E_{31} & E_{32} & E_{33} & E_{34} & E_{35} \\ E_{41} & E_{42} & E_{43} & E_{44} & E_{45} \\ E_{51} & E_{52} & E_{53} & E_{54} & E_{55} \end{Bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \\ X_4 \\ X_5 \end{bmatrix} = \begin{bmatrix} R_1 \\ R_2 \\ R_3 \\ R_4 \\ R_5 \end{bmatrix}. \quad (1)$$

In general, therefore, the model in light industry can be represented as

$$\{E\}[X]=[R]. \quad (2)$$

Where: $\{E\}$ - the matrix elements of the production process,

$[R]$-vector of indicators of quality,

$[X]$ - vector of regulatory support.

At this stage, we are not known, most indicators of system elements. Unfortunately, the development of formal methods for their determination is an elusive goal. For indicators of the weight to perform a complex expert research in the garment industry in Kharkov. The basis of the research was the Delphi method, which is a method of group survey.

Statistical characterization of the group of the answer is that our group is the metric value, containing the views of the majority of experts, this point of view, which could accept most of the group.

For each phase was conducted ranking sequence control and production, that is the location of objects in descending order of importance of the process.

This was followed by direct measurement. Range of the characteristics of an element of the system is divided into separate intervals, each of which is assigned a certain score (score), from 0 to 10. Then determines the share of each item by dividing the amount of points received a separate item on the total number of points for each stage.

In order to form a generalized assessment of the expert group used averages.

Point estimate was determined for a group of experts, which is calculated as the arithmetic mean:

$$\overline{W} = \frac{\sum_{k=1}^{m} W_k}{m}. \quad (3)$$

And identifies how a particular factor is important in terms result. In this case, determine the weight of each factor.

Determination of weights produced in that order. Let x_{ij} - evaluation factor i, this j-th expert, n - the number of objects to be compared, m - number of experts. Then the weight of the i-th unit, calculated estimates of the experts (w_i), is:

$$\overline{E} = \frac{\sum_{k=1}^{m} E_k}{m}. \quad (4)$$

where: w_{ij} - weight of i-th unit, calculated estimated j-th expert, is:

$$E_{ij} = \frac{Y_{ij}}{\sum_{i=1}^{m} Y_{ij}}. \quad (5)$$

In case of participation in a survey of several experts differences in their assessments are inevitable, but the magnitude of this difference is important. Group assessment can be considered sufficiently reliable only if good consistency answer individual specialists.

To analyze the spread and consistency of ratings used statistical data - measures of variation.

The standard deviation, calculated from the known formula:

$$\sigma = \sqrt{\frac{\sum_{j=1}^{m} \left(E_j - \overline{E}\right)^2}{m-1}}. \quad (6)$$

where: E_j - assessment of the j-th expert;

m - the number of experts.

Determine the coefficient of variation $V = \frac{\sigma}{\overline{E}} \cdot 100\%$, which showed consistency expert opinions.

As a result of expert research, was compiled table 1 the weighting elements system of production in the apparel industry.

Table 1. Indicators weighting system of production in the apparel industry

	Control methods	Defining materials	Process	Defining output
preparation	0,15	0,22	0,43	0,2
cutting	0,1	0,17	0,44	0,29
connection	0,12	0,19	0,47	0,22
treatment	0,17	0,25	0,35	0,23

Illustration of the results obtained may serve as a weighty volume chart the different stages and elements shown in (fig. 6).

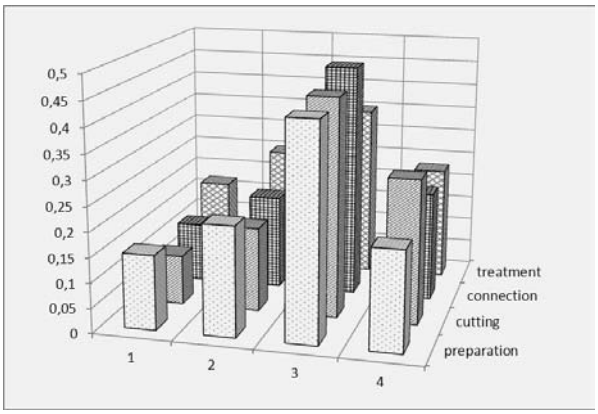

Fig. 6. The weight factors of production according to expert estimates

A similar study for the weight of quality at every stage of the data showed the following (fig. 7).

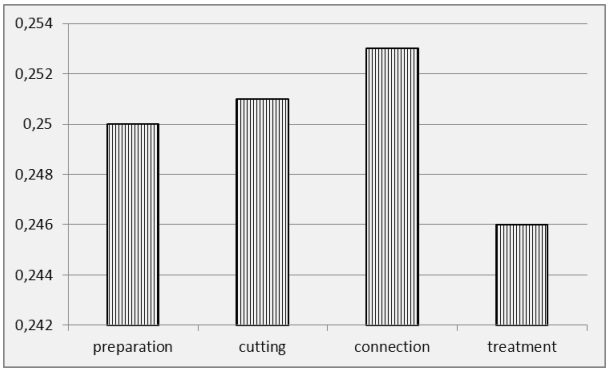

Fig. 7. The weight of quality production in stages

We pay an attention to the fact that the mathematical model in the form of (2) is nothing but a system of linear equations with unknown parameters of regulatory support. The solution is determined by the weight of a legitimate need regulatory support (fig. 8).

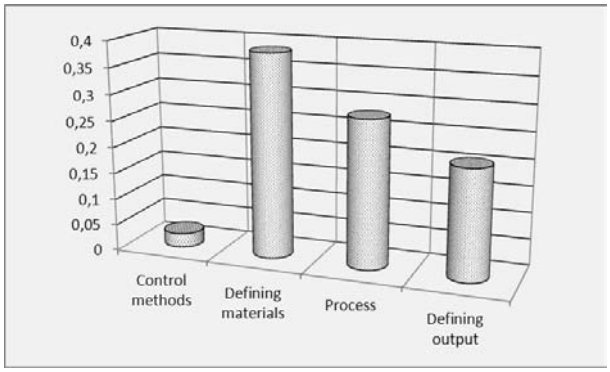

Fig. 8. Required the weight of regulatory support

Drawn to the fact of the contradictions between the existing system of regulatory support, the weight is shifted to the initial methods and distributed between the last point. Meanwhile, according to evidence-based methodology, the greatest weight should be provision in the preliminary direct control. We draw attention to the lack of regulatory control processes to ensure the preparation of connecting actions and especially in the control of materials in the preparation of wet heat treatment [6,7].

CONCLUSIONS

Scientifically article is based on matrix algorithm dynamics effect elements process with stages of normalization on quality of products is an effective means of identifying reserves to improve the quality in determining the weight of the elements of regulatory support production processes and controls in light industry. Determined by weight of the elements using the peer reviews. By solving the matrix model identified the necessary steps to ensure the weight of regulatory quality. Identified short comings of the current system of regulatory support.

REFERENCES

1. **Archinova E.V., 2001.:** Improving the methods of computer-aided design process set-cutting production dissertation of Science, Moscow State University of Design and Technology. - 246 p.
2. **Buzov B., Pozhidaev N., Modestova T., Pavlov A., Flerova L., 1972.:** Laboratory practices on the course of "Study of sewing production" / - M.: Light industry. - 383 p.
3. **Sadov M., Matetskiy A., 1968.:** Light industry. - 784 p.
4. **Deyneka I., Mychko A., 2010.:** Protective factors of textile materials foe special designation clothes / / Commission of motorization and power industry in

agriculture. TEKA / Lublin university of technology. - Lublin. - p. 98 - 102.
5. **Deyneka I.:** The development of theory and practical improvement of reliability of acid defended clothes for workers of engineering enterprises: the thesis abstract for the Doctor's Scientific Degree / Engineering /: specialty 05.26.01 "Labour protection". Luhansk. - 40 p.
6. **Deyneka I., Mychko A., 2008.:** Methodical foundations for the investigations of protective materials against aggressive reagents / / Scientific Herald, Mukachev, Technological Institute. - No 5 - p. 39 - 45.
7. **Dimitrieva I., Mihalovskaya L., 1970.:** Physical-mechanical tests of chemical fibers. Higher School. - 103 p.
8. **Gricyuk Y.I., 2009.:** System analysis and methods of combinatorial optimization cutting process: Dissertation PhD: 01.05.04 / Y. Gritsuk, National University "Lviv Polytechnic." - 36 p.
9. ISO 11646:2005 Leather. Measurement of the area. - Enter. 2006 - 07 - 01. State consumer standard. – 8 p.
10. ISO / TS 14253-2:2006 Requirements for geometric sizes of products. Checking measurement of working samples and measuring equipment. Part 2. Recommendations for evaluation of uncertainty of measurement of geometric dimensions of products, calibration of measuring equipment and control products intr. - 01.10.2007 State consumer standard. - 64p.
11. **Kolaydenko S., Mesaychenko V., Kokoshinskaya V., 1981.:** Marketability of textile materials - M. Economics. – 312 p.
12. **Mihailova N., Deyneka I., Fedina L., Sapronova S., 2009.:** Scientifically grounded choice of materials for making special clothes // [Electronic version]: Ukrainian National Library named after V.I. Vernadskiy / Electronic. Herald of EUNU
13. **Mokeeva N., Ponomareva N., 2009.:** Prediction in cutting textile materials / / Design and Technology. - №13- p. 33-35.
14. **Mokeeva N., Yudina Y., 2009.:** Designing clothes for small-scale production with The applied methods of combinatorial synthesis using elements of discrete mathematics / / Modern problems of Engineering. - №5 - p. 72 - 73.
15. **Mychko A., 1997.:** The development of estimation methods of defending properties and selection textile materials for special goods under the extreme conditions: the thesis abstract for the Doctor‘s scientific degree: specialty 05.19.01 ”Marketability of textile production and light industry”. – SPb – 50 p.
16. **Pashkova N.V., 1999.:** Improving the organization of pre-production in the market environment management: the example of the garment industry, Kostroma State Technological University. Thesis Doctor of Science. -137 p.
17. **Ripka G., Mychko A., 2010.:** Actual problems of industrial computer embroidery / / Modern problems of the development of light and food industry: thesis of the report at the International Scientific - practical conference of young scientists and students, November 3 - 4, 2010 - L.: EUNU named after V. Dahl,. - p. 148.
18. **Ripka G., Mychko A, 2011.:** The analysis of directions to achieve the embroidery competition / / Herald of EUNU - No1 (155). P. 1. - p. 193 - 198.
19. **Rvachev V., 1967.:** Geometric algebra application logic. - Kiev: Tehnika.
20. **Shapovalov V., Nezhinskiy Y., 2010.:** The development and applying of flexible technical facilities is effective way of agriculturay production mechanization in industry. TEKA / Lublin university of technology, - Lublin. - p. 157-161.
21. **Stratmann M., 1957.:** ges Textilind, No 24, p. 1035 - 1036; No 23, p. 981 - 982.
22. **Yaroshchuk O., 2011.:** Complex estimation of textile materials for children's clothes / / Herald of the East-Ukrainian National University named after V.Dahl. - No 1 (155), P.1. - p. 266-273.
23. **Yurina Y.V., Svorovskaya D.L., 2012.:** Outsourcing of technical training of manufacture and cutting of garments Scientific magazine Kuban Krasnodar GAU:, № 75 (01).

АЛГОРИТМЫ УСОВЕРШЕНСТВОВАНИЯ НОРМАТИВНОГО ОБЕСПЕЧЕНИЯ ЛЕГКОЙ ПРОМЫШЛЕННОСТИ

Ольга Мокшина, Александр Рябчиков, Светлана Челышева

Аннотация. Количество и уровень нормативных действий в процессе производства продукции легкой промышленности до сих пор является интуитивно назначаемыми действиями. В статье научно обоснован матричный алгоритм описания динамики влияния элементов технологического процесса совместно с этапами нормирования на показатели качества продукции. Определены весомости элементов с помощью метода экспертных оценок. Путем решения матричной модели выявлены необходимые весомости нормативного обеспечения этапов обеспечения качества. Выявлены недостатки существующей системы нормативного обеспечения.

Ключевые слова: легкая промышленность, показатель качества, нормативное обеспечение, алгоритм, элементы производственного процесса.

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Iron ore benefication processes optimization

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S u m m a r y . Optimal separation characteristics for the spiral classifier, operating in a closed loop with primary reduction stage ball mill of the processing plant, the deslimer and flotation machine were obtained in this work.
These characteristics were obtained by Sugeno fuzzy model, information about the performance of technological units, pulp density and solid phase particle size distribution dynamics under the radiation pressure of a high-energy ultrasound as well as economic indicators of the process.
K e y w o r d s : mineral processing, high-energy ultrasound, particle size distribution, the characteristics of pulp.

INTRODUCTION

Process optimization of mineral processing requires a rigorous mathematical and economic-mathematical methods for calculating the optimal separation limits φ_{sopt} of physical properties variation range of the feedstock particles [Tihonov 1984].

A compact theory of the benefication processes, based on the concepts of minerals fractional composition and separation characteristics of processing machines, presented in [Tihonov 1984]. Fractional composition allows to estimate the distribution of pulp solid phase and mineral components by fractions, differing by physical properties of the particles. Separation characteristics estimates the extraction degree of each fractions to the concentrate in relation to processing raw materials. These two concepts allows to predict the benefication technological results (recovery, content, extraction) of any material by any process flowsheet, compare with each other processing machines and process flowsheets and solve the economic optimization problems of multicomponent raw benefication etc.

The conceptions of mineral particles $\gamma(\xi)$ and valuable components $\beta(\xi)$ distribution by fractions with different physical properties ξ, introduses for quantitative evaluation of mineral products while the separation characteristics $\varepsilon(\xi)$ evaluating the extraction ε of narrow mineral fractions to the products, introduces to quantify agregates and flowsheets.

The solution of this task allows to define both the best benefication technological line structure, and the technological units parameters providing its maximum productivity at set quality of the final product and the minimum costs for process.

Since useful iron-containing minerals have strong magnetic properties, the most logical and promising way of processing is the combined use of magnetic fields and other factors, for example, ultrasound [Morkun 1998, Morkun 2004, Porkuian 2005, Porkuian 2006, Kobus 2008].

The key characteristic is the crushed ore particle-size distribution function for a large class of concentrating technologies. To build a particle-size distribution function of pulp solid phase is possible by prior spatial particle separation in the test medium and using the radiation pressure of a high-energy ultrasound for these purposes is presented in [Morkun 2010] This approach will be used to evaluation of particle vector velocity field $\vec{v}(\xi, x, y, z, t)$ and finding the function of $\gamma(\xi,x,y,z,t)$.

RESEARCH OBJECT

The task of research is mathematical modeling of the benefication technology separation

processes, analytical description and pilot testing of the high-energy ultrasound radiation pressure effects on pulp flow to estimate crushed ore particle-size distribution, determine its mineral species and build the separation characteristics of classifying and processing units.

RESULTS OF RESEARCH

The expression for the radiation pressure force, represented by total and differential cross sections for scattering and absorption of ultrasonic waves on the particles is predented in [Morkun 2007]:

$$F_r = \frac{I}{c}\left(\sigma_p + \sigma_s \mu\right), \qquad (1)$$

where: I - incident wave intensity; c - velocity of wave propagation;

$$\mu = \frac{2\pi}{\sigma_s}\int_{-1}^{1} d\cos v \frac{d\sigma}{d\Omega}(\cos v)(1-\cos v)$$

For spherical particles of radius r the differential scattering cross section is given by:

$$\frac{d\sigma}{d\Omega}(\cos v) = \frac{r^2}{9}(kr)^4\left(a_1 - \frac{3}{2}a_2\cos v\right)^2, \qquad (2)$$

where: $a_1 = 1-\left(rc^2/\rho_т\, c_т^2\right)$;

$a_2 = 2\left(\rho_т - \rho/2\rho_т + \rho\right)$;

$\rho_т, c_т$ - density of a particle and ultrasound velocity in a particle material;

ρ - medium density.

At high frequencies $\sigma_p \ll \sigma_s$, thus

$$F_r = \frac{4}{9}\pi r^2 (kr)^4\left(a_1^2 + a_1 a_2 + \frac{3}{4}a_2^2\right)\frac{I}{c}. \qquad (3)$$

Behavior of the particles concentration and their distribution by size in the field of high-energy ultrasound depends on the mass of the particle, the frequency and intensity of actuating radiation[Landau 1954, Morkun 1999]. Let's evaluate the effect of the ultrasound radiation pressure on the change in concentration of particles of radius r. Let's suppose that slurry flows with velocity V in the positive direction of the x-axis and $n_r(Z,t)$ is a particles concentration of radius r at a depth Z in time t (Fig. 1). On this basis:

$$\frac{\partial n_r(Z,t)}{\partial t} = -\frac{\partial}{\partial Z}\left[V_r(Z,t)n_r(Z,t)\right] \qquad (4)$$

where: $V_r(Z,t)$ is the velocity of the particle displacement of radius r with coordinate Z in ultrasonic field.

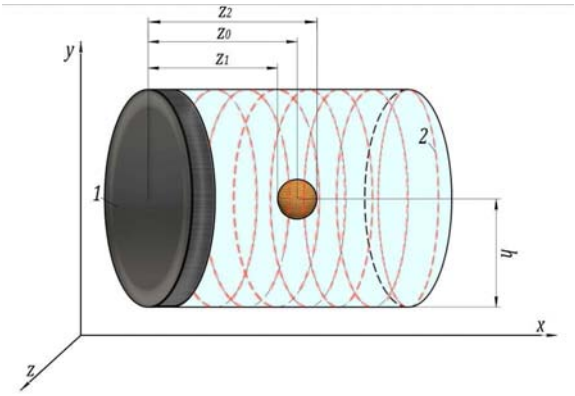

Fig. 1. Motion of the crushed ore particle in the pulp flow under the radiation pressure of high-energy ultrasound

Numerical characteristics of ultrasonic pulse propagation process in the the pulp produced with HIFU Simulator v 1.2 [Soneson 2011].

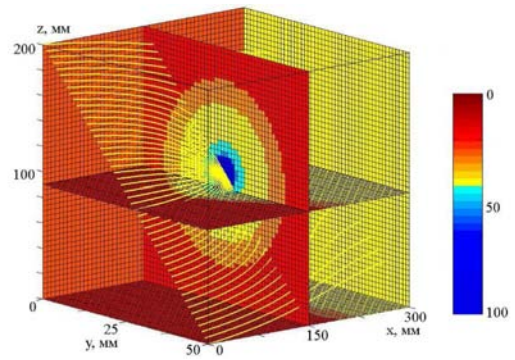

Fig. 2. Intensity step sampling of the ultrasonic field in the spatial coordinates

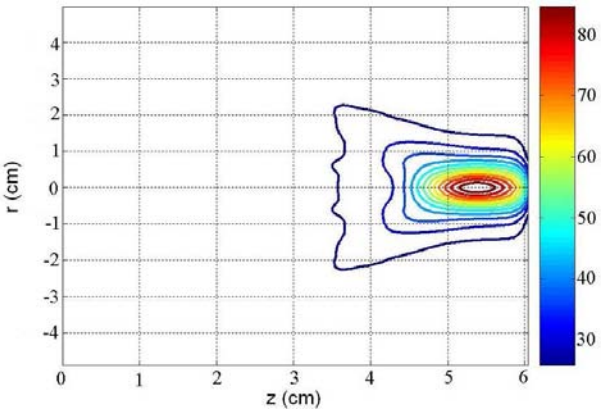

Fig. 3. Power distribution of the ultrasonic radiation at a distance z = 5,37 cm from the source.

The results of three size fractions ore particles displacement modeling in the pulp flow under radiation pressure of the high-energy ultrasound are shown in Fig. 4. Positions of each particle size on the tenth step connected by solid lines.

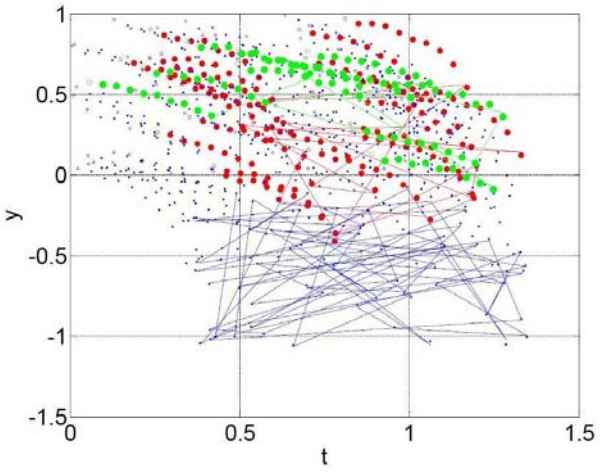

Fig. 4. The results of three size fractions ore particles displacement modeling under radiation pressure of the high-energy ultrasound

The developed program calculates the high-energy ultrasound intensity at a certain point of the measuring range which allows to implement the predicted displacement of crushed ore particles of a certain mass and changes in the size distribution of the pulp solid phase under the controlled high-energy ultrasound radiation pressure.

Optimal separation characteristics for the spiral classifier, operating in a closed loop with primary reduction stage ball mill of the processing plant, the hydrocyclone and flotation machine were obtained in this work.

These characteristics were obtained by Sugeno fuzzy model, information about the performance of technological units, pulp density, solid phase particle size distribution dynamics under the radiation pressure of a high-energy ultrasound as well as economic indicators of the process. Mean square error of the model identification for control sample of 36 points is 0.94.

Flotation is the most complete and versatile operation of mineral processing.

Dynamics and results of the flotation process depends on many factors. There are the mineral composition, the nature of impregnation, and other minerals properties, solid phase size distribution, the density and temperature of the pulp, composition of the water, reagent treatment, flotation machine design, etc [Glembotskyi 1981, Brożek 2012].

For the simulation of physical processes that determine flotation, accurate data of the gas phase characteristics, the most important of which are the concentration and gas bubbles distribution, are required. These parameters are highly dependent on a variety of operational, technical, and physical-chemical factors, the effects of which should be considered in the modeling of the flotation process. [Miskovic 2011]

Efficiency of the flotation process is directly related to the number of collisions between particles and bubbles, which are strongly dependent on the ratio of particle diameter to bubble diameter. In a flotation system where bubbles are much larger than particles, a flow streamlines around the bubble sweep particles near the bubble surface and prevents attachment of valuable mineral particles to the bubble. Hence, in order to provide optimal conditions for the flotation, it is necessary to generate bubbles with sizes similar to the size distribution of particles in the pulp.

Bubble size is considered to be one of the most important parameters affecting the performance of froth flotation cells. However, monitoring, controlling and predicting bubble size is a very challenging task[Brożek 2012].

For floatation process intensification the method of the combined effects of ultrasound on reagents and the liquid phase of the pulp is offered.

The use of ultrasound in the flotation technology related to a number of specific phenomena accompanying the propagation of ultrasonic vibrations in liquid media. Among these phenomena the special place is taken by cavitation. It is expressed in the appearance of gas bubbles (cavities)in the liquid in which ionization of molecules and atoms, pressure (up to several thousand atmospheres) and temperature (hundreds of degrees) increasing. It is known that gas (cavitation) bubbles are formed easily at the liquid-solid interface, energetic acting on the surface of the latter [Chernykh 2003].

Ultrasonic pulp treatment significantly increases floatability of minerals and reduces reagent-collector consumption. Treatment of the ore particles surface layer leads to the emergence of active regions with uncompensated bonds, which is one of the reasons for sonicated minerals floatability improvement .

The proposed flotation control method allows to operate the phase composition of pulp more effectively, it is more eco-friendly by reducing the amount of flotation reagents, as well as energy efficient.

An important element in iron ore concentrate production string of mining-and-processing integrated works is hydraulic benefication in deslimers [Shohin 1980, Shinkorenko 1980], the application of which, can improve the iron total

mass fraction in underflow to 0.5 – 2,3%, depending on the stage of benefication.

A characteristic feature of the feedstock separation process in deslimers is the feed stream power formation. [Lyashchenko 1940] These flows are the result of the movement of the solid phase particles, the division of which is due to their different gravitational size. Exactly these flows generated by initial feed supply, providing the ability to separate the solid phase components and to obtain underflow with high content of useful component.

It is established that efficiency of hydraulic benefication process increases at longer interaction of initial raw material particles with the two-phase medium in the reception capacity of a deslimer, namely in a zone of airborne particles. Hence it was offered to change the spatial orientation of a initial feed stream with traditionally descending to the ring - radial. Change of initial feed stream spatial orientation leads to change of a particles movement trajectory allows to remove littering nonmetallic particles of -0,025+0 mm to the drain.

The calculation of ore particle mass hydraulic granularity with size of - 0.07 + 0 mm with a density of 2.6-4.2 g/cm^3, suggests that the hydraulic granularity is related with geometrical parameters of particles and their density. Change dynamics of a magnetite ore hydraulic granularity has a parabolic dependence of density from geometrical parameters.

Analysis of the calculations results showed that mostly rock and re-crushed ore particles with high-grade joints (which is basically less than 0.025 mm) get to the drain with updraft flow velocity of 0.0025 m/s for the radial initial feed of deslimer (with respect to 9 m-long deslimers).

The presence of the larger particles in the drain due to the turbulent flows, which spontaneously perform mass transport of solids to the upper part of the tank of drain formation zone.

Radial feed has the advantage over the descending feed because the finding time of suspended particles in the apparatus airborne area higher in 1.8-2 times than descending feed. Flow distance, which it passes to interacting with the thickening area is 1.6 m. -1.8 Whith descending feed this value is 0.8 m.

It is established that desliming efficiency depends on particles finding time in the apparatus airborne area. This time were 5,2-5,5 seconds with a radial feed (with efficiency of 22,1-22,3%) that is almost twice more, than with a descending feed - 2-2,2s. where desliming efficiency is 17,8-18%.

Proposed benefication technologies optimisation methods is expedient to use in automatic control systems of iron ore beneficiation technological processes [Morkun 2007, Ulshin 2010].

CONCLUSIONS

Evaluations of size distribution and particle velocities vector field $\bar{v}(\xi, x, y, z, t)$ of pulp solid phase at any technological process point *(x,y,z)* helps to form the status function $\gamma(\xi,x,y,z,t)$ and determine the separation characteristics of $\varepsilon(\xi)$ of classifying and processing machines based on economic performances.

REFERENCES

1. **Tihonov O., 1984.:** Regularities of effective minerals separation in mineral processing processes/M.:Nedra. p. 208.
2. **Morkun V. 1998.:** Evaluation of physical and mechanical characteristics of mineral resouurces in relation to problems of automatic control//Development of ore deposits.- Krivyi Rih: KTU. V.65. p. 39-41.
3. **Morkun V., Morkun N., 2000.:** Analysis of the methods of ultrasonic testing of the density of industrial suspensions // Development of ore deposits.- Krivyi Rih: KTU. V.73. p. 84-89.
4. **Morkun V., Porkuian O., Sotnikova T., Barsky S., 2004.:** Measurment of the ferromagnetic component in the flow of pulp // Development of ore deposits.- Krivyi Rih: KTU. V.6. p. 39-47.
5. **Morkun V., Morkun N., Podgorodecky N., Pikilnyak A., 2010.:** Hybrid fuzzy model initialization of ore crushing closed loop. Journal of Krivyi Rih Technical University. Krivyi Rih., KTU, V. 26. p.290-293.
6. **Porkuian O.V., 2005.:** The use of Love waves to control the characteristics of the medium. // The quality of mineral raw materials. Collection of scientific papers. p/ 102-117.
7. **Porkuian O.V., 2006.:** Absorption of Love waves in a magnetic field. Vestnik Krivoy Rog Technical University. V.15. p. 112-116.
8. **Kobus Z. Kusiǹska E. 2008.:** Influence of physical properties of liguid on acoustic power of ultrasonic processor. TEKA Kom. Mot. i Energ. Roln. - OL PAN, V.8a, p. 71-78.
9. **Morkun V.,Potapov V., Morkun N., Podgorodetskiy N. 2007.:** Ultrasonic characteristics testing of crushed materials in ACS of processing industry. - Krivyi Rih. KTU. p. 283.
10. **Morkun V. 1999.:** Ultrasonic characteristics testing of crushed materials and ore crushing-classification processes adaptive control based on it /PhD dissertation: 0.5.13.07. – Krivyi Rih. p.401.
11. **Landau L., Lifshitz E., 1954.:** Theoretical physics. Continuum Mechanics.- M.: GITTL., p.796.

12. **Soneson J. 2011.:** HIFU Simulator v1.2. http://www.mathworks.com/ /matlabcentral/fileexchange/30886-high-intensity-focused-ultrasound-simulator.
13. **Glembotskyi V., Klassen V. 1981.:** Flotation benefication methods/ M.:Nedra. p. 238-250.
14. **Brożek M., Młynarczykowska A., 2012.:** The distribution of air bubble size in the pneumo-mechanical flotation machine. Arch. Min. Sci., Vol. 57, No 3, p. 729–740
15. **Miskovic S., 2011.:** An investigation of the gas dispertion properties of mechanical flotation cells: an IN-SITU approach. - Blacksburg, Virginia, p.8
16. **Chernykh S., Rybakova O., Lebedeva N., Zhirnova T., 2003.:** On the study of the influence of ultrasound, magnetic fields and electric current on the flotation of gold // Non-ferrous metals, V. 6. p.15.
17. **Shohin V., Lopatin A., 1980.:** Gravitational benefication methods.- M.:Nedra. p.400.
18. **Shinkorenko S., 1980.:** Ferrous metal ores benefication guide/2 ed. – M.: Nedra. p- 527.
19. **Lyashchenko P., 1940.:** Gravitational benefication methods. M. -L.: Gostoptekhizdat. p -359.
20. **Ulshin V., Yurkow D., 2010.:** The adaptive system on the basis of artificial neuron networks. TEKA Kom. Mot. i Energ. Roln. - OL PAN, V. 10D, p. 15-24.

ОПТИМИЗАЦИЯ ПРОЦЕССОВ ОБОГАЩЕНИЯ ЖЕЛЕЗНОЙ РУДЫ

Владимир Моркун, Сергей Гончаров,
Андрей Пикильняк, Андрей Кривенко

Аннотация. В работе получены оптимальные сепарационные характеристики для спирального классификатора, работающего в замкнутом цикле с шаровой мельницей первой стадии измельчения обогатительной фабрики, дешламатора и флотационной машины. Эти характеристики получены при помощи нечёткой модели Сугэно, информации о производительности технологических агрегатов, плотности пульпы, динамики гранулометрического состава её твёрдой фазы под действием радиационного давления высокоэнергетического ультразвука и экономических показателях процесса.
Ключевые слова: Обогащение полезных ископаемых, высокоэнергетический ультразвук, распределение частиц по размерам, характеристики пульпы.

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Synthesis of toothed gearing with reduced energy capacity

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S u m m a r y. Recommendations for synthesis of an original profile providing reduction of friction in toothing have been developed; geometrical parameters of the profile have been determined.
K e y w o r d s. Synthesis, original profile, energy capacity, slide velocity, toothed gearing.

PROBLEM

Operational performance and economic efficiency of modern machines in different industries mostly depend on performance quotient of gear transmissions. Designing a gear transmission with high performance quotient results in both perfection of the transmission and the machine itself, which is of vital importance in modern machine-building. One way of perfecting gear transmissions is development of toothed gearing with reduced energy capacity.

ANALYSIS OF RESEARCH LITERATURE

Energy capacity of toothed gearing depends on friction in gearing [1] which is determined mainly by the geometric parameters of the original profile used for shaping teeth of the gear wheel. Recently there has been an intensive research on designing non-involute gearing with high load capacity [1-6, 8-20]. Tooth geometry of these transmissions reduces, in some degree, the friction in gearing [1] of gearing wheels. Research on synthesis of toothed gearing whose teeth profiles are determined according to target values of friction in gearing, however, has not been carried out.

AIM AND OBJECTIVES

Development of a mathematical model of synthesis; synthesis of the original profile according to target values of friction in gearing which reduces energy capacity of the toothed gearing in cylindrical gear wheels.

MATHEMATICAL MODEL OF SYNTHESIS AND SYNTHESIS OF THE ORIGINAL PROFILE

Let us consider the order of geometric synthesis of the original profile according to the friction value in gearing. Friction value is:

$$F_{mp} = F_n f \,, \tag{1}$$

where: F_n - the normal value in gearing;

f - friction coefficient in gearing.

We use friction coefficient value in sliding friction for the synthesis and comparative evaluation of friction [1]:

$$f = 0{,}09 q_n^{0,1}\left[10 + \lg\left(\frac{HB \cdot R_a \cdot \chi}{E_{np}}\right)\right]\chi^{0,25}\nu^{-0,07}V_{\Sigma}^{-0,1}V_{12}^{-0,35} \tag{2}$$

where: q_n –normal force acting on the unit of length of the contact line of teeth;

HB – hardness of the less hard of the contacting teeth;

R_a – roughness of the harder of the contacting teeth;

E_{np} – reduced elasticity module of gearing teeth materials;

ν – oil viscosity;

χ – relative curvature of teeth working surface;

V_{12} – sliding velocity in gearing;

V_{Σ} – rolling velocity sum in gearing.

For the assessment of forces of friction in gearing of the synthesized and involute transmissions we use the equation

$$\bar{f} = \frac{F_n f}{F_{n\text{э}}\, f_{\text{э}}}, \tag{3}$$

where: $F_{n\text{э}}$, $f_{\text{э}}$ – values for the involute transmission.

Analysis shows that $\frac{F_n}{F_{n\text{э}}} \cong 1$ at similar parameters of the synthesized and involute transmissions and at similar loads on these transmissions. We can also assume in the first approximation that the ratio of values in the square brackets (2) for the synthesized and involute transmissions can equal one. Then equation (3) with the account of (2) will take the form :

$$\bar{f} = \frac{\bar{\chi}^{0,25} V_{\Sigma}^{-0,1} V_{12}^{-0,35}}{\bar{\chi}_{\text{э}}^{0,25} V_{\Sigma\text{э}}^{-0,1} V_{12\text{э}}^{-0,35}}, \tag{4}$$

where: $\bar{\chi}$, $\bar{\chi}_{\text{э}}$ – relative curvatures for the synthesized and involute transmissions.

At large values of the radii of the pitch circles for the synthesized transmission (1) [1]:

$$V_{12} = \frac{(u+1)}{u}\frac{f}{\xi}; \qquad V_{\Sigma} = 2R_1\sqrt{\frac{\xi}{\chi}}, \tag{5}$$

where: u – gear ratio;

R_1 – circle radius of the smaller wheel;

$\xi = \sin\alpha$ – (α - pressure angle of the original synthesized transmission, fig. 1)

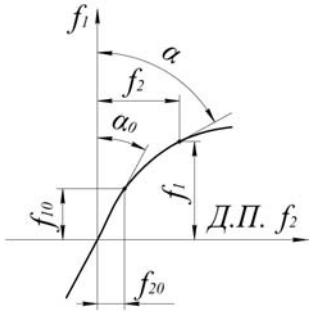

Fig. 1. Schematic diagram of the original profile (*ДП* – pitch line)

For the involute transmission [1]

$$V_{12\text{э}} = \frac{(u+1)f_1}{u\sin\alpha_{\text{э}}}; \qquad V_{\Sigma\text{э}} = 2R_1\sin\alpha_{\text{э}}; \qquad \bar{\chi}_{\text{э}} = \frac{1}{\sin\alpha_{\text{э}}}. \tag{6}$$

With the account of (5), (6) we receive from (4)

$$\bar{f} = \bar{\chi}^{0,3}\xi^{0,3}. \tag{7}$$

Relative value $\bar{\chi}$ for the synthesized transmission equals to [Shishov V.P. 2006]

$$\bar{\chi} = \frac{(\xi - f_1\xi')^2}{\xi^3}, \tag{8}$$

where: ξ' – derived function ξ for f_1;

f_1 – profile coordinate of the original profile (fig.1)

From equations (7) and (8) follows:

$$\xi' f_1 = \left(1 - \bar{f}^{1,67}\right)\xi. \tag{9}$$

Solution of differential equation (9) determines the actual angle of the original profile of the synthesized transmission. $\bar{f}$ <1 shows in which degree the friction of gearing in the synthesized transmission is less than that in the involute transmission. It should be noted that $\bar{f}$ can be both constant and variable in the area of gearing of gear wheels. When $\bar{f} = const$ equation (9) can be solved as follows

$$\xi = Cf_1^{\lambda}., \tag{10}$$

where: C – constant value. This value can be determined giving $\alpha = \alpha_0$ at $f_1 = f_{10}$. The n from equation (10) follows

$$\xi = \xi_0 f_1^{\lambda}, \tag{11}$$

where: $\xi_0 = \alpha_0$ (α_0 – is the angle of the original profile at $f_1 = f_{10}$)

At the preset value $\bar{f}$ equation (11) determines the angle of the original profile at a certain point. The value of this angle permits to determine the curvature equation which describes the original profile. This can be done as follows:

-take the constant value $\bar{f} < 1$ (at $\bar{f} = 1$ we have $\xi = \xi_0 = const$ - the original profile for involute teeth);

-take $\alpha_{\max}$ and $f_{10} = f_{1\max}$ ($f_{1\max}$ can be $f_{1\max} = 1$ at module $m = 1$ mm). Then $\xi_0 = \sin\alpha_{\max}$, and value $\alpha_{\max}$ must provide overlapping coefficient $\varepsilon_\alpha \geq 1{,}2$ and teeth thickness at knot point $S_a = (0{,}2...0{,}4)m)$ [11];

-determine from (11) and (10) values ξ .and ξ' within value limits $f_{\min} \leq f_1 \leq f_{\max}$ and determine the derived function f_2 by equation [1]:

$$f_2'' = \frac{\xi'}{\left(1-\xi^2\right)^{1,5}}, \qquad (12)$$

where: f_2'' – constant coefficients;

$$f_2'' = \sum_{i=1}^{k} a_i f_1^i, \qquad (13)$$

where: a_i – constant coefficients;

-integrating (13) we receive [7]:

$$f_2'' = \sum_{i=1}^{k} \frac{a_i}{(i+1)} f_1^{i+1} + C_1;$$
$$f_2'' = \sum_{i=1}^{k} \frac{a_i}{(i+1)(i+2)} f_1^{i+2} + C_1 f_1 + C_2, \qquad (14)$$

where: C_1, C_2 – arbitrary constants.

Constants C_1, C_2 equal to:

$$C_1 = tg\alpha_{\max} - \sum_{i=1}^{k} \frac{a_k}{(i+1)} f_{10}^{i+1};$$
$$C_2 = f_{20} - \sum_{i=1}^{k} \frac{a_k}{(i+1)(i+2)} f_{12}^{i+2} - C_1 f_{12}, \qquad (15)$$

where: f_{20} – value of function f_2 at $f_1 = f_{12}$.

According to anticipatory data f_{12} should be set within limits $f_{12} = 0{,}025...0{,}1$.

The original profile at $0 \leq f_1 \leq f_{12}$ can be outlined by the radial arc with the radius (fig.2):

$$\rho = \frac{\left(\sqrt{1+(f_{20}')^2}\right)^3}{f_{20}''}, \qquad (16)$$

where: f_{20}', f_{20}'' – values (13) and (14) at $f_1 = f_{12}$. Function f_{20} is thus determined applying equation (fig.2):

$$f_{20} = \rho(\cos\alpha_n - \cos\alpha_{20});$$
$$\sin\alpha_n = \sin\alpha_{20} - \frac{f_{12}}{\rho}; \qquad (17)$$
$$\cos\alpha_{20} = \frac{1}{\sqrt{1+(f_{20}')^2}},$$

where: α_n – profile angle of the original profile on the pitch line;

α_{20} - profile angle of the original profile at $f_1 = f_{12}$.

Radius ρ_Γ (fig.2) is determined on the assumption of complete rounding of the base of the original profile.

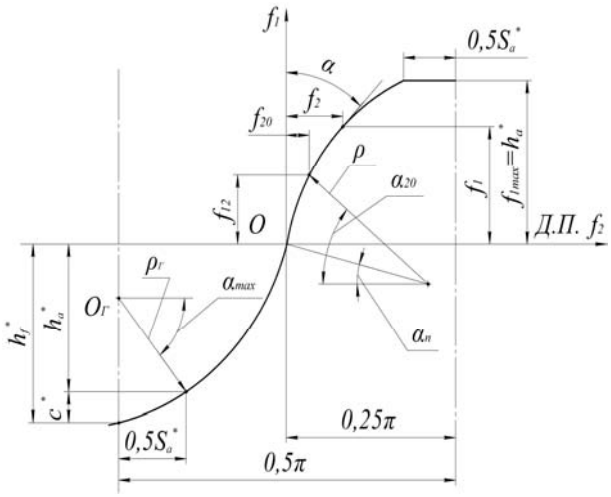

Fig. 2. Original profile ($m = 1$ mm, *ДП* – pitch line)

It equals :

$$\rho_\Gamma = 0{,}5S_a^*\sqrt{1-(f_{2\max}')^2}, \qquad (18)$$

where: $f_{2\max}'$ – value of the first derivative (14) at $f_1 = f_{1\max}$;

$$S_a^* = 0{,}5\pi - 2f_{2\max}, \qquad (19)$$

$f_{2\max}$ – value of function f_2 from (14) at $f_1 = f_{1\max}$.

Radial clearance in gearing of gear wheels is determined by value C^* which equals:

$$C^* = \rho_\Gamma\left[1 - \frac{f_{2\max}'}{\sqrt{1+(f_{2\max}')^2}}\right]. \qquad (20)$$

CONCLUSIONS

1. Recommendations for synthesizing the original profile reducing friction in teeth gearing have been developed.

2. Geometrical parameters of the original profile which permits to reduce energy capacity of the toothed gearing have been determined.

REFERENCES

1. **Shishov V.P. Nosko P.L., Fil P.V., 2006.:** Theoretical foundation for synthesis of gear transmission: Monography. – Luhansk: Publishing House of East-Ukrainian Volodymyr Dahl National University. – 408 pp
2. **Shabanov I.R., 1967.:** On toothed gear with conchoidal line of gearing Durability and quality of toothed gearing. – NII TYAZHMASH. 18-67-106. –p. 1-8
3. **Anikyn Y.V.. 1975.:** Sinusoidal gearing – Voronezh: Publishing House of Voronezh State University. – 56 pp
4. **Bashansky M., Tokoli P., Vanya F., Kozhuh I., 2011.:** Possibility of use of non-involute gearing in the gearbox of agricultural machines Bulletin of NTU 'KhPI' - Kharkiv: NTU 'KhPI' . – 2011. - №29. – p.21-30
5. **Shishov V.P. Nosko P.L., Muhovatiy A.A., 2011.:** Highly loaded toothed gearing Bulletin of NTU 'KhPI' . – 2011. - №28. p. 180-186
6. **Protasov R.V., Ustinenko A.V., 2011.:** Research of overlapping coefficient of non-involute transmission Bulletin of NTU 'KhPI' . – №29. – p. 154-165
7. **Vinberg E.V., 1980.:** Polynomial algebra – M.: Education, 1980. - 176 pp
8. **Shishov V.P., Tkach P.N., Revyakina O.A., 2000.:** Cutting of teethsof cylindrical cogwheels with the generalized geometry. Lugansk, Visnik East Ukrainian national University. - №9(31). – p. 227-229
9. **Shishov V.P., Pilipec D.A., Revyakina O.A., Muhovaty A.A., 2001.:** About factors of overlapping of cylindrical tooth gearings with corcet and arch teeths. Lugansk, Visnik East Ukrainian national University. - №2(36). – p. 144-147
10. **Shishov V.P., Fil P.V., Revyakina O.A., Muhovaty A.A., 2001.:** The geounderground – kinematic indicators of cylindrical tooth gearing with arch teeths. Lugansk, Printing House of EUNU. The collection of proceedings: Resursosberegajushchie technologies manufactures and processings pressure of materials in mechanical engineering – p. 193-200
11. **Shishov V.P., Fil P.V., Revyakina O.A., Muhovaty A.A., 2001.:** The loaded tooth gearings with arch teeths. Lugansk, Visnik East Ukrainian national University. - №6(40). – p. 217-222
12. **Shishov V.P., Revyakina O.A., 2001.:** Definition of losses a friction in gearing of cylindrical wheels with arch teeths. Kharkov, Visnik National Technical university «KhPI». The thematic collection of scientific works «Technologies in mechanical engineering». - №12. – p. 41-48
13. **Shishov V.P., Pilipec D.A., Revyakina O.A., Muhovaty A.A. 2001.:** Cylindrical tooth gearings with extreme geometrical kinematic indicators. Lugansk, Visnik East Ukrainian national University. - №11(45). – p. 143-147
14. **Shishov V.P., Tkach P.N., Sklyar U.A., Tkach I.G., 2009.:** Geometrokinematichesky criterion for synthesis of the loaded cylindrical transfers with direct teeths. Odessa, The Odessa national polytechnical university. The podemno-transport technics №3 (31), - p.109-114
15. **Shishov V.P., Nosko P.L., Tkach P.N., Sklyar U.A., 2009.:** Bases of syntesis of a target contour of cylindrical tooth gearings with the raised wear resistence of wheels. . Kharkov, Visnik National Technical university «KhPI». The thematic collection of scientific works «Technologies in mechanical engineering». – p. 171-176
16. **Sklyar U.A., 2010.:** Geometrical criteria conhoidal transfers with displacement of an initial contour. . Kharkov, Visnik National Technical university «KhPI». The thematic collection of scientific works «Technologies in mechanical engineering». - №27. – p. 162-167
17. **Shishov V.P., Revyakina O.A., Tkach P.N., Sklyar U.A., 2010.:** Criteria of working capacity rod transfers with displacement rod. Kharkov, Visnik National Technical university «KhPI». The thematic collection of scientific works «Technologies in mechanical engineering». - №26. – p. 187-194
18. **Shishov V.P., Tkach P.N., Muhovaty A.A., Sklyar U.A., 2010.:** Geometrical kinematic criteria of cylindrical transfers with direct teeths at displacement of an initial contour. Odessa, The Odessa national polytechnical university. The podemno-transport technics №2 (34), - p.31-37
19. **Shishov V., Nosko P., Revyakina O., Muhovaty A., Karpov A., 2010.:** Teeth geometry of arched transmissions within initial contour shift TEKA Commission of Motorization and Power Industry in Agriculture, p. 279-286
20. **Shishov V., Nosko P., Revyakina O., Muhovaty A., Fil P., 2010.:** Geometrical and kinematic criteria of arched transmissions within initial contour shift TEKA Commission of Motorization and Power Industry in Agriculture, p. 287-293

СИНТЕЗ ЗУБЧАТЫХ ПЕРЕДАЧ С ПОНИЖЕННОЙ ЭНЕРГОЕМКОСТЬЮ

Александр Муховатый

Аннотация. Разработаны рекомендации по синтезу исходного контура, обеспечивающего снижение сил трения в зацеплении зубчатых колес, определены геометрические параметры такого исходного контура.

Ключевые слова. Синтез, исходный контур, энергоемкость, скорость скольжения, зубчатая передача.

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The prediction of myocardial infarction consequences as a result of vectorcardiography research using «Decision trees» data mining algorithm

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S u m m a r y . The article represents the possibility of the new MTM-SKM cardiodiagnostic complex use in the acute myocardial infarction diagnostics. The prognostic criteria for adverse prognosis in acute coronary pathology can be a small group of vectorcardiogram indicators, found with the help of "Decision trees" data mining algorithm.
K e y w o r d s : vectorcardiography, "Decision tree" algorithm, prediction.

INTRODUCTION

Widespread coronary heart disease has become the most important health issue of our time. Today the largest part of mortality structure belongs to the diseases associated with the circulatory system [Musayeva, Belaya 2011]. At approximately 5% of patients hospitalised with acute chest pain acute coronary syndrome is impossible to recognize, which causes the development of myocardial infarction (MI); the mortality rate, however, remains relatively high in the world, as well as in Ukraine. Therefore, it is especially important to find early MI diagnostics methods. In this regard, the new hardware diagnostic methods together with information technologies can detect cardiac abnormalities in cases where conventional methods of laboratory and instrumental diagnostics can not provide any comprehensive information for early diagnostics and the possibility to predict the disease development [Parkhomenko 2010, Tseluyko 2009, Kopitsa 2011, Yang 2011, Ghista, Acharya, Nagenthiran 2010, David Strauss, Charles Olson, Katherine C. 2009] .

In recent years, MTM-SKM polygraph has been used to study the electromotive force of the heart (EMF) changes in patients with acute myocardial infarction period at Luhansk Clinical Multihospital № 1, that combines electrical (ECG) and vektorkardiography (VCG). The device is designed by Severodonetsk Scientific Production Association "Microterm" together with Volodymyr Dahl East-Ukrainian National University under the guidance of professor B. Yu Dobrin. This method allows to determine the features of the EMF distribution over the surface of the heart in real time except for the "dead zones", and to increase the studied sections of the route up to 3000 times.

OBJECTS AND PROBLEMS

VCG analysis in patients with acute myocardial infarction revealed certain patterns of changes of the heart EMF. Firstly, there is a sudden spatial displacement of QRS loop, especially its initial part, from the infarction localization in the opposite direction. Separate areas or large areas of myocardium, affected by necrobiosis, do not give their portion of normal electrical power and therefore oppositely directed unbalanced electrical forces of intact areas "pull" QRS loop in the opposite direction from the lesions. Secondly, together with acute coronary pathology the direction of QRS loop route changes as the indicator of abnormal spread of excitation wave over myocardium. The process of myocardium impulse conduction can be disrupted in the form of additional QRS loop nodes, as well

as in the concentration of time stamps (the reflection of speed indicators changes). Intersections, convexities, and additional QRS loop poles are formed. In addition, the reduction in the total QRS loop area is typical, that becomes the most distinct in the case of left ventricle aneurysm. Thirdly, unclosed QRS and T loops, as well as ST ECG intervals displacement indicate the unbalanced electrical forces presence in the phase of depolarization/repolarization transition. The positive pole of electrical forces of damage vector is directed to the necrobiosis lesion and is also referred to as ST vector. T loop in acute myocardial infarction may have a normal size, but the decrease of its deviation angle is possible with its direction to the initial part of QRS rout and even further. T loop shape resembles a horseshoe [David Strauss, Charles Olson, Katherine C. 2009, Belaya 2010, Belaya 2011].

Information, received after VCG, enables to confirm the focal myocardial changes and to get the additional information about heart EMF for more objective assessment of myocardium pathological changes [Belaya 2010, Belaya 2011]. The use of data mining can provide a narrow group of VCG parameters that determine an adverse outcome, and to represent consistent pattern in analytical form that will enable the prognosis in patients with atypical acute coronary pathology, uncertain ECG dynamics and questionable laboratory data.

THE DECISION OF THE TASK

To implement this task, Decision Trees data mining algorithm can be used, which is one of the most popular methods in classification and prediction problems solving. Sometimes this data mining method is also called Decision Rules, Classification and Regression Trees. Decision Trees allow to create classification models in cases, where it is difficult for an analyst to formalize knowledge [Berestneva, Dobrianskaya, Muratova 2005, Panchenko 2004, Zubov, Ulshin, Gorbunov 2010, Ulshin, Klimchuk 2010].

There are basic concepts of the Decision Trees theory. One of the first concepts is an object that is observed. The sign of the independent variable is an attribute concept. The dependent variable or attribute that defines the class of an object (the death in this case) is called class label. Node is the internal node of the tree, the check node; leaf is the end node of the tree, the decision node and test is a condition in the node [Akobir Shahidi].

Decision Trees are a way of representing the rules in hierarchical, sequential structure, where each object has a single node that gives the solution.

The rule is a logical construction, presented in the form of "if ... then ...".

All problems solved by the Decision Trees algorithm can be grouped into three types. Description, classification and regression [Murthy 1997]. In this paper we solve the problem of classification, the grouping of objects into one of known classes. Class in this particular case is a logical variable that attributes an object to the "survivors" class or "dead" class.

Learning set T (50 patients) is given, that contains objects (examples), each of them is characterized m attributes (QRS loop clockwise rotation; loops location in the coordinate system; the direction of main vector in the coordinate system; the distinctive route look; the maximum vector size and the loops area; the speed of excitation spread through QRS, P and T loops; the presence of unclosed QRS and T loops; angular divergence of QRS-T and QRS-P loops). One of the attributes indicates that an object belongs to a particular class - dead or survivors.)

The idea of decision trees building from a set T, first proposed by Hunt, will be given according to R. Quinlan [Ross Quinlan 1993].

Let $\{C_1, C_2, ..., C_k\}$ represent the classes (class label value), then there are three situations:

1. The set T contains one or more examples of the same class C_k. Then, the decision tree for T is a leaf that defines class C_k;

2. The set T does not contain any examples, it is empty. Then it is a leaf again, and the class associated with this leaf, is selected from another set, different from T, for example, from the set associated with the parent;

3. The set T contains examples that belong to different classes. In this case, the set T must be divided into subsets. To do this, one of the signs is chosen, that has two or more distinct values $O_1, O_2, ..., O_n$. T is divided into subsets $T_1, T_2, ..., T_n$, with each subset T_i containing all the examples that have value O_i for the chosen sign. This procedure will be recursively conducted until an end set consists of examples of the same class.

The above procedure is the basis for many modern decision trees algorithms; this method is also known as Divide and Conquer.

As all objects have been previously attributed to the known classes, the process of

decision tree building is called Supervised Learning.

The algorithm of decision tree building does not require a user to select the input attributes (independent variables). The algorithm input can use all existing attributes, the algorithm will choose more substantial among them, and only they will be used to build a tree. In comparison with neural networks, for example, it is much easier to work, because neural networks selection of incoming attributes significantly affects the studies [Barseghyan, Kupriyanov, Stepanenko, Holod 2004, Paklin 2012].

Deductor Studio Academic software is used as a tool of data analysis. It is a complete analytical platform.

Thus, with the help of this software the decision tree has been constructed and rules has been formed. About 50 patients, which have been examined earlier, were chosen as an initial data sample.

The results are interpreted with the available visualizers. For a start we will analyze the contingency table (table 1).

Table 1. Contingency table

	Classified		
Factually	False	True	In total
False	36	2	38
True	1	11	12
In total	37	13	50

The examples that have been correctly recognized are located diagonally, in other cells the examples that have been attributed to another class are located. In this case, the tree has correctly classified 47 cases and three cases have been misclassified. We can say that the result has an accuracy of 94% (fig. 1).

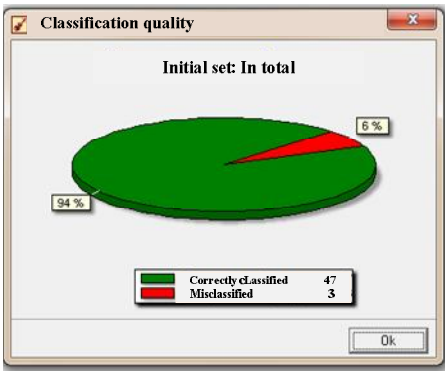


Fig. 1. Classification quality

Move to the main visualizers for this algorithm – "Decision Tree" and "Rules" (fig. 2, 3). Apparently, the decision tree is not very complicated, most factors have been cut off, that is, their influence on the fact of death in patients is minimal or absent. This visualizer allows to see the examples that were grouped to a particular node, and the information on the node.

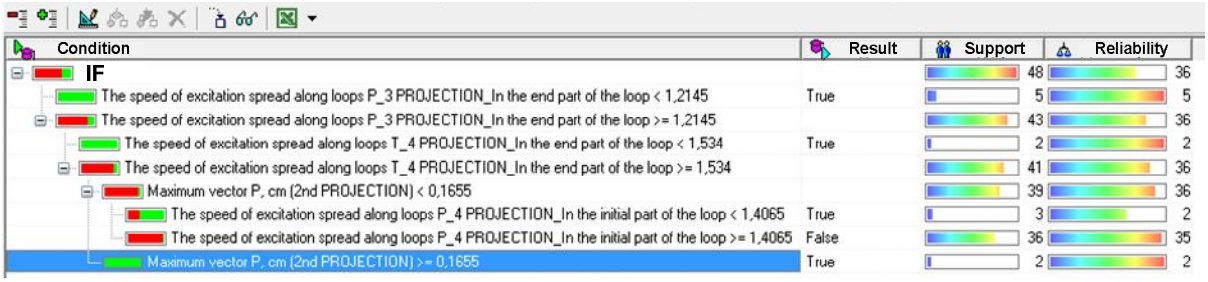
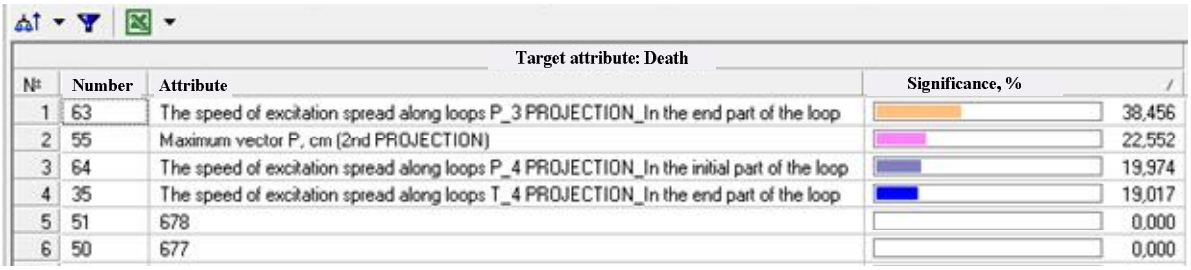


Fig. 2. "Decision tree" tab

№	Rule Number	Condition: Index	Sign	Value	Result: Death	Support: Quantity	Support: %	Reliability: Quantity	Reliability: %
1	1	9.0 The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	<	1,2145	True	5	10,42	5	100,00
2	2	9.0 The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	>=	1,2145	True	2	4,17	2	100,00
		9.0 The speed of excitation spread along loops T_4 PROJECTION_In the end part of the loop	<	1,534					
3	3	9.0 The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	>=	1,2145	True	3	6,25	2	66,67
		9.0 The speed of excitation spread along loops T_4 PROJECTION_In the end part of the loop	>=	1,534					
		9.0 Maximum vector P, cm (2nd PROJECTION)	<	0,1655					
		9.0 The speed of excitation spread along loops P_4 PROJECTION_In the initial part of the loop	<	1,4065					
4	4	9.0 The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	>=	1,2145	False	36	75,00	35	97,22
		9.0 The speed of excitation spread along loops T_4 PROJECTION_In the end part of the loop	>=	1,534					
		9.0 Maximum vector P, cm (2nd PROJECTION)	<	0,1655					
		9.0 The speed of excitation spread along loops P_4 PROJECTION_In the initial part of the loop	>=	1,4065					
5	5	9.0 The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	>=	1,2145	True	2	4,17	2	100,00
		9.0 The speed of excitation spread along loops T_4 PROJECTION_In the end part of the loop	>=	1,534					
		9.0 Maximum vector P, cm (2nd PROJECTION)	>=	0,1655					

Fig. 3. "Rules" tab



Target attribute: Death

№	Number	Attribute	Significance, %
1	63	The speed of excitation spread along loops P_3 PROJECTION_In the end part of the loop	38,456
2	55	Maximum vector P, cm (2nd PROJECTION)	22,552
3	64	The speed of excitation spread along loops P_4 PROJECTION_In the initial part of the loop	19,974
4	35	The speed of excitation spread along loops T_4 PROJECTION_In the end part of the loop	19,017
5	51	678	0,000
6	50	677	0,000

Fig. 4. "The Relevant attributes" tab

It is easier to see the importance of factors or attributes in the Relevant Attributes visualizer (fig 4).

This visualizer demonstrates how much the output field depends on each of the input factors. The more the significance of the attribute is, the larger contribution it makes into the classification. In this case, the largest contribution is the speed of excitation spread over R loop (mV/c) in BA3 in the end part of the loop.

Rules visualizer (fig. 3) represents the complete list of the rules, according to which a patient can be attributed to a particular class.

The data is presented in a table. The fields of the table are [BaseGroup™ Labs Company, 1995-2012]:

- rule number;
- condition that uniquely identifies belonging to a group;
- consequence – is a patient dead or not;
- support - the number and percentage of the original sample of examples that meet this condition;
- reliability - the percentage of correctly recognized examples that meet this condition, the total number of examples that meet this condition.

This table data analysis allows to assert, up 97%, what exactly influences the fact of death, what is the value of this influence (support) and what is the rule accuracy. In this case, it is obvious that of the entire list of rules the most reliable is rule number 4.

IF
The speed of excitation spread over R loop (mV/s) Ba3 in the end part of the loop> = 1.2145
AND
the speed of excitation spread over T loop (mV/s) BA4 in the end part of the loop> = 1.534
AND
the maximum vector value of P loop in mV (cm) Ba2 <0.1655
AND
the speed of excitation spread in R loop (mV/s) BA4 in the initial part of the loop> = 1.4065
THEN
Death = False (belongs to the survivors)

CONCLUSIONS

Thus, the prognostic significant set of vectorcardiography indicators of favourable course of acute myocardial infarction with 97% accuracy, found with "Decision Trees" algorithm, are:

1. The speed of excitation spread over P loop in the end part in BA3 > = 1,2145 mV / s.
2. The speed of excitation spread over P loop in the initial part in BA4 > = 1,4065 mV / s.
3. The speed of excitation spread over T loop in the end part in BA4> = 1,534 mV / s.
4. The value of P loop maximum vector in Ba2 <0.1655 cm

Failure of at least one criteria or group of criteria means absolutely unfavourable outcome. In this case, further research is needed.

REFERENCES

1. **Akobir Shahidi**, Decision Trees Internet Resource - general principles. Access mode. http://www.basegroup.ru/library/analysis/tree/descriptio/
2. **Barseghyan A., Kupriyanov M., StepanenkoV., Holod I., 2004.:** Methods and models of data analysis: OLAP and Data Mining. St. Petersburg.: BHV-Petersburg, 336.
3. BaseGroup™ Labs Company, 1995-2012.: Internet resource. Analyst's Guide Deductor 5.2. Download mode www.basegroup.ru/download/guide_analyst_5.2.0.pdf
4. **Belaya I., 2010.:** The value of Policardiography in myocardial infarction complications prediction. Ukrainian therapeutic magazine, № 3, p. 101-106.
5. **Belaya I., 2011.:** System approach to the acute period of myocardial infarction diagnosis. Russian cardiological magazine, № 4 (90), p. 46-52.
6. **Belaya I., 2011.:** Vector-electrocardiographic parallels in the diagnosis of myocardial infarction. Heart and blood vessels, № 3, p. 105-117.
7. **Berestneva O., Dobrianskaya R., Muratova Ye., 2005.:** Application of Data Mining technology in labor outcome prediction. Reports of the XII All-Russian

Conference Mathematical Methods for Pattern Recognition MMRO-12, Moscow.
8. **David G. Strauss, Charles W. Olson, Katherine C., 2009.:** Wu et al. Vectorcardiogram synthesized from the 12-lead electrocardiogram to image ischemia. J. of Electrocardiol, Vol. 42, № 2, p. 190-197
9. **Ghista D., Acharya U., Nagenthiran T., 2010.:** Frontal plane vectorcardiograms: theory and graphics visualization of cardiac health status. J. Med. Syst., Vol. 34, № 4, p. 445-458.
10. **J. Ross Quinlan. 1993.**: C4.5: Programs for Machine learning. Morgan Kaufmann Publishers.
11. **Kopitsa N., 2011.:** Fast identification and prognosis in patients with acute coronary syndrome. Ukraine therapeutic magazine, № 1, p. 102-106
12. **Musayeva E., Belaya I., 2011.:** Analysis of existing methods of acute coronary syndrome prediction. Journal of Volodymyr Dahl East-Ukrainian National University, № 2 (156), S. 360-364.
13. **Paklin N., 2012.:** Business Intelligence: From Data to Knowledge: Tutorial - 2nd ed., Corrected, St. Petersburg.: Peter, 704.
14. **Panchenko M., 2004.:** Development of mathematical, algorithmic and program software for decision making in various fields based on the Decision Trees method tree: dissertation for the scientific degree of Candidate of Technical Sciences: spec. 05.13.06 "Automated systems and advanced information technologies", Kyiv, 16 p.
15. **Parkhomenko A., 2010.:** The problem of myocardial infarction in 2009: Making new discoveries, do not forget about available opportunities. Health of Ukraine, № 4 (233), p. 16.
16. **S.Murthy, 1997.:** Automatic construction of decision trees from data: A Multi-disciplinary survey.
17. **Tseluyko V., 2009.:** A complex clinical case. How to make the correct diagnosis? Health of Ukraine, № 17 (222), p. 18.
18. **Ulshin V., Klimchuk S., 2010.:** Decision support system for bridge granes diagnostics on the basis of cases. TEKA Commission of Motorization and Power Industry in Agriculture, V. XD, p. 5-14.
19. **Yang H., 2011.:** Multiscale recurrence quantification analysis of spatial cardiac vectorcardiogram signals. IEEE Trans. Biomed. Eng., Vol. 58, Issue 2.- p. 339-347.
20. **Zubov D., Ulshin V., Gorbunov A., 2010.:** Analogue complexing algorithm's usage in Data Mining. TEKA Commission of Motorization and Power Industry in Agriculture, V. XD, p. 81-90.

ПРОГНОЗИРОВАНИЕ ИСХОДОВ ИНФАРКТА МИОКАРДА ПО РЕЗУЛЬТАТАМ ВЕКТОРКАРДИОГРАФИЧЕСКОГО ИССЛЕДОВАНИЯ ПРИ ПОМОЩИ АЛГОРИТМА DATA MINING «ДЕРЕВО РЕШЕНИЙ»

Эвелина Мусаева, Инна Белая

Аннотация. В статье представлены возможности использования нового кардиодиагностического комплекса МТМ-СКМ в диагностике острого инфаркта миокарда. В качестве прогностических критериев неблагоприятного течения острой коронарной патологии может быть использована выделенная с помощью алгоритма Data Mining «Деревья решений» узкая группа показателей векторкардиограммы.

Ключевые слова: векторкардиография, алгоритм «Деревья решений», прогноз

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Increasing the industrial locomotives resource by improving technologies of the crankshaft engine rehabilitation

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Summary. The technological process of renewal of crankshafts of large diameters is described by the method of polishing and induction hardening of necks. The stages of technological process are described in detail, a flow-chart is built.

Key words: technological process, crankshaft, peening, polishing, quirk, neck of billow, oily channel, nitrided layer

FORMULATION OF THE PROBLEM.

One of the most pressing problems of Ukrainian railways is the physical and mental aging of locomotive fleet. The resource of previously issued locomotives has been exhausted, so the technical services of Ukrzaliznytsya had to develop a strategy of providing the traffic on the railways of the country. The Ukrainian Cabinet of Ministers approved the locomotive fleet renewal program of the Ukrainian railways for 2012-2016. [1, 14]. The purpose of this program is to upgrade the locomotive fleet of the railways of the country to ensure a smooth transportation of passengers and cargo. Given the state of the Ukrainian economy and the distribution of operating costs for rail locomotive economy prospects replacing the worn-out locomotives with the new ones, more fuel-efficient, id unlikely. The most realistic way is the modernization of the existing locomotives. The problem of renewal of the traction rolling stock will be addressed, in addition to the development and procurement of the rolling stock of the new generation, in two areas [2, 3, 4, 20]:

- improving the efficiency and the use of the existing rolling stock through the *modernization and reduction of non-working park;*
- lengthening the service life of the existing rolling stock by performing the overhaul and refurbishment.

The same way chose the industrial enterprises engaged in a substantial amount of in-plant rail.

Crankshaft, without doubt, is one of the main, if not the most important, engine parts, that determines its reliability and durability. This is easily seen, if to compare the price of the crankshaft to the price of any other engine parts. [5, 13] Therefore, the crankshaft repair in the case of its damage during the usage of the locomotive is economically more advantageous than buying a new one. The technological process of repair and restoration of the crankshaft provides not only a remedy in the operation of geometric parameters, but also, and mainly, the containment of the destructive processes that naturally occur on the surface of its part. It means, for sufficiently large number of ways to restore the crankshaft, the urgent task still is to find new and effective repair technologies providing increase of their working surfaces.

ANALYSIS OF THE LATEST RESEARCHES AND PUBLICATIONS.

For recovery of the worn crankshafts the treatment for repairing size is the most commonly used. The essence of the method – the treatment of the crankshaft damaged surfaces in order to repair the damages, without changing the detail's geometrical axis [5]. The advantage of the method is its simplicity and low cost, as no additional

metal and sophisticated equipment is needed. The disadvantage of the method stems from the fact that the depth of the hardened layer necks, initially, in the manufacture of shafts, as a rule, does not exceed 0.25-0.4 mm, and reconstruction measures differ from one another in 0.25-0.5 mm in diameter, starting from the second repairing size, due to removal of the hardened layer of metal wear, the crankshafts rate wear rate of the main and connecting rod journals grows, which dramatically reduces the service life of the engine.

In order to overcome this limitation the re-nitriding recommended to use, but it has disadvantages, such as the duration of the process, the hazards of production, the use of high temperatures and deformation of hardened parts, and, consequently, the increase in allowances for machining, as well as high energy consumption[6].

Over the past several decades, the extensive use of non-traditional methods of hardening the details increased durability and strength characteristics of products, one of which is a discrete hardening. The method involves setting up a working surface of the detail with alloy materials in the form of spaced apart lines of all possible configurations etc. According to the research the result is a significant in - 1.5-3.5 times increase in wear resistance of samples surfaces with discrete hardening. This method is used to improve the wear resistance of the necks within the nitrided layer[5].

The method of discrete hardening is only applied within the removed layer of 2 mm in diameter, in practice. Because of the use of low quality oils, lack of proper oil level control, and late replacement of the filters, continuous operation of the engine at maximum output, etc., 10-15% of the crankshaft get damages indigenous or crank pins in the form of cracks, deep scoring, the size of which comes to 3 - 3.5 mm in diameter, such crankshafts cannot be restored using the above method [19].

Therefore, for diesel engines new, more advanced methods of restoration of crankshafts are needed. It is offered to repair these crankshafts by the method of grinding with subsequent induction hardened HDTV.

Technological processes of recovery of small size crankshafts for engines of the automobiles and tractors and described in the literature [6, 7, 8, 9, 15]. Repair and restoration of large crankshafts for diesel locomotive has a coherent description of the structure, there are only descriptions of the individual processes.

THE PURPOSE OF THE ARTICLE

The application of the method of grinding and induction hardening of the necks during the recovery of large diameter crankshaft used on diesel 5D49. Holistic description of the process of restoring the crankshaft 5D49 diesel by the method of grinding and induction hardening of the necks. Crankshaft 5D49 diesel engine is part of the shaft group with a diameter of the main and connecting rod journals from 150 mm to 300 mm, which are used in shunter locomotives in metallurgical, chemical, mining and other industrial plants.

During the operation these crankshafts work surface necks is damaged in depth up to 1.3 mm in the form of wear cracks, dents, corrosion.

Materials and research results. Preparatory step crankshaft recovery technology by using the method of grinding and induction hardening of the necks are works on the cleaning, pre-stripping and "sanding" of all its necks. These transactions are made in order to prepare the shaft for detailed measurement and research, which will enable to produce all repairs and restoration operations in high quality.

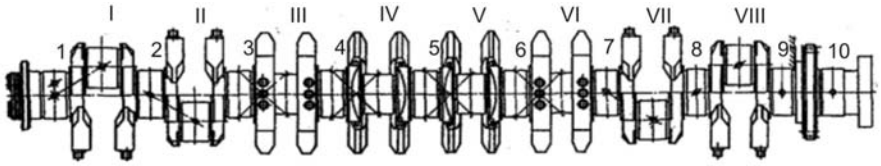
The first step is to carefully measure the shaft necks, to conduct the damage and visual inspection, the results of which are recorded in a defect paper (table 1) [17].

Next is the disassembly of the shaft, the removal of balances for this the shaft is mounted on a stand, the installation marking of the balances is checked, and it is restored if it is absent.

The next step in the restoration of the crankshaft is gagging on a special stand. In order to hold the shaft gaging should the amount of each main necks beats in 2 planes should be measured. The shaft gaging is made in order to preserve the "natural axis" and to provide a uniform metal removal at the reducing shaft necks [10]. Many manufactures do not pay attention to the deformation of the crankshaft. They take and polished curves crankshafts, and think that they would become straight after that. And that's enough. But it is not. As, at the ends of the crankshaft there are seating surface gears, pulleys, flywheels, and the working surface of the packing. All of these surfaces after repairing the crankshaft grinding are misalignment to the main necks, it means they acquire mutual beating. In addition, this crankshaft in further operation "remembers" its correct position and returned to it, and therefore, once again comes into disrepair.

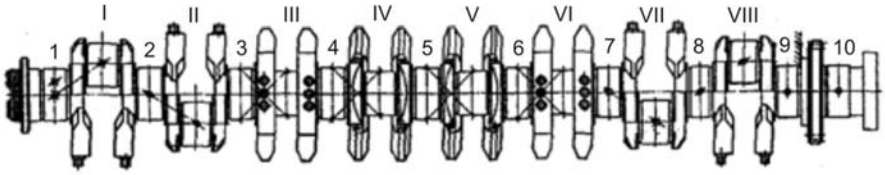
Table 1. Defect sheet of the crankshaft,

that is given in for repair according to the agreement №_____ from _____year
diesel locomotive №_____section_____diesel_____№_____ crankshaft №____
place of examination_____ date_____



measuring diameters of indigenous necks should be performed at the location of the 1st and 8th crank necks at the upper position (see the figure)

beating of the indigenous necks relating the axis	Number of neck	diameter indigenous necks	Diameter of indigenous necks, mm									Notes
			Size from drawing∅ 220									
			Waist of measuring									
			A-A			B-B			C-C			
			Plane of measuring									
			I-I	II-II	III-III	I-I	II-II	III-III	I-I	II-II	III-III	
	1											
	…											
	10											



measuring diameters of indigenous necks should be performed at the location of the 1st and 8th crank necks at the upper position (see the figure)

Number of neck	Diameter of indigenous necks, mm Size from drawing ∅ 190									Notes
	Waist of measuring									
	A-A			B-B			C-C			
	Plane of measuring									
	I-I	II-II	III-III	I-I	II-II	III-III	I-I	II-II	III-III	
1										
…										
8										

Representative of the customer_____ Representative of the executive

Now it is needed to conduct the work on the crankshaft preparing to quenching HDTV: cut and cement the fillet damaged necks, re-check or correct the axis of the crankshaft, by grinding to remove the defects (scratches, cracks, flows, etc.) on a damaged necks. In preparation for the restoration of damaged necks the attention should be paid to completely remove the nitrided layer from them. Particularly the removal of the nitrided layer is checked in oil canals of the damaged necks to a depth of 40 mm. This is done so that when hardening HDTV not to created the conditions for the appearance of cracks in the oil canals.

Next, the shaft should be put on a special rig on hardening HDTV crankshaft necks (fig. 1)

Before you begin the process of hardening it is necessary to isolate the inductors from possible closure. It is done using protective devices made from fiberglass, which isolate the inductor from the cheeks of the crankshaft. On broken neck the protection device is installed in a copper cap (fig. 2), which is put into the oil canal tightly and secured by a special pin. The protrusions of the pins are gashed with the surface of crankshaft neck. Then the surface of the neck and the cheeks is cleaned from copper shavings and dirt, and the

degreasing is done. The next step is setting the inductor, withstanding the necessary gaps by connecting the inductor to the power supply, water cooling of the setup.

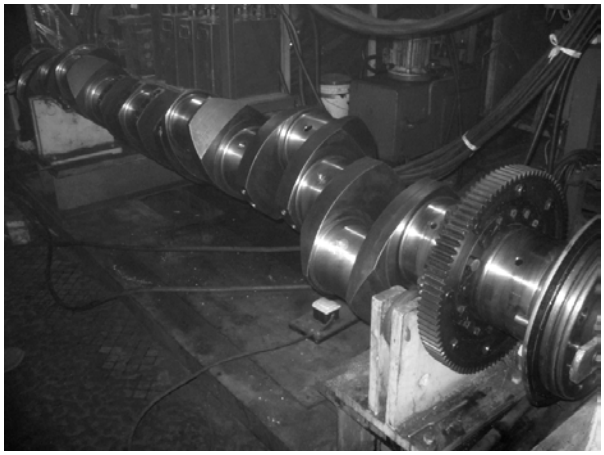


Fig. 1. The setting of the shaft on a special stand

Fig. 2. A copper pin, installed on the damaged neck and polish flush

Immediately before the actual process of tempering it is necessary to make testing:

- of the isolation of the rotating parts of the shaft and the inductor with OM-meter;
- the feed rate of inductor on the length of the quenched neck;
- the voltage and current on the inductor.

After testing the hardening of the crankshaft is performed according to the technological regimes (fig. 3). Then, the cooling of the shaft is conducted in position on the cheeks reduction (fig. 4).

The removal of inductors after hardening is permitted, and it is necessary to prevent the ingress of water from the inductors on the surface of the neck.

After quenching the hardness is checks, the protection is removed and the oil canals are gashed on the depth of the nitrided layer removal that is followed by a test for cracks. After quenching HDTV, before finishing sanding, it is necessary to re-establish the axis of the shaft by editing.

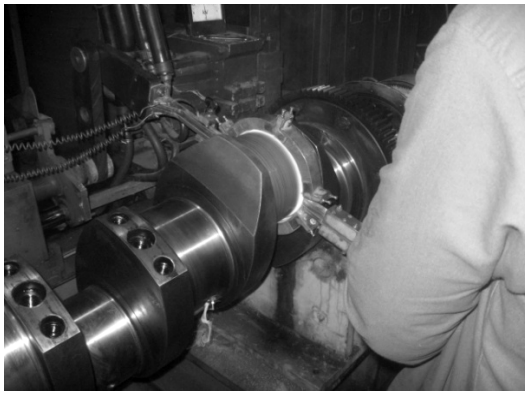


Fig. 3. Induction crankshaft hardening

Fig. 4. Hardened crankshaft radical necks

After the final sanding it is mandatory to blunt a radius of 2 mm of oil canaledge to the surface of the neck [11]. This edge is needed to be cemented, by polishing the surface of the necks which should be brought up to the required amount of surface cleanliness. The crankshaft must necessarily pass the penetrant for cracks, the measuring of diametrical sizes to match the size of the drawing, as well as the axial and axial and end face beats. [12]

Fig. 5. Shaft construction on a special stand

Fig. 6. Preserved crankshaft

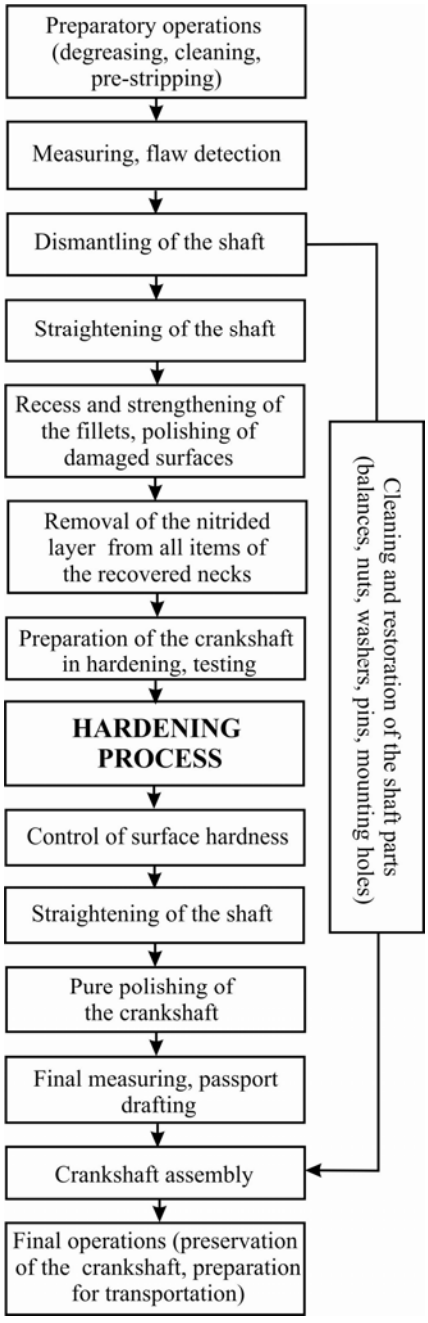


Fig. 7. The technological process of the crankshaft recovery by the method of quenching HDTV

The final stage of the process is construction of the shaft on a special stand. Counterweights are installed in accordance with the marking on the places. The studs and tighten are screwed with a special key with the use of a small-sized hydraulic tool (press) (fig. 5) The crankshaft, having last overhaul and refurbishment should be carefully preserved, so that during the storage and transport its surface does not corrode (fig. 6).

The entire cycle of recovery of the crankshaft is implemented in the new process (fig. 7).

CONCLUSIONS

1. This method allows to recover 20-40 crankshaft per year, in condition that the repair cost will not exceed 40-60% of the cost of a new crankshaft, this method can be considered appropriate.

2. Holistic process for recovery by using the method of grinding and induction hardening of the crankshaft necks 5D49 gives the opportunity to optimize the recovery process of large diameter shafts. 5D49 shaft is a part of the shafts with a diameter of main and connecting rod neck from 150 mm to 300 mm, which are used in shunter locomotives in metallurgical, chemical, mining and other industrial plants.

REFERENCES

1. **Nechaev G.I. Balitskaya O.M., 2011.:** Improving the performance of the rolling stock by improving the technology of repair its units. - Visnyk of ENU named after V. Dal. - № 4 (158) part 2. - p. 126-131.
2. **Nechaev G.I. Balitskaya O.M., 2011.:** Perfection of technology of repair of rolling stock of railway transport // Lokomotiv-Inform. - December, p. 68-70.
3. **Dotsenko G.N., 1970.:** Restoring of iron crankshafts using the automatic welding. M., Transportation., 56 p.
4. **Nechaev G., Izotov S., Kaver I. 2010.:** Transit potential of Ukraine. Post-crisis strategy// Teka. Kom. Mot. I Energ. Roln. – OL PAN, 10 D, p. 207-213.
5. **YesenberlinR.E., 1989.:** Major car repair. – M.: Transport, 335p.
6. Instruction manual on repairing the crankshafts by grinding and induction hardening of the necks (TI-RDM/ITAO-07), Moscow.
7. Diesel Crank Shaft 5D49. Repair method of grinding and induction hardening of the necks. Specifications. Poltava regional scientific and technical center of standardization metrology and certification. TU 35.2-01124483-060:2009
8. **Grybinichenko M.V. Dzetsyna A.P., 2007.:** Maintenance and repair of motor vehicles Transport:

Manual. - Lugansk: publ. ENU named after V. Dal, 218 p.

9. **Blokhin, A.S., 2007.:**About the trends in the development of the park trunk locomotives in the 2006-2010. - Railway Transport of Ukraine. - № 1. - p. 9-19.
10. Complex Program of Ukrainian railway rolling stock updates for 2006-2010. - Kiev, 2006. -27 p.
11. **Sergienko N.I., 1999.:**Ways of reduction of the usage expenditure in locomotive economy of Ukrainian Railways - Railway Transport of Ukraine, - № 4.-p. 28-30.
12. **Pushkarev Y.F., Pakhomov E.A., 1985.:** Monitoring and Evaluation of locomotives technical conditions.- M.: Transport, 160 p.
13. **Nikitin E.A., 1987.:** Diesel diagnostics -M.: Engineering, 224p
14. **Korop G., Zaverkin A., Shikun O., 2010.:** Development of procedure of search of rational variant of tehnological treatment of incoming car traffic volume// Teka. Kom. Mot. I Energ. Roln. – OL PAN, 10 A, p. 276-284.
15. **Gonchar B.M., 1968.:** Numerous modeling of diesel working process. - Enerhomashynostroenye., № 7, pp. 34-35.
16. Patent for invention № 2296169 "Method of crankshaft restore with using the method of hardening HDTV"
17. **Nechaev G.I., Balytskaya A.M., 2012.:** Description of technological process of the crankshaft restore of the industrial locomotives. – Visnyk ENU after V. Dal. - № 6 (177) Part 1. - p. 325-333.
18. **Nechaev G.I., Kamel, G.I., Yakovleva A.G., Balitskaya O.M., 2011.:** Decomposition of functional parameters and types of mating surfaces wear of conical tribosystem. - Visnyk of ENU after. V. Dal. - № 5 (159) part 1. - p. 305-310.
19. **Tartakovsky E.D., Goncharov, V.G., Sapozhnikov V.M.,2009.:** Analysis of the existing methods effectiveness of diesel crankshaft 5D49 repair.
20. **Dyachenko S.S., Savchenko B.V., Goncharov V.G., Ponomarenko, I.V., AksenovS.I., Sapozhnikov V.M., 2007.:** Study of diesel crankshaft maintainability. // Lokomotiv-Inform. - August, p. 16-17.

ПОВЫШЕНИЕ РЕСУРСА ПРОМЫШЛЕННЫХ ТЕПЛОВОЗОВ ЗА СЧЁТ СОВЕРШЕНСТВОВАНИЯ ТЕХНОЛОГИИ ВОССТАНОВЛЕНИЯ КОЛЕНЧАТОГО ВАЛА ДИЗЕЛЯ

Григорий Нечаев, Ольга Балицкая

Аннотация. Описывается технологический процесс восстановления коленчатых валов больших размеров методом шлифования и индукционного закаливания шеек. Подробно описаны этапы техпроцесса, построена блок-схема.

Ключевые слова: технологический процесс, коленчатый вал, рихтовка, шлифование, галтель, шейка вала, маслоканал, азотированный слой.

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Ways to increase the energy efficiency of locomotives

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S u m m a r y. This article gives an analysis of the energy reserves of the locomotive, consider using them. The results of theoretical studies on the effect of ozone and hydrogen as a fuel additive on the fuel consumption and toxicity exhaust. The possibility of the use of these additives in the locomotives with regard to their use in the process of obtaining energy electrodynamic braking.
K e y w o r d s. A locomotive, energy reserves, the efficiency, the electrodynamic braking, compressed air energy, the energy of exhaust.

INTRODUCTION

Rate of growth of greenhouse gas emissions over the last twenty years continue to grow. The report of the International Energy Agency (IEA) states that energy-related emissions of carbon dioxide equivalent last year exceeded 30 Gt, which is 5% more than in a record year 2008, (fig 1) [Kick the Habit: A UN Guide to Carbon Neutrality, 2008].

In this case, existing alternative technologies for production and use of energy rather expensive. Analysis of the role of existing technologies to reduce CO_2 emissions has shown that the main effect at this stage of energy is achieved by the introduction of energy saving technologies (fig. 2) [IEA, 2006].

However, despite the huge amount of research work towards the improvement of existing technologies of burning fuels, including in locomotive[Romanov K., 2007], in the last decade there was no breakthrough technology that would fundamentally solve the problem of fuel efficiency and thus reduce the environmental load of emissions. Growth efficiency in the conversion of the chemical energy of fuel into mechanical work for the last 10 years has not changed and remains at the level of 40-50% [Viarshyna H., Volochko A., Pilatau A., Nozhenko E., Izabela A., 2010].

Economic efficiency any kind of transport is determined by the completeness of its technical capabilities, management and economical use of energy resources [Mogila V., Nozhenko Y., Ignatev O., Nozhenko V., 2011].

ANALISIS OF LAST REASEACHES AND PUBLICATIONS

Functioning of the internal combustion engine, locomotive auxiliary systems, a energy wheels in contact with the rail are the main sources of possible energy reserves of the locomotive.

The trend of improving workflow ICE now bears optimization nature, according to the survey presented in [Marchenko A. ets, 2004], and the energy of combustion is only 25% is used for useful (fig. 3) [GREEN CAR CONGRESS, 2005].

Huge spread in recent years for the idea of the use of alternative fuels [Werner K., 1995., Vasilev I.P., 2009, Semenov V.G., 2002, Mysłowski J., Wołoszyn R., 2007], replacing some or all hydrocarbons. However, in most cases, for the successful use of such fuels requires a constructive re-engine or the technology is not enough to get a rational and economically justified. Therefore, in the current realities of the transition to renewable energy sources, relevant research aimed at improving the working process is:

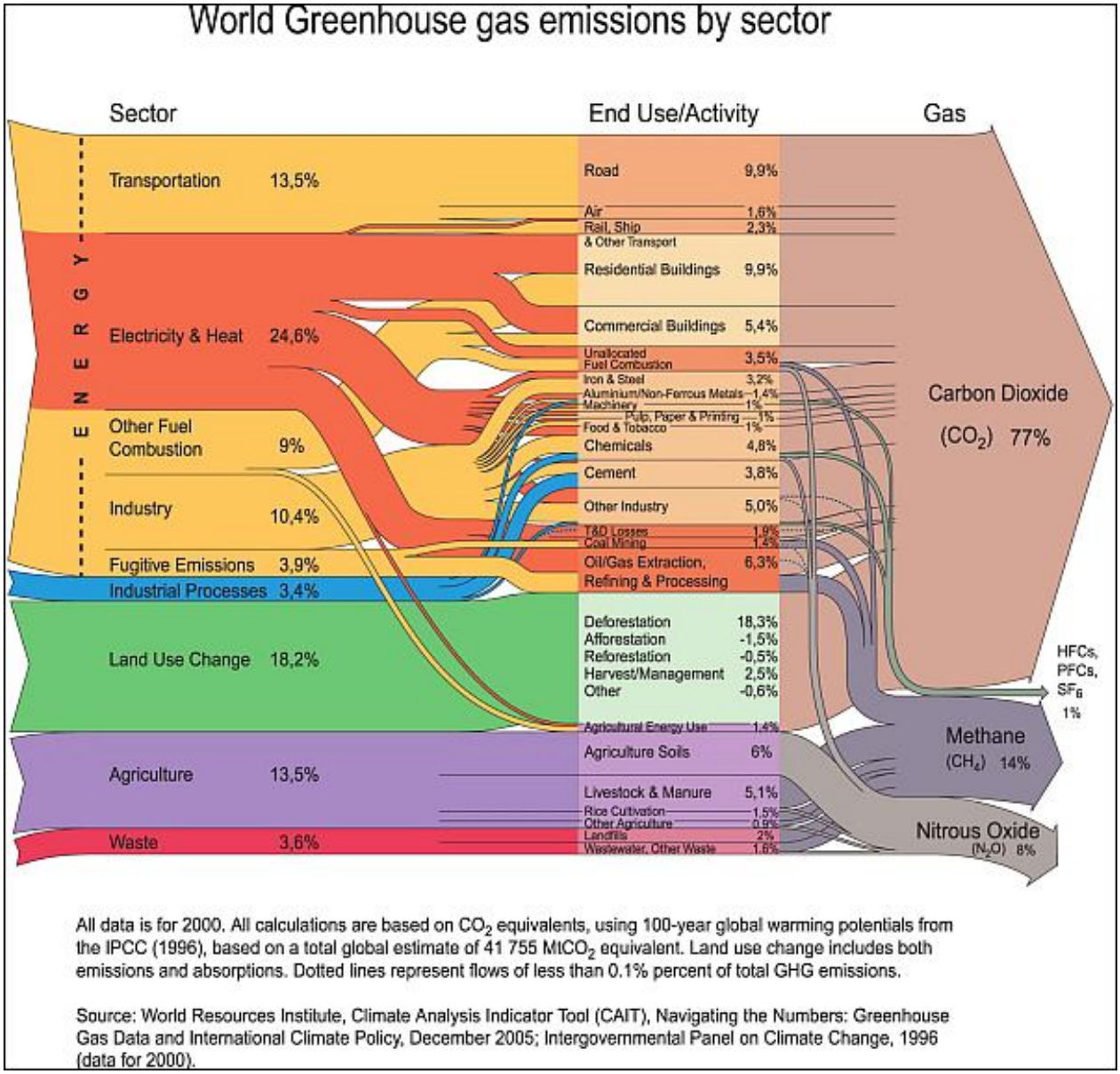

Fig. 1. The structure of the greenhouse gas emissions according to [Kick the Habit: A UN Guide to Carbon Neutrality, 2008].

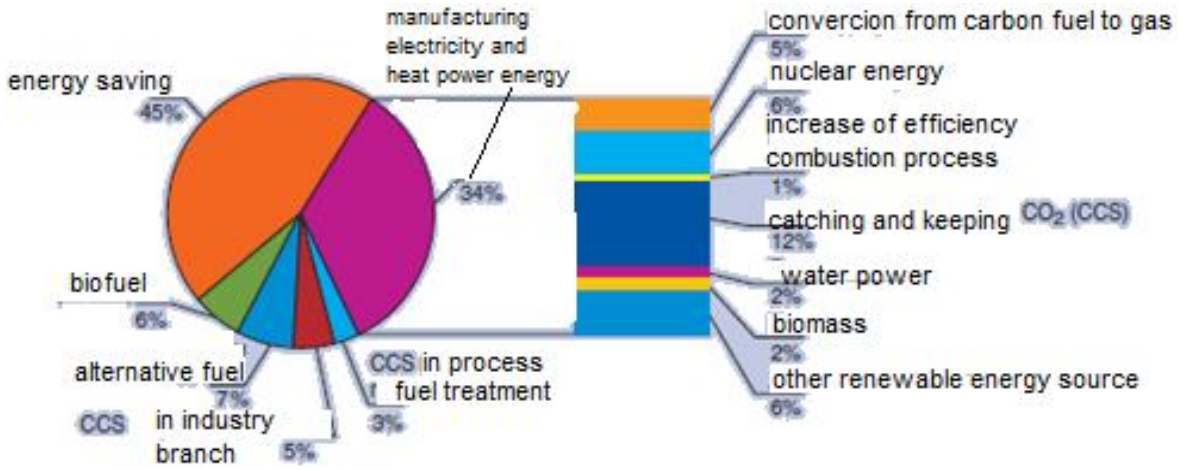

Fig. 2. Measures to reduce greenhouse gas emissions [IEA, 2006.]

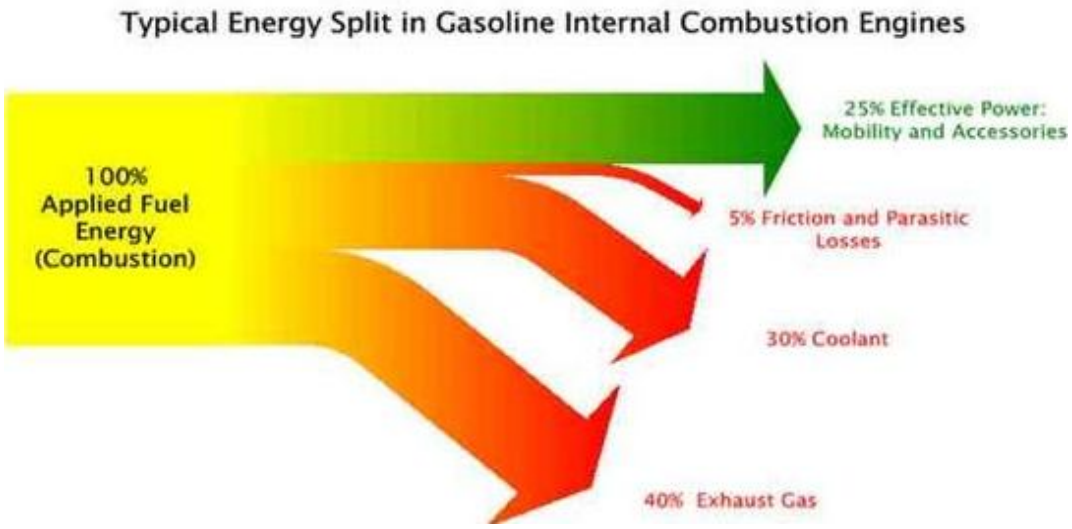

Fig. 3. Diagram of the heat balance of modern internal combustion engines [GREEN CAR CONGRESS, 2005]

- improving the uneven distribution of fuel-air mixture in the cylinders, reducing mechanical losses, improved carburetion fuel mixture by treatment with a variety of ways (handling electric field plasmatron magnetic field, ionization, ultrasound), the use of multi-stage fuel injection, changing the shape of the combustion chamber, a special place of which is the use of additives or change the properties of fuels [Nozhenko E.S., 2010]. Good results in improving the quality of combustion achieved using additives, which increase the cetane number [Danilov A.M., 2004], interesting work aimed at changing the physical and chemical properties of the fuel during engine operation, the so-called physical and chemical regulation [Kaznacheevsky V.L., 2006]. Main problem with such a regulation is to find an activator (catalyst) burning or additives, which to respond to changing conditions of the diesel engine. As this additives can be used ozone and hydrogen for subsequent saturation of fuel. Significant energy reserve lies in the use of energy electrodynamic braking, the maximum value of which is 1 - 1,2 Ne locomotive. [Mogila V., Nozhenko Y., Ignatev O., Nozhenko V., 2011].

The energy of the compressed air in brake system of the locomotive is a energy source on the lokomotives. The preliminary calculations showed that for the train on the basis of the composition of the locomotive 2TE116 60 and freight cars hourly consumption of compressed air braking is 60,000 liters, which are produced in the atmosphere after braking. At the same time, taking into account the power consumption of locomotive compressors on their work for the restoration of the brake system for the issued volume of air required from 540 to 600 kW (depending on the model of the compressor).

In addition, up to 6% of the consumed diesel fuel to drive the cooling fan traction electric motors, which operate in a stationary mode, regardless the position of controller driver and operation of traction electric motors. 4 - 5% of the effective power is spent on fan drive cooling system of the locomotive.

MATERIALS AND RESULTS OF RESEARCHES

- Where is the energy reserves of the locomotive, the above-summarized in the diagram shown in fig. 4. As can be seen from fig. 4, the greatest untapped energy potential is a system of electrodynamic braking of the locomotive.

Analysis of the use of braking energy on the locomotive showed [Nozhenko E.S., 2010], what the efficiency of the electrodynamic brakes do not meet modern requirements for economic criteria:

- 84 - 90% of the energy is absorbed by the braking resistors, which transforms it into heat and dissipate it into the environment;

- other ways to use this energy in the locomotive (the creation of a compression point in a diesel engine, the use of energy storage devices, etc.) proved to be ineffective and therefore do not currently apply.

One of the most effective and promising, in our opinion, the use of braking energy for to accumulate in the energy storage device. This circuit braking energy recovery has the best prospects, after accumulating a huge amount of

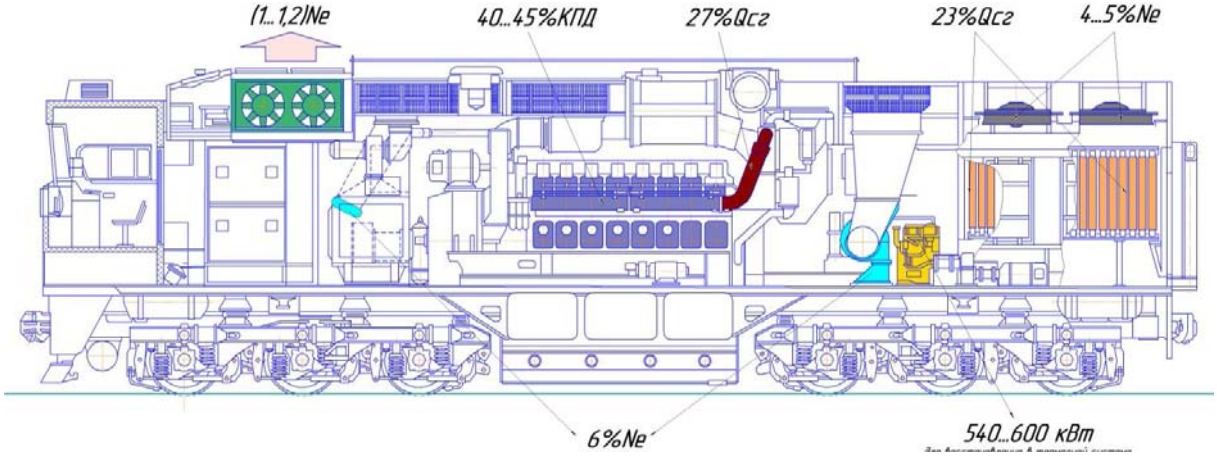

Fig. 4. Analysis of the energy reserves of the locomotive

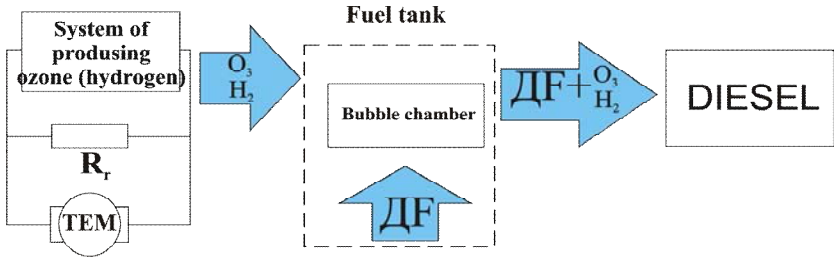

Fig. 5. Energy diagram of of electrodynamic braking for improved fuel economy of diesel locomotive

energy, to use it as needed and eliminates the need for additional storage devices, such as an activated mixture, eliminates the problem of instability of the received energy. However, the use of such devices on a given level of technology is not acceptable, in connection with such a lack of "supercapacitor", its much weight and high cost, which probably does not pay off entirely from regenerative braking. As noted above, one of the most promising ways to improve the locomotive is the improvement of its ICE. The author conducted research on the use of ozone and hydrogen as a fuel additive to reduce its consumption and emissions. One of the obstacles to wide use of these methods in transportation are significant energy cost on production of ozone and hydrogen. This disadvantage can be overcome in a normal operation of the locomotive using electrodynamic braking energy (fig. 5).The authors conducted research on the use of ozone and hydrogen as a additive fuel to reduce its consumption and emissions by the example of diesel generator 18-9DG locomotive 2TE116 . In the calculations the tabulated data rheostat test diesel [Bulygin Y.I., 2006] and the results of experimental and theoretical studies of the effect of ozone on the efficiency of diesel, described in [Nozhenko E.S., 2010., Pilatau A.Y., 2011] and hydrogen - [Vagner V.A., 1984].

Thus, the greatest effect of the fuel ozonation was observed in 11 position of controller driver, where the effective specific fuel consumption decreases by 2,5%. By the method of A.E. Khomich was determined fuel consumption per unit of work done to drive the main generator for the entire time of operation $g_{сэ}$, which for diesel generator 18-9DG at work on ozonized fuel is $g_{сэ}=0{,}233847\ {}^{kg}/_{kW\cdot h}$, and when working on a standard diesel fuel - $g_{сэ}=0{,}23769\ {}^{kg}/_{kW\cdot h}$, from which it follows that the use of ozone in the locomotive diesel average operational fuel consumption is 1.6% (fig. 6).

Specific fuel consumption when operating on fuel saturated with hydrogen, is also reduced by after modeling conducted by the authors. On different modes of decline of 2 - 9 g / (kW · h) (fig. 6). Power on different modes increased by 15 - 25 kW. Significantly reduce emissions of oxides of nitrogen, and the reduction of smoke and soot formation has not happened.

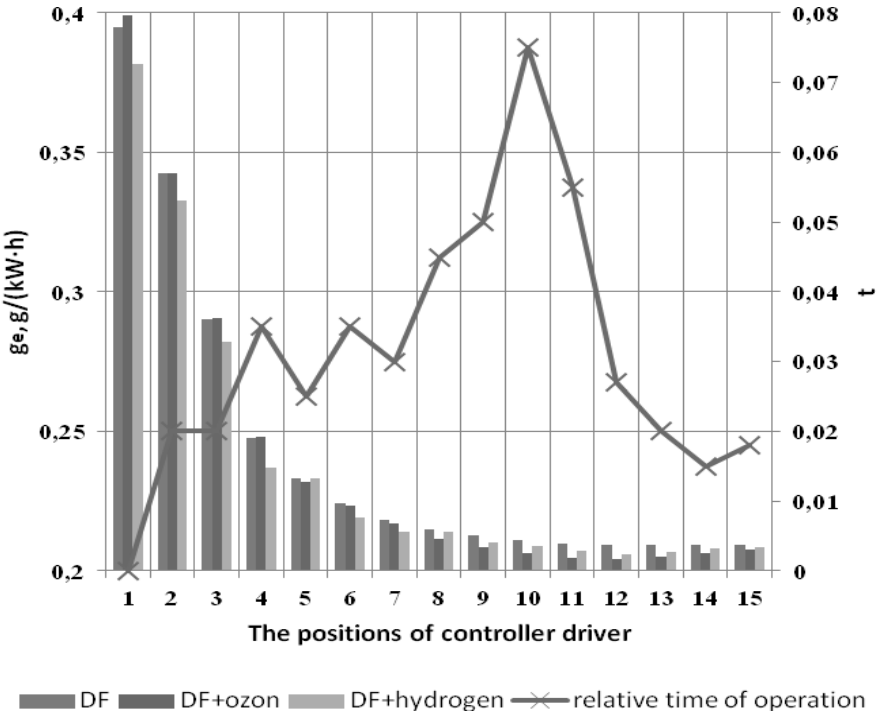

Fig. 6. Changes in specific fuel efficiency for diesel 16GHN 26/26 of locomotive 2TE116U in operation according to the diesel characteristic

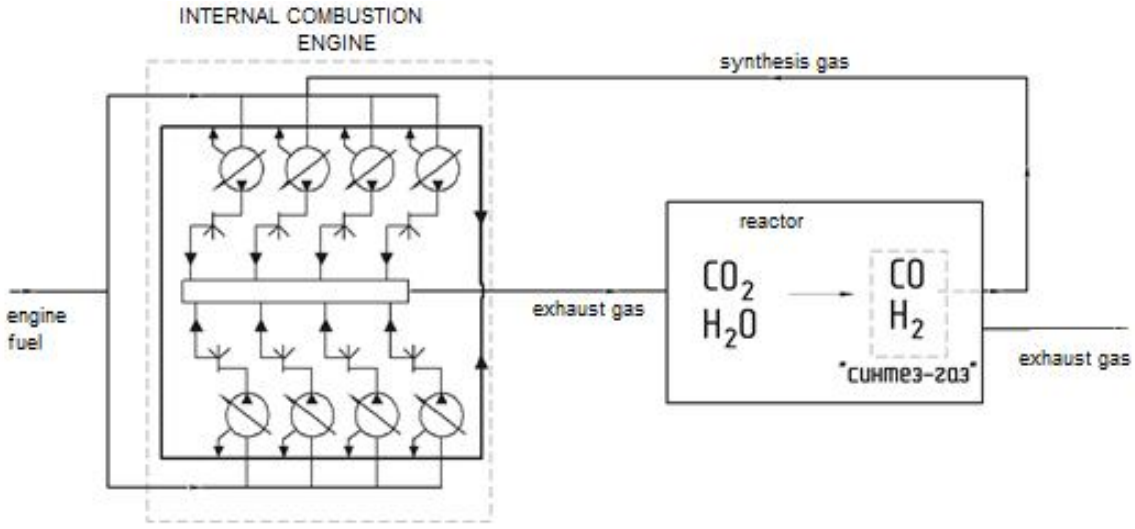

Fig. 7. The diagram of thermochemical reforming during gasification process

One way to improve the energy efficiency of the locomotive can also serve the energy of compressed air brake system of the locomotive. The authors conducted research to develop ways to use the energy of compressed air for:

- cooling the brake discs of the locomotive, in order to reduce energy for a motor-fan cooling them;
- accumulation of air in the pneumatic accumulator and then use on support needs of the locomotive;
- conversion compressed air energy into electricity with subsequent accumulation in the battery;
- the compressed and purified and dried air from the brake system sent in the air supply system of diesel, in order to reduce the cost of cleaning and drying of the air;
- compressed air to cool the braking resistors to reduce the cost of power for a cooling motor-fan;

- the compressed air in the tank to prevent caking, sandbox sand, which will increase the efficiency of the sand system.

Greater energy potential has heat from exhaust gases. The principal schematic of the process for use of diesel exhaust as gasifying agent for the engine based recycling fuel system is presented at fig.7. Burnt gases from an internal combustion engine enter in the carbonic reactor. Process of a chemical reduction of carbon dioxide and water proceed in reaction zone of carbon surface turning to combustible ingredients of syngas (CO and H_2).

For carrying out of researches as prototype the engine of family D245 which is manufactured of Minsk Motor Plant (Belarus) with exhaust gases recirculation is chosen.

On the basis of physical and chemical analysis of the process recuperation it is found [Kravchenko O.P., Lepeshko I.I., Pilatau A.Y., Nozhenko O.S., 2011] that the physical-chemical process is possible in the exhaust manifold engine exhaust gas temperature of about 1400K with exergy efficiency 22-28%. On the basis carried out experimental researches [Sklyarenko E.V., 1988] on a partial mode was found that the total and specific fuel consumption by the same power down to 12%, with the use of conversed fuel to 6%. To determine the performance of the engine for different modes of operation of the engine type, which can work on the synthesis gas is recovered, and to predict efficiency reducing the consumption of diesel fuel it was simulated engine (table 1) in different modes.

Table 1. Parameters of an Engine Scania

Bore, mm	Stroke, mm	Compression ratio	Mode	Power, kW	Engine speed, rpm	Fuel consumption, kg/h	Pressure aspiration, MPa	Inject duration, CA^0
127	160	13	1	25	1800	73	0.25	15
			2	387	1800	8	0.12	10.8

The composition of the synthesis gas recovered by the method [Kravchenko O.P., Lepeshko I.I., Pilatau A.Y., Nozhenko O.S., 2011] is shown in table 2.

Table 2. Synthesis gas composition (% Volume)

CO carbon monoxide	H_2 hydrogen	N_2 nitrogen
34.1	51.1	14.8

Mathematical description of the workflow engine was carried out at the initial stage to the previously developed method [Kucko DR.A., Pilatau A.Y., Tamkovich E.S., 2009] of calculating the diesel engine. The basis of the physical model of the combustion process that has been determine the fact that the combustion process of a diesel engine with the addition of synthesis gas is homogeneous-diffusion process fuel combustion of diesel, which is dominated by this addition its homogeneous component.

The result of the simulation of main diesel engine performance are presented on the fig. 8. The analyze of the obtained results have established that the synthesis gas addition can be increased the maximal cylinder pressure up to 1 MPa and cylinder temperature up to 200 K for the engine especially for the high-boosted mode which result is drawn on the right.

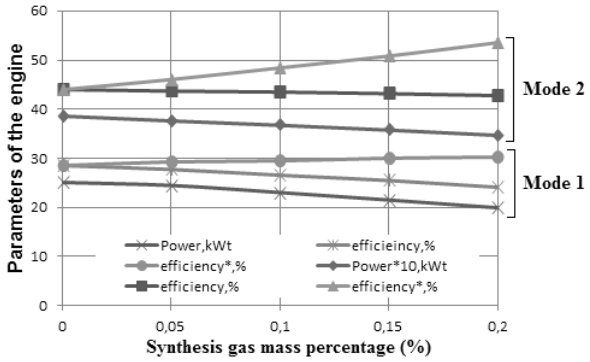

Fig. 8. Simulated diesel engine (table 1) performance. «Efficiency» is an efficiency of the engine with syngas addition through without recuperation. «Efficiency*» is fuel saving as efficiency of the engine with syngas addition through with recuperation.

On the basis of the above, based on an integrated systems approach to solving the problem of energy efficiency of the locomotive, the attempt of construction schemes locomotive with the "ideal" use of its energy resources (fig. 9), which suggested the use of diversified them for the different needs of the locomotive from the use of energy storage, activation work environments, the electrification of sand, hydrogen, ending with production of carbon monoxide from the exhaust gases for use in microclimate and increase towing characteristics, etc.

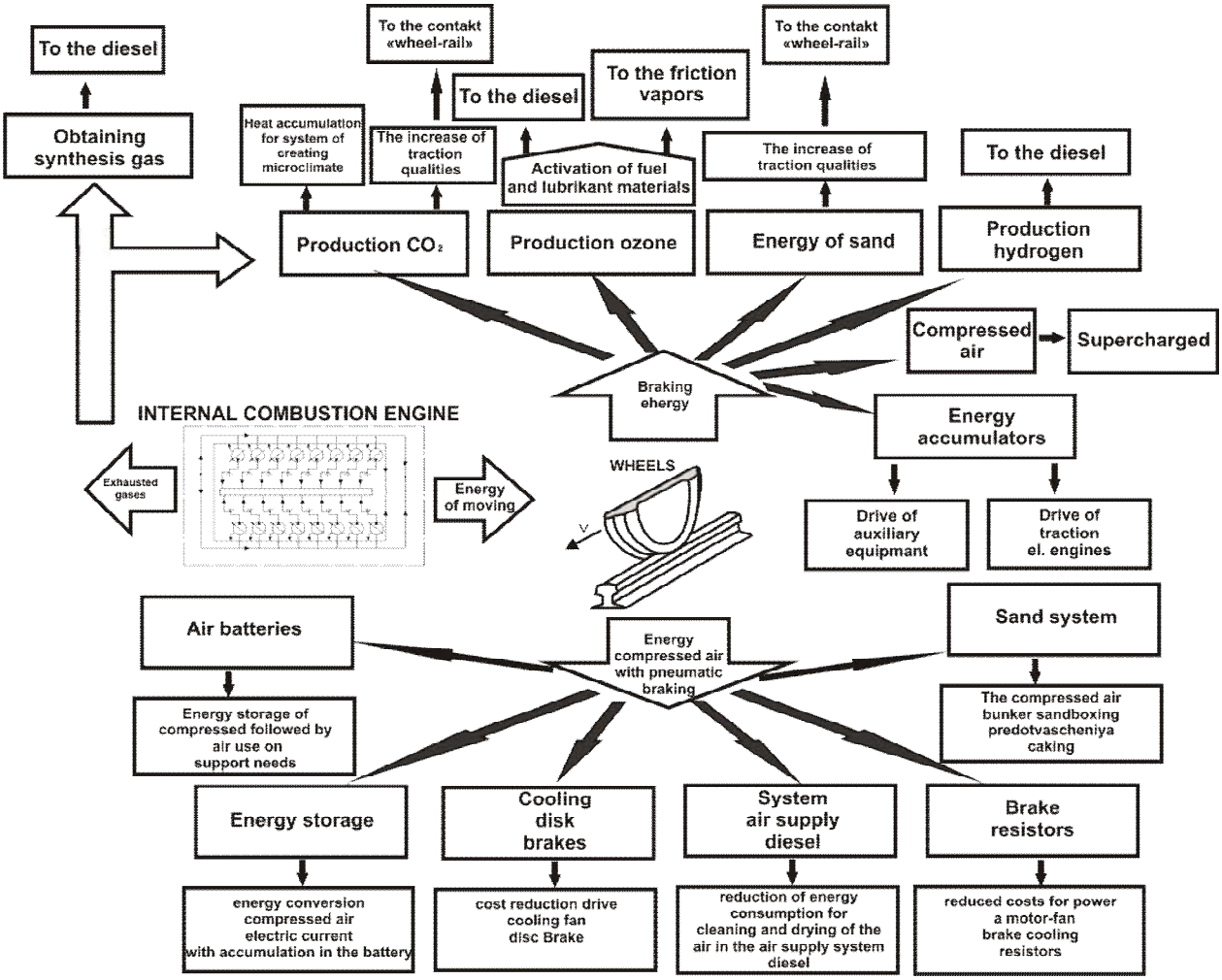

Fig. 9. The scheme of the vehicle with the "ideal" use of energy resources

CONCLUSIONS

The preliminary studies of the energy reserves of the locomotive, allowed to establish possible areas for improvement. In particular, the expediency of using the energy of compressed air exhausted from the brake system, the brake release and directions of use. And also shown that the use of electrodynamic braking energy for improvement engine (production of ozone, hydrogen) and improve contact with the rail wheels (sand electrification, supply of ozonated air).

REFERENCES

1. **Bulygin Y.I., 2006.:** Modeling framework vnutritsilindrovyh processes and toxicity diesel engines, thesis Doctor of Science, Rostov, RSUPS, 548 p.
2. **Danilov A.M., 2004.:** Status and prospects of fuel additives in Russia and abroad, Energy Technology, №2, pp. 7 – 14.
3. GREEN CAR CONGRESS, 2005.: http://www.greencarcongress.com/
4. **IEA, 2006**.: International Energy Agency. Energy Technology Perspectives – 479 pp. www.iea.org.
5. **Kaznacheevsky V.L., 2006.:** Increase energy, economic and environmental quality of diesel 8CH13/14 control of physical and chemical properties of fuels, thesis PhD, Moscow, RUDN, 168 p.
6. Kick the Habit: A UN Guide to Carbon Neutrality, 2008.:
7. **Kravchenko O.P., Lepeshko I.I., Pilatau A.Y., Nozhenko O.S., 2011.:** Mathematical model of diffusive-kinetic renewal of foods of combustion of hydrocarbon fuels, Coll. Donetsk academy of motor transport, vol. 2, pp. 58 – 69.
8. **Kucko DR.A., Pilatau A.Y., Tamkovich E.S., 2009.:** Design of unevenness of rotation of crankshaft on the basis of calculation of process of combustion of multicylinder diesel engine, Coll. scient. reasons of military academy of Belarus, vol. 17, pp. 110 – 117.
9. **Marchenko A. ets, 2004.:** Internal combustion engine, Kharkov, Prapor, 360 p.
10. **Mysłowski J., Wołoszyn R., 2007.:** Search for alternative fuels for combustion engines. TEKA Komisji Motoryzacji i Energetyki Rolnictwa VIIA, p. 80 – 91.

11. **Nozhenko E.S., 2010.:** Improving energy efficiency of the locomotive activation environments, thesis PhD, Lugansk, East-Ukrainian National University named after Volodymyr Dahl, 207 p
12. **Pilatau A.Y., 2011.:** Theoretical justification ozonation fresh charge diesel engine, thesis PhD, Minsk, 2011, 139 p.
13. **Romanov K., 2007.**: Engine-driver of a OPK. RCB, №11.
14. **Semenov V.G., 2002.:** Biodiesel. Physico-chemical characteristics and energy-economic characteristics of the diesel engine, Kharkov, NTU "KPU", 276 p.
15. **Sklyarenko E.V., 1988.:** Analysis of heat in a diesel engine with the addition of the converted fuel, Heat and mass transfer devices, pp. 95 - 98.
16. **Vagner V.A., 1984.:** Improving environmental and economic performance of diesel engines by the saturation of the liquid hydrogen fuel, thesis PhD, Barnaul, 227 p.
17. **Vasilev I.P., 2009.:** Effect of plant fuels for environmental and economic performance of a diesel engine, Lugansk, East-Ukrainian National University named after Volodymyr Dahl, 240 p.
18. **Viarshyna H., Volochko A., Pilatau A., Nozhenko E., Izabela A., 2010.**: Method for combustion control in diesel engines. International Congress of Heavy Vehicles, Road Trains and Urban Transport. Book of Papers. Part .2. Minsk, 2010, pp. 69 - 73.
19. **Werner K., 1995.:** Status and Development of biodiesel production and projects in Europe, SAE Tech. Pap. Ser., №952768, pp. 249 – 254.
20. **Mogila V., Nozhenko Y., Ignatev O., Nozhenko V., 2011.:** Improving the energy efficiency of diesel locomotives by rational using the enegry of electrodymanic, Commission of Motorization and Power Industry in Agriculture "TEKA", Volume XIA, Lublin, pp. 176 – 184.

ПУТИ ПОВЫШЕНИЯ ЭНЕРГОЭФФЕКТИВНОСТИ ЛОКОМОТИВА

Елена Ноженко, Николай Горбунов, Валентин Могила, Александр Пилатов, Вячеслав Черников, Андрей Анофриев

Аннотация. В статье выполнен анализ энергетических резервов локомотива, рассмотрены возможности их использования. Приведены результаты теоретических исследований по влиянию использования озона и водорода как присадки к топливу на расход топлива тепловозом и токсичности его отработавших газов. Рассмотрена возможность применения этих присадок на тепловозе с учетом их получения в процессе эксплуатации при использовании энергии электродинамического торможения.

Ключевые слова. Локомотив, энергетические резервы, КПД, электродинамическое торможение, энергия сжатого воздуха, энергия отработавших газов.

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Experimental measurement complex running gear for research and of interaction conditions rolling stock

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S u m m a r y . The processes occurring in the contact wheel and rail, depends on the work of railway rolling stock. Energy consumption is realized in touch "wheel-rail", and efficient use of this energy depends mainly on the friction on the rail. The article describes the testing equipment enables the investigation of the condition of the chassis and the interaction of the newly created and operated by the Department of rolling stock Railway East-Ukrainian National University. Dal in the laboratory "Friction and lubrication in the drive locomotives"
K e y w o r d s : rail vehicle, test bench, the clutch, the friction coefficient

INTRODUCTION

Evaluation of such technical systems, as rail vehicle, - a very complex task. To solve it, you need not only to select and evaluate the basic properties of the vehicle, such as speed, power, durability, indicators of dynamics, traction and so on, but also to combine them into a single consolidated index. For an objective assessment necessary to determine the factors which may assess the rail vehicle. Given that the primary of function transport is ensuring carrying capacity of freight transportation and high comfort of passenger transportation. It is advisable implement assess by traction and by dynamic qualities (fig. 1). At the same time the clutch wheel the locomotive with rails has a significant effect for traction and dynamic quality of the locomotive.

The problem of friction on the rail is one of the most vital for rail transport [Golybenko A., Kostyukevich A., Tsyganovskiy I., Nozhenko V. 2011, Gorbunov N., Kostyukevich A., Kravchenko K., Kovtanets M. 2011, Poole W. 2008]. The above problem is complex and the solution should be based on research in the area of contact interaction of solids with the features of the state of the contact surfaces (moisture, lubricant on the surface, abrasive particles, etc.), as well as in physics and surface chemistry.

The large number of influencing factors (physical, chemical, electrical, etc.) on the coupling quality of the locomotive creates difficulties in the theoretical description of processes in tribocontact, which led to widespread development of experimental methods.

The most reliable information for the newly created and exploited railway vehicles in assessing characterization of interacting pairs of friction materials and their conjugation provide experimental methods [Isaev I., 1988, Buhanchenko S.E. 2005, Prudnikov M.I. 2009, Churkin A.V. 2008, Luzhnov Y.M. 1978, Burstow M.C. 2006], implemented by:

- on physical and mathematical models in the laboratory;
- on roller rig with the field units of rolling stock;

- during field tests in operational conditions..

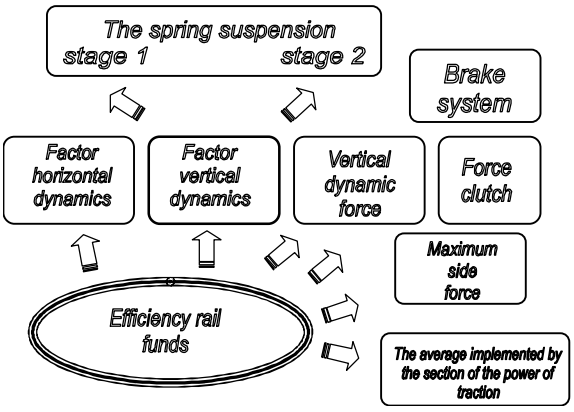

Fig. 1. Factors that assess the effectiveness of rail vehicles

Existing test bench allow you to study the process of friction on the rail in the laboratory. But the only complexity that can be difficult to reproduce in the laboratory - this is the real rail pollution rail those products that and to the extent that exist in different parts of the road. Therefore, for this type of measurement there are machines of friction, tribometer.

Based on the test bench «Friction machine», developed at the department of railway transport Volodymyr Dahl East-Ukrainian National University created automatically measuring and simulator test bench (AMSTB) for study the frictional properties of the contact "wheel-rail" [Kostyukevich A., Gorbunov M., Kovtanez M., Noghenko V., Chernikov V., Tsyganovskiy I.,2011, Kostyukevich A.I. 1991, Kostyukevich A., Gorbunov M., Kravchenko K., Popov C., Nozgenko V., Kovtanets M., 2010], which allows to solve the problems, which presented in fig. 2.

Automatically measuring and simulator test bench for the study of frictional contact properties "wheel-rail" consists of orienting and measuring unit. Block scheme shown in fig. 3.

Processing of the results of experiments conducted using software developed by the authors, which allows to process signals received.

According to the results of experimental studies based on the data from the encoders and tensor amplifier software system that incorporates a mathematical model, which allows to obtain the dependence of the coefficient of rolling friction sliding on the temperature in the contact "wheel-rail."

According to the results of experimental studies on the effect of activating surfaces implemented friction offered:

- way to increase friction on the rail, which consists of passing an electric current through the contact "wheel-rail". This is achieved by control the heating of the contact area due to the relatively high current density, increasing plastic deformation and, consequently, an increase in the contact area, which is especially important when emergency braking to improve traffic safety. The advantage of this method is the ability to increase adhesion without the use of traditional sand, which promotes in increased wear of wheel sets and pollution ballast;

- way to increase friction on the rail [Golybenko O., Gorbunov M., Kachyra O., Kostyukevich A., Kravchenko K., Popov C.,Krisanov M., 2009, Gorbunov N.I., Kravchenko E.A., Lewandowski V.A., Nesterenko V.I., Kovtanets M.V., Nozhenko V.S., 2010, Gorbunov N., Kovtanets M., Kravchenko E., Krysanov M., 2010, Gorbunov M.I., Kostiukevych O.I., Kovtanets N.V. , Kravchenko K.O., 2010], which is abrasive

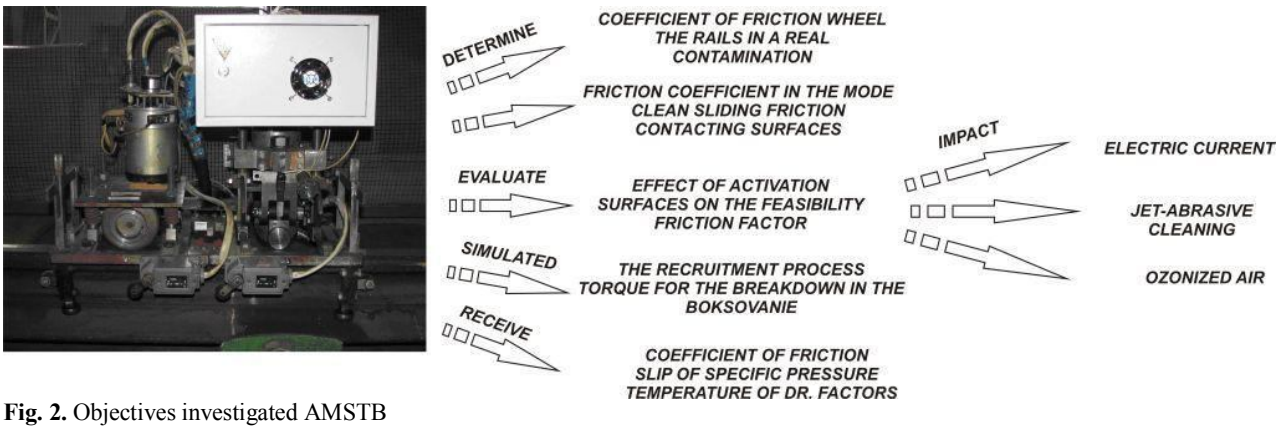

Fig. 2. Objectives investigated AMSTB

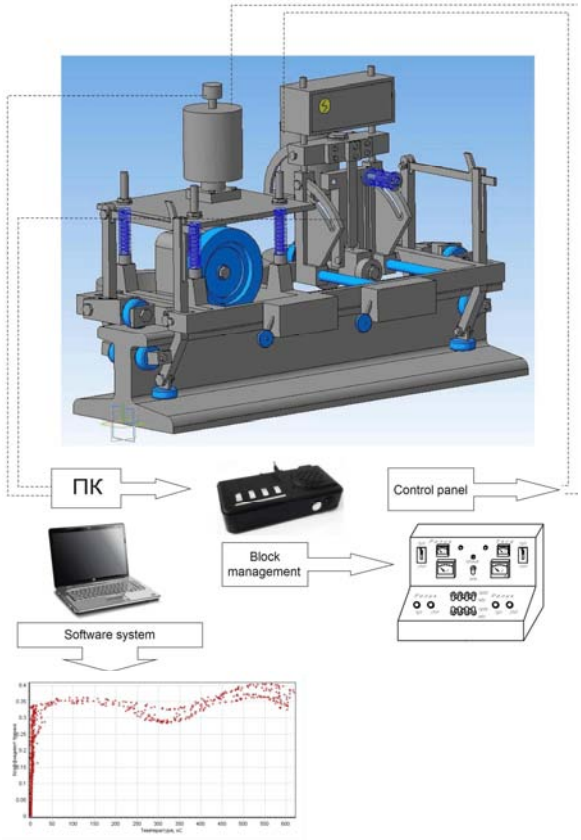

Fig. 3. The basic block scheme of the AMSTB for the study of frictional contact properties "wheel-rail"

blasting the rail surface (or wheelset and rail), the implementation of which the abrasive action of compressed air under high pressure acts as a cleanser and embedded in the surface layer of the rail, clears it from surface contamination, produce or cleaning or microcutting or sharzhirovanie surface. After cleaning, the proposed method corresponds to the rail surface purity, setting international standards ISO 8501-1:2007 (SA1, SA2, SA2.5, SA3). The advantage of this method is not just about cleaning tribocontact from surface dirt, and creation the effective surface roughness (by increasing the contact area of the wheel-rail), which leads to a significant increase in adhesion, but also in the ease of use, low cost of abrasive material, reducing resistance to the movement of trains over the traditional way of the feed sand, where sand gets on wheels composition, increasing by 12-20% resistance to the movement of trains [Osenin Y.I., Marchenko D.M., Shvedchikova I.A., 1997];

- way to reduce the friction "crest wheel-rail", which consists in the supply of ozonated air, which control the destruction of the surface contamination, and, thanks to the diffusion of atoms in the metal surface ozone, control the impurity concentration in the surface layers, which leads to the formation of oxides iron Fe_3O_4. The advantage of this method is that it is environmentally friendly, and efficient supply material to the desired surface, unlike conventional designs: systems with liquid lubricants have a high cost, instability lubrication properties, depending on the temperature, the higher the probability of hitting the wheel rolling on a track with a rail , solid lubricants pencils have low adhesion, high cost, fixed costs pencil regardless of whether the two-point contact.

The processes occurring in the contact interacting wheel and rail, depending on the whole efficiency of traction rolling stock. One of the important factors that determine the power consumption in the contact area is the coefficient of friction. According to the molecular-mechanical theory of friction coefficient of friction decreases with increasing load on the wheelset and speed, as evidenced by numerous experimental data. In addition, the friction coefficient is influenced by many additional factors, such as the type of rolling stock, track structure, weather conditions, presence of contaminants on the wheels and rails.

The analysis of the basic methods of increasing the friction coefficient showed that these include, first, the method of mechanical, thermo-mechanical, chemical, electrical discharge, plasma, etc. cleaning surfaces, and secondly, the methods of increasing the actual contact area by changing the geometric parameters of the contact surfaces, and, third, the means and the feeder in the contact zone of abrasive materials.

To determine the experimental dependences of the friction on the rail on factors such as the stiffness of rail, angle of attack, the vertical load handling, material and condition of the wheels and the rail, dynamic forces in contact, at the department of railway transport Volodymyr Dahl East-Ukrainian National University designed test bench "wheel-rail"[Gorbunov M.I., Kashura O.L., Spiryahin V.I., Kostyukevich M.I., Mikheyev A.S., 2003] (fig. 4), which allows us to study the implementation of the cohesive forces during acceleration, and slippage in straight and curved track sections.

The experimental setup is designed so that eliminates the effect of adverse factors observed in the full-scale test of locomotives, the process of adhesion and conduct the study of friction coefficient in contact, close to reality, to the different modes of motion. It also allows you to simulate the vertical oscillations of the rail, changing the characteristics of rail base, the

transverse vibrations of the rail, subsidence the rail in the vertical plane.

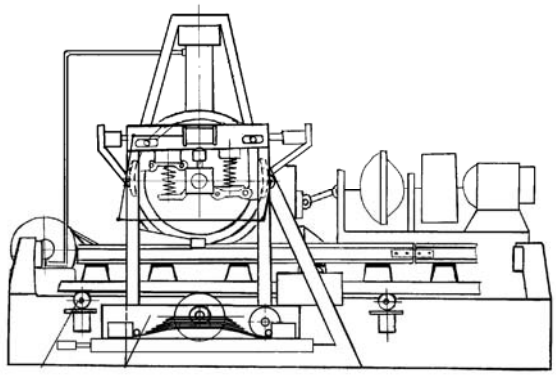

Fig. 4. Overview of the test bench for the study of friction on the rail

Another way to study the actual processes that occur while driving on the rail track at different rates, and, above all, under the power of the dynamic loads on the chassis elements is the simulation of field crews on roller rig which also performed studies of the effect of elastic and damping characteristics in motion.

Full-scale stand "roller rig" designed for the study of a new method of non-contact motion wheel flange wheelsets in straight and curved sections of track (fig. 5).

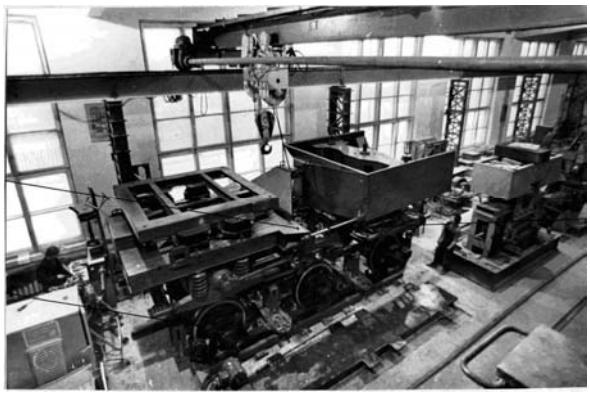

Fig. 5. General view of the bench area

Road wheels are stand in rotation from the rotating wheels of the crew, equipped with individual electric motors for all four wheels. Transmission from each motor to its wheels - V-belt, which significantly reduce the noise level in laboratory bench tests.

To study the transmission curve sections of track on the stand are simulated curves areas by curving the upper frame trolley stand, consisting of two parts, with the help of special actuators. In this case, wheel sets are shifted relative to the rails. This offset is fixed sensors located above the rails. After reaching the maximum displacement of wheelsets sensors generate and send a signal to the special power of the drive to start a reverse bias of wheel sets, which prevents convergence of wheel sets with rollers. On the right upper frame trolley stand provides simulation turn roll and lateral movement, the passage of carts curve sections of track. These displacements and returns to its normal position by means of special actuators.

Important in the design stage is to study the effect of various design changes due to the car body and a choice of values for which the dynamic qualities of locomotives would be satisfactory in a given speed range. This is explained by the fact that the locomotives 2TE116, 2TE121 between car body and bogies fitted combined rubber-metal bearings, carries an elastic mass separation truck and car body and provide lateral displacement and angular rotation relative to the car body have large variations in mechanical properties. As you know the mechanical properties of parts made of rubber hardness depends connection car body and bogie frame, which is one of the main characteristics that define the dynamic qualities of locomotives. Test bench, as shown in fig. 6, allows for field testing support for a shift in the oscillation frequency ranges from 0 to 3 Hz and amplitudes of the oscillations from 0 to 0.4 m in the harmonic loading in symmetric and asymmetric (with the introduction of the static component of deformation) cycles.

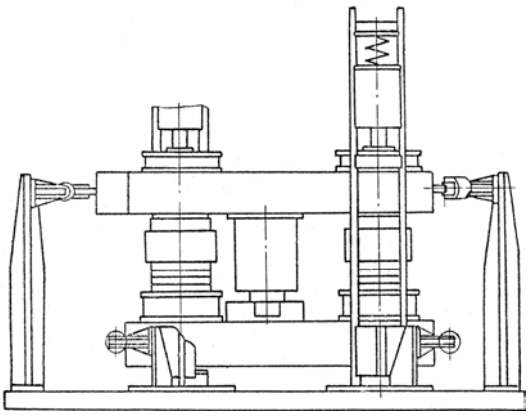

Fig. 6. General view of the test bench for testing car body with trolleys

On the test bench has to evaluate the dynamic properties of the set of ITR depending on the frequency of deformation and the oscillation amplitude.

Experimental studies to determine the resistance forces and moments acting in the supporting-return units in turn applies to carriage performed four test bench.

If necessary, test bench simulates:

- the dynamic fitting into the locomotive into curves track sections, accompanied by a car body of the locomotive and relates the change in the load bearing, pressure reducing valves alter the loading towers, located on either side of the longitudinal axis of the truck at the same distance by changing the pressure in the hydraulic cylinders;

- galloping carts and sales traction, pressure reducing valves dropping pressure in hydraulic cylinders, creating a difference in load bearing front and rear facing carts.

CONCLUSIONS

Experimental and measurement system for investigating the carriage and the terms of engagement of the rolling stock ensure a complete set of test chassis rail vehicle with the theoretical and practical problems of creating new technology. It reduces a series of studies of the newly created and existing rolling stock, increases the accuracy of the results and their reliability, improves the quality and information content of experimental studies.

The advantage of an experimental measurement system for investigating the carriage and the terms of engagement of the rolling stock is:

- easy management of frictional contact conditions, by controlled delivery of test substances into contact;

- possibility to simulation traction, braking, slippage;

- possibility study of contamination on a real rail.

REFERENCES

1. **Buhanchenko S.E. 2005.:** An automated system for tribological tests of structural materials and lubricants under static and dynamic conditions PhD, Tomsk Polytechnic University,187 p.
2. **Poole, W. 2008.:** Guidance on Wheel/Rail Low Adhesion Measurement, Rail Safety and Standards Board, GM/GN2642, Londen.
3. **Churkin A.V. 2008.:** An automated system for the study of frictional properties of surfaces with anisotropic roughness PhD, Udmurt State University, 178p.
4. **Burstow M.C. 2006.:** Rolling Contact Fatigue Laboratory Testing, February 2006, Rail Safety and Standards Board, AEATR-ES-2004-907 Issue 1, Londen.
5. **Golybenko A., Kostyukevich A., Tsyganovskiy I., Nozhenko V. 2011.**: The influence of a rail lateral bending on the stress – strain state of a wheel-tail contact, TEKA Komisji Motoryzacji i Energetyki Rolnictwa VXC, p. 78-84.
6. **Golybenko O., Gorbunov M., Kachyra O., Kostyukevich A., Kravchenko K., Popov C.,Krisanov M., 2009.:** bulletin № 6 20.08.2009 Patent for useful model № 48516, cl. V61S 15/00. Method of improving adhesion in the contact wheel with rail.
7. **Gorbunov M.I., Kostiukevych O.I., Kovtanets N.V., Kravchenko K.O., 2010.:** Increasing friction wheels rail by sandblasting cleaning their contact Transportation and Logistics: II Ukrainian scientific-practical conference of young scientists and students, 13 - 14 October 2010, Donetsk, pp. 166 - 169.
8. **Gorbunov N., Kostyukevich A., Kravchenko K., Kovtanets M. 2011**.: Influyense of operational factors on redistribution of wheel pairs wertical loads upon rails, TEKA Komisji Motoryzacji i Energetyki Rolnictwa VXC, p. 92-98.
9. **Gorbunov N., Kovtanets M., Kravchenko E., Krysanov M., 2010.:** Increased coupling as the engine clutch control interaction "wheel-rail", Proc. 1 stud. scient. conf. "Innovative technologies for rail transport", 23 - 25 September, Lugansk, pp. 46 - 49.
10. **Gorbunov N.I., Kravchenko E.A., Lewandowski V.A., Nesterenko V.I., Kovtanets M.V., Nozhenko V.S., 2010.:** Ways to solve the problem of increasing the towing and dynamic qualities of locomotives, Int. inf. scient. and tech. J. "Lokomotivinform», № 5, pp. 38-41.
11. **Isaev I., 1988.:** Improvement of experimental studies traction locomotives and rail, Railways of the world, № 10. – p. 2 – 10.
12. **Kostyukevich A., Gorbunov M., Kovtanez M., Noghenko V., Chernikov V., Tsyganovskiy I.,2011.:** bulletin №24 26.12.2011, Patent for useful model № 65999. Machine to determine the friction properties of friction contact "wheel-rail".
13. **Kostyukevich A., Gorbunov M., Kravchenko K., Popov C., Nozgenko V., Kovtanets M., 2010**.: Automated measurement and modeling bench unit "machine friction" for the study of frictional contact properties "wheel-rail", Sat. scientific papers X Intern. Conf. "Tribology and Reliability", Saint Petersburg, 165 – 174 p.
14. **Kostyukevich A.I., 1991.:** Numerical and experimental identification process traction locomotives with rails PhD, Lugansk, East-Ukrainian National University named after Volodymyr Dahl, 214 p.
15. **Luzhnov Y.M. 1978**.: Physical and patterns traction locomotives with rails PhD, 355 p.
16. **Osenin Y.I., Marchenko D.M., Shvedchikova I.A., 1997.:** Friction interaction with rail wheels, Lugansk, 228 p.

17. **Prudnikov M.I. 2009.:** Development of the normalized method and automated testing friction machines PhD, Bryansk State Technical University, 201 p.
18. **Gorbunov M.I., Kashura O.L., Spiryahin V.I., Kostyukevich M.I., Mikheyev A.S., 2003.:** Stand for research traction wheels with rail and test items axle spring suspension and rolling stock, Patent for useful model № 52970 A., Lugansk.

ЭКСПЕРИМЕНТАЛЬНО-ИЗМЕРИТЕЛЬНЫЙ КОМПЛЕКС ДЛЯ ИССЛЕДОВАНИЙ ХОДОВОЙ ЧАСТИ И УСЛОВИЙ ВЗАИМОДЕЙСТВИЯ ПОДВИЖНОГО СОСТАВА

Владимир Ноженко, Николай Горбунов, Сергей Мокроусов, Вячеслав Черников, Максим Ковтанец, Ростислав Демин

А н н о т а ц и я . От процессов, происходящих в контакте колеса и рельса, зависит работа подвижного состава железных дорог. Потребляемая энергия реализуется в контакте «колесо-рельс», а эффективное использование этой энергии зависит в основном от сцепления колеса с рельсом. В статье описано стендовое оборудование позволяющее исследовать ходовой части и условие взаимодействия вновь создаваемого и эксплуатируемого подвижного состава на кафедре железнодорожного транспорта Восточноукраинского национального университета им. В. Даля в лаборатории «Трение и смазка в приводах локомотивов».
К л ю ч е в ы е с л о в а *:* подвижной состав, стендовая установка, сцепление, коэффициент трения.

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The mechanism of the analysis of entering Internet traffic for the presence of threats

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S u m m a r y. The mechanisms of defense of AIS from the external threats are investigated in the article. There have been shown the classification of threats, technology of prognostication of the appearance of the external threats with the help of the Markovskiy processes, and the mechanisms of protecting from them. It is given the mechanism of watching the changes in the development of threats in a virtual network on the base of semantic neuron network for teaching of the system to their counteraction.
K e y w o r d s: external threats, defense of the informative system, Markovskiy processes, semantic neuron networks, virtual networks.

INTRODUCTION

Providing the safety of confidential information (KI) from affecting the automated informative systems (AIS) of the external threats presently acquires the special actuality. The indicated problem is confirmed by the analysis of the present statistical information about the influence of the external threats on safety of KI, circulatory in AIS [Babenko, Makarevich, Peskov, 2003.],[Khayretdinov, 2005], [1. Babenko, Makarevich, Peskov , 2003.], [Rosenko, Kopytov, Lepeshkin, 2004.], [Rosenko, 2000.], [Rosenko, Gricyk, 2001.], [Saveliev, 2000.], [Voronenko, 2000.], [Voyaobuev, 2002.], [Zaegorodny, 2001.] Because of the loss of KI, representing the intellectual property or the information of «know-how», can be inflicted a considerable financial and moral damage to the owner of the information [Internal IT threats in Russia. Research companies InfoWatch. 2006.]. Therefore, the task of the defense of the informative system from the unauthorized division from outside is actual.

Threats can be classified according to the different programmatic factors. For example, on the features of defeat viruses and programmatic failures **[**Foster, Kesselman, Tuecke, 2001.**]** viruses and worms, spam, are selected, attacks of type «refuse in service», financial swindle, gaps in the systems of safety of software.

Threats can be classified according to the different consequences which they render **[**Foster, Kesselman, Tuecke, 2001.**]**: violation of KI; distortion of the information, failures in-process AIS, loss of the information, delete of the information, theft of equipment, etc.

THE ANALYSIS OF THE PREVIOUS PUBLICATIONS

The authors in their previous researches consider the method of counteraction attacks in local calculable network (LCN) in a virtual imitation network, built for discrete stochastic systems with the use of theory of the Markovskiy processes **[**Petrov, 2011.**].** It has been also discussed the model of defense of the up-diffused local network by the queuing systems with the use of network sluice and Internet of sluice with a built-in virtual imitation network, built on the base of the Markovskiy closed system of the mass service**[**Petrov, 2011.**].** It has been also considered the realization of switching of the system of

defense in the case of the appearance of threat in a virtual network **[**Petrov, 2012.**].**

THE PURPOSE AND THE DEFINITION OF THE TASK OF RESEARCHES

The purpose of this work is in the development of the mechanism of the analysis of entering the Internet traffic in the presence of threats. Realization of anti-virus verification and checking is offered by various external - to vulnerability, got from the network of data, on a server. It is more profitable because of wider possibilities and the exception of hit of undesirable and nocuous information or potentially dangerous information. We'll name this block as the administrator the Internet of safety of network (AISN), which analyses the basic parameters of the loaded files and assess the legitimacy of the source of the new data. If a source is doubtful or the information is contained by presence of nocuous code bits, they are fully loaded on proxy-server, their anti-virus scan-out is whereupon conducted. This decision is based on the anti-virus verification, to verification on vulnerability and attack on the side of remote computer or server. Thus, there is the possibility of automatic choice of test of the loaded files algorithm that makes the system of defense more effective and saves resources.

In case of discovering the suspicion on external threats or origins of vagueness, what should be done with this potential threat? There is a version either to block, or to carry out the analysis of uncertain and suspicious data in the so-called virtual mode for a further analysis: both information and record of changes of what is going on in a network with the purpose of accumulation of necessary information. In case of the not confirmed information about nocuity of this software all of these changes happened on a virtual computer can be carried on the real computer with the certain lateness depending on the power of server and desire of user. And, thus, the accumulated information will be analyzed and utilized on teaching the system with the purpose of more effective interpretation of the external traffic. Such technology of work with entrance information will allow to save time in future and the resources of network. In this case the system of exchange is described by the information from each concrete computer of network of enterprise with a network the Internet by an administrator the Internet of safety of network (AISN).

REALIZATION

General statement of the question.

The influence of external threats on the elements of the system of AIS in a general view carries casual character and can result in two ends.

• happy end in case if purpose of influence of external threats, on AIS has not been achieved;

• an unhappy end is in all the other cases.

In this connection as a criterion of estimation of safety of KI it is possible to accept probability of happy end at the influence on AIS of external threats.

We will designate the indicated probability through Probability of opposite event, i.e. probability of unhappy end at influence on AIS of the external threats, will be equal to q. The indicated events make the complete group of independent events. Then

$$p + q = 1. \qquad (1)$$

It ensues from expression (1), that probabilities of **p** and **q** are the analytical criteria of estimation of safety of KI.

For the estimation of safety KI can be used different approaches [Dolgov, Kasatkin, Sretenskiy, 1978.] . However, as the analysis [Gavryushin, 2002.] shows, for such estimation it is necessary to take into account circumstance that as the result of influence on AIS of external threats it can pass from the initial (normal) state in other, special, state, proper the origin of exception condition[Zegzhda, 2002.:]. At the same time the appearance of exception conditions is related to the threat safety of KI, to circulatory in AIS [A. Kusz, P. Maksym, Andrzej W. Marciniak 2011].

A transition of AIS from one state into the other one is the investigation of fully concrete reasons. However, they appear, as a rule, in arbitrary moment of time, that's why their appearance is casual therefore. Every particular situation can result both in happy and unhappy end for KI taking into account success (to not success) of actions of employees on the reflection of consequences of the appearance of exception conditions [G. Bartnik, G. Kalbarczyk, Andrzej W. Marciniak 2011].

We will designate the probability of origin of i-th exception condition through q_i conditional probability of reflection of its consequences through r_i and probability of non-reflection – through $\overline{r_i}$ Then for the determination of probabilities p_i and q_i will present the sequence of transitions of AIS from one (initial) state to the other one by the Markovskiy casual process with

the account number of the states and by continuous time. Such presentation is conditioned by the following assumptions:

• in the initial state AIS is in normal state;

• a sequence of the appearance of exception conditions of i-th kind is the simplest stream with intensity λ_i intensity of happy end is marked through $\lambda_i r_i$, and unhappy - $\lambda_i \overline{r_i}$

The essence of the method of calculation of probabilities p_t and q_t at the use of the Markovskiy process consists of that unknown probabilities are determined from the decision of differential equalizations which describe this process. Such a process should be presented in the form of logical and probabilistic process [Philinov, Boychenko , 2001.]**.**

We will suppose that the possible states of AIS in the process of the influence on them of external threats are defined. Besides, the directions of its casual transitions are known from the state into the state. Then it is possible to build the logical chart (count) of the state of AIS, which at the known probabilities of transition of the system from the state into the state is logical-probabilistic model of AIS (please, see fig. 1, by analogy with [Kornevec, Payachun, Prokofev, 2005.], [Zegzhda, 2002.]).

On the fig. 1 the logical chart of influence is presented on AIS one i-th of external threat.

The competence of such presentation of AIS is based on that possible ends from influence on AIS are random events by virtue of chance of appearance of one or the other external threats.

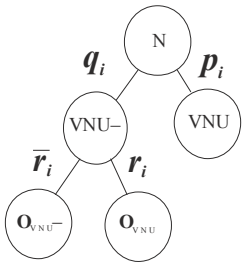

Fig. 1. Logic diagram of the impact on AIS one i-th external threat.

In accordance with the fig. 1 it follows that in the process of functioning of AIS there is some danger, related to affecting it i-th external threats. At such influence AIS can be in the following states (see of fig. 1.1):

• «N» is the initial state of AIS;

• «VNU» is the state, when i-th an external threat does not show up with probability p_i ;

• «VNU-» is the state, when i-th an external threat showed up with probability $q_i = 1 - p_i$;

• « O_{vnu} » it is the state of reflection of external threat with probability of r;

• « O_{vnu-} » it is the state of not reflection of consequences of display of external threat with probability $\overline{r} = 1 - r$.

Final states of «VNU», and « O_{vnu} », correspond to the happy end at the influence on AIS i-th of external threat.

The state « O_{vnu-} » corresponds to the unhappy end at the influence on AIS i-th of the external threat. Then, in accordance with the fig. 2, the probability of happy end from the influence on AIS i-th external is determined by the following way:

$$P_{(vnu)h_i} = p_{(vnu)i} + q_{(vnu)i} r_{(vnu)i}$$

and the probability of unhappy end

$$Q_{(vnu)} = q_{(vnu)i} \overline{r_{(vnu)i}}$$

Because probabilities $P_{(vnu)h_i}$ and $Q_{(vnu)h_i}$ make the complete group of events

$$P_{(vnu)h_i} + Q_{(vnu)} = 1 ; \quad (2)$$

From (2) it follows that

$$P_{(vnu)h_i} = 1 - Q_{(vnu)}$$

$$Q_{(vnu)} = 1 - P_{(vnu)h_i}$$

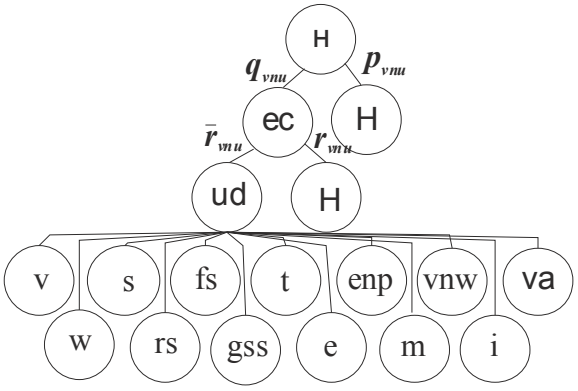

Fig. 2. Logic diagram of the possible states AIS

Thus, from the point of view of the consequences of the influence on AIS of external threats on the basis of analysis of expressions (2) it is possible to come to the following conclusions.

1. By a quantitative measure, characterizing the consequences from the influence (i-th of external threat, on KI, are probability of happy end of P_h and probability of opposite event, I.e. probability of unhappy end as a result of the

influence of i-th of external threat on AIS, I.e., $Q_{(vnu)h_i}$.

2. The analysis of the expression (2) testifies that probabilities $P_{(vnu)h_i}$ and $Q_{(vnu)}$ are the quantitative estimation of the consequences from the influence on AIS i-th of external threat.

3. The analysis of expression (2) shows also, that for the quantitative estimation of consequences of influence external threats on AIS it is enough to define any constituent, for example $Q_{(vnu)h_i}$. The definition of the other constituent from the expression (2) is not complicated.

Let's consider the application of the quantitative estimation for the determination of the probabilities of the consequences from the influence on AIS of external threats. The consequence from affecting of external threats safety of KI can be different.

• «N» is the initial (initial) state of AIS;

• «H» - an external threat did not show up with probability p_{vnu} ;

• «EC» - an external threat showed up $q_{ec} = 1 - p_{vnu}$ with probability, that had resulted in the origin of exception condition;

• an exception condition with probability r_{ec} is reflected;

• an exception condition with probability $\overline{r_{ec}} = 1 - r_{ec}$ is not reflected, that resulted in outgrowing of exception condition in the unauthorized division of NSD to KI;

• $q_v, q_w, q_s, q_{rs}, q_{fs}, q_{gss}, q_t, q_e, q_{enp}, q_m, q_{vnw}, q_i, q_{va}$ — according to probability there are viruses and worms, spam, attacks of type «refuse in service», financial swindle, gaps in the systems of safety of software, theft, elimination (destructions), errors and misconducts of personnel, substitution (modifications), violation of normal work of AIS intercept and violation of access to KI.

The definition of probabilities of such states of AIS is carried out taking into account that the casual display of external threats, as potentially hazardous occurrence, and also not the reflection of exception condition, accompanied an unauthorized division to information.

In accordance with the fig. 2.3, the probabilities of the consequences from affecting of external threats safety of KI are determined by the following way:

• the probability of happy end from the influence on AIS of external threats

$$P_{ph} = p_{vnu} + q_{vnu} r_{ec} ; \quad (3)$$

• the probability of the opposite event, that the probability of unhappy end from influence on AIS of external threats viruses and worms, spam, attacks of type «refuse in service», financial swindle, gaps in the systems of safety of theft, elimination (destructions), errors and misconducts of personnel, substitution (modifications), violation of normal work of AIS, intercept and violation of access to KI software.

$$Q_{vnu} = q_{vnu} \overline{r_{ec}} ; \quad (4)$$

• the probability of infection viruses

$$p_v = Q_{vnu} q_v \quad (5)$$

• the probability to be infected by worms

$$p_w = Q_{vnu} q_w \quad (6)$$

• the probability of the appearance of the spam

$$p_s = Q_{vnu} q_s \quad (7)$$

• the probability of attack of type «refuse in service»

$$p_{rs} = Q_{vnu} q_{rs} \quad (8)$$

• the probability of financial swindle

$$p_{fs} = Q_{vnu} q_{fs} \quad (9)$$

• the probability of gap is in the systems of safety software

$$p_{gss} = Q_{vnu} q_{gss} \quad (10)$$

• the probability of theft of KI

$$p_t = Q_{vnu} q_t \quad (11)$$

• the probability of elimination (destructions) of KI

$$p_e = Q_{vnu} q_e \quad (12)$$

• the probability of errors and misconducts of personnel

$$p_{enp} = Q_{vnu} q_{enp} \quad (13)$$

• the probability of substitution (modifications) of KI

$$p_m = Q_{vnu} q_m \quad (14)$$

• the probability of violation of normal work of AIS

$$p_{vnw} = Q_{vnu} q_{vnw} \quad (15)$$

• the probability of intercept of KI

$$p_i = Q_{vnu} q_i \quad (16)$$

• the probability is violation of access of KI

$$p_{va} = Q_{vnu} q_{va} \quad (17)$$

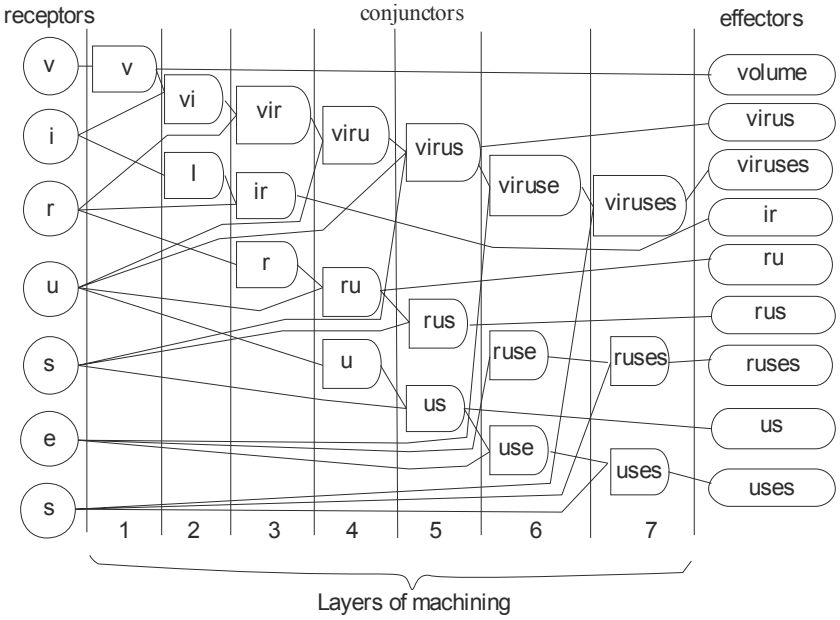

Fig. 3. Fragment processing layers of linear tree

The expression (3) allows to define the probability of happy end, and the expression (4) – of unhappy end on the whole from the influence of external threats on AIS. The expressions (5)-(17) allow to define strength of KI security on the types of the consequences from the influence on AIS of external threats.

At the practical use of the expressions (3)-(17) it is necessary, for the verification of the competence of the got results, to utilize expression (1). It is related to that for a branching out process the sum of probabilities of the subsequent states of AIS, outgoing from proceeding, is equal to unit.

We analyze the traffic by a neuron network, built with conjunctors and disjunctors. Let's suppose that all of the neurons are identical, and they realize one transmission function, and the weight and thresholds will be realized by equal and general possibilities. It is required to build a neuron network under this task.

This network must analyze the traffic and reflect attacks, and in the case of non-reflection the attack or suspicious application, to pass from the real network into the virtual one, and there to make the analysis of vulnerabilities and attacks, as well as the training of the neural network for these vulnerabilities.

The information about what is going on is written down in a text file. Therefore the typical method of the text processing with the purpose of determination of his maintenance consists in a text translation in human language in the internal form of the system and possible leading out from this presentation of new information [Gerasimenko, Mayayuk, 1997.]. The process of treatment will be realized on three levels: morphological, syntactic and semantic. On morphological and syntactic levels from a text separate words which are divided into separate morphemes are selected. Syntactic copulas are determined interword after it. The purpose of the first two stages is a receipt of word-parts with the cut completions. To the each inter word belongs every word-part in accordance of value of certain grammatical signs. The purpose of semantic interpretation is an exposure of maintenance of words and combinations of words [Luger, 2003.]. In the process of semantic interpretation the knowledge which are in the simulation model are compared with the facts, presented in the text [Shuklin, 2003.]. The result of comparison becomes the internal, from the point of view of the system treatment, structured presentation of text [Tereykovsky, 2007.]. That determination of the maintenance of text is the process of comparison of the encoded denotations of the phenomena of subject domain, which are contained directly in the text corresponding to these phenomena by the fragments of simulation model of that subject domain. The information about the syntactic structure of text is the criterion of decision of possible dissimilarities of the indicated comparison. The final result of the analysis of text is a semantic network which is considered for today as the most complete and reliable description of its maintenance.

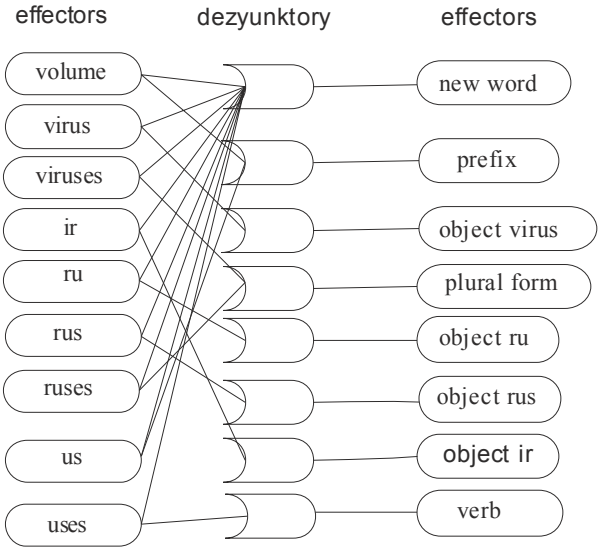

Fig. 4. Structure of an aggregating layer neurons

In general case under the concept of semantic neuron network is understood the network of the dynamically CPLD between itself neurons, that parallel or kvazi parallel execute the operations of fuzzy logic, exchanged between the information itself and organized in the unique unit by the certain mechanisms. As well as for the other types of neuron networks, base operations of the treatment information are executed by separate neurons. Thus, for perception the semantic neuron network of information from an external environment are used receptors (entrance neurons). For passing the information from a network on external are used receptors (initial neurons). Organizing mechanisms can have own calculable activity and co-operate with neurons. Accordance of some elements of semantics of subject domain or model of text is appointed inter neurons. Thus, an element can present separate character, aggregate of some characters of text or aggregate of concepts and relations between the concepts, that can be abstracted as the unique unit.

The studies of semantic neuron network with the structure of type of the synchronized linear tree consist in memorizing, by it to new information, to forbidden for a reception/transmission. Thus selection of separate words from a text it is expedient to conduct by the preprocessor dissociated from a neuron network. In the mode of studies, information a symbol-by-symbol is given at the entrance of the synchronized linear tree. On each stage of studies the search of the excited neurons is conducted in a neuron network. If such neurons are, it is considered that a network is already taught this character sequence, and to bring in it additional information it is not needed. In opposite case to the network the new disjunctors are added, that at once translated in the excited state. Thus, not only the weighing coefficients of connections but also neuron network structure itself changes at the studies of the synchronized linear tree.

Educational information, given at the entrance of networks, due to present a database and base of knowledge of simulation model of subject domain in the complement of which information enters forbidden for a reception/transmission. A simulation model will be formed as a result of studies of semantic neuron network. As a database and base of knowledge of simulation model for the synchronized linear tree, adjusted for the morphological and syntactic analysis of the text, the grammatical dictionaries of language which the text is written can be used The conducted calculations show that the volume of depository information of the synchronized linear tree for the analysis of text in Ukrainian or Russian languages make less than 10 gigabyte. For the basis of calculations is taken one size of the most complete grammatical dictionaries [Grammatical Dictionary of the Russian language: inflection 1980.].

CONCLUSIONS

The conducted researches specify the possibility of construction realization of anti-virus verification and checking for various external - to vulnerability, got from the network of data, on the side of server of AIBS. Due to the application of semantic neuron networks with the purpose of rich in content analysis of the text of written in the file changes, happened on a virtual computer, started virtually suspicious applications, and also conduct of monitoring of threats.

It is formed the general methodic of work of AIBS, analyzing the changes made by suspicious applications. On their basis it is formed the teaching of semantic neuron networks. Afterwards the specification of this threat appears and the block of conduct is formed at these threats. Monitoring is carried out and the strategy of conduct of the system is forecast on external threats on the frame of base, used for teaching of the network. The accumulated statistics allows the system to be self taught taking into account the accumulated information.

This method gives more flexible adaptation of AIBS to the concrete network, and also adequate and reliable system of reflection of external threats. The basic prospects of subsequent

researches in this direction consist in application of modifications of AIBS for protecting from the different type of threats - external, internal and hidden.

REFERENCES

1. **Babenko L.K., Makarevich O.B., Peskov O. U., 2003.:** Development of an integrated intrusion detection system. Information security. Of the V International scientific-practical conference of Taganrog, RAL. tech. Univ. Taganrog pp. 194-197.
2. **Bartnik G., Kalbarczyk G., Andrzej W. Marciniak 2011.:** Application of the operational reliability model to the risk analysis in medical device production TEKA Kom. Mot. i Energ. Roln. – OL PAN, 11c, pp. 361–377
3. **Dolgov V. A., Kasatkin A, S., Sretenskiy V. N., 1978.:** Radio electronic automatic control systems (systems analysis and implementation techniques). Moscow: Soviet radio. 384 p.
4. **Foster I., Kesselman C., Tuecke S. 2001.:** The Anatomy of the Grid: Enabling Scalable Virtual Organizations. International Journal of High Performance Computing Applications, 15 (3).pp. 200-222.
5. **Gavryushin E. I., 2002.:** The human factor in ensuring the security of information, http// www.ii26.ru/it263.view2.page22.h4nl
6. **Gerasimenko V.A., Mayayuk A.A., 1997.:** Fundamentals of information security. M., MiFi. 538 p.
7. Grammatical Dictionary of the Russian language: inflection 1980.: / [comp. Zaliznyak A.A.] M. : Rus. lang., 880 p.
8. Internal IT threats in Russia. Research companies InfoWatch. 2006.: www.info Watch.ru.
9. **Khayretdinov R. 2005.:** Internal threats and fight against them // Computers. №7-8. pp. 15-18.
10. **Kornevec I. G., Payachun. B.P., Prokofev A. S., 2005.:** The ways of the increase of the efficiency are sewn up acoustic information in the selected apartments. Informative safety. Materials of the VII International Scientific and Practical Conference. Taganrog, RAL. tech. Univ. Taganrog, pp. 231-232.
11. **Kusz A., Maksym P., Andrzej W. Marciniak 2011.:** Bayesian networks as knowledge representation system in domain of reliability engineering TEKA Kom. Mot. i Energ. Roln. – OL PAN, 11c, pp.173–180.
12. **Luger F., 2003.:** Artificial Intelligence: Strategies and methods for solving complex problems, 4th Edition / F. Luger, trans. from English. N.I. Galagan M. Williams, 864 p.
13. **Pankratova I. D., 2002.:** The formation and development of analysis of the systems as the applied scientific discipline. // System research & information technologies IASA. № l. pp. 65-94.
14. **Petrov A.S., 2011.:** Method of counteraction attacks in LVS in a virtual imitation network / A.S. Petrov, S.A Velchenko. // Informative safety. №1(5). pp. 8-14.
15. **Petrov A.S., 2011.:** Model of defense of the up-diffused local network built on the basis of the Markovskikh queuing systems / A.S. Petrov, S.A. Velchenko // Informative safety. №2(6). pp. 88-93.
16. **Petrov A.S., 2012.:** Method of management defense of the informative system in off-wire sets on the base of game theory / A.S. Petrov, S.A. Velchenko // Announcer of SLEEP the name of Dalya. №.8(1),- pp 69-79.
17. **Philinov E.I., Boychenko A. V., 2001.:** Standards of protection of information in the draft IP. Proceedings of the scientific-practical conference "Information Security". Taganrog, rad. tech. Univ. Taganrog. pp. II-I9.
18. **Rosenko A. P., Kopytov V. V., Lepeshkin O. M., 2004.:** Security Threats North Caucasus region in the field of information and ways of reducing them. Threats safety of Russia in North Caucasus; Monograph. Stavropol. pp. 136-188.
19. **Rosenko. P., 2000.:** Methodological aspects of the dynamic of the expert system of information protection. A mathematical design is in scientific researches. Materials of the All-Russian scientific conference. 4.2. Stavropol. pp. 206-208.
20. **Rosenko A. P., Gricyk B. A., 2001.:** Analysis of existent approaches on the selection of personnel, working with KI. Informative safety. Sat works of the scientific-practical conference of Taganrog, rad. tech. Univ. Taganrog, 243 p.
21. Research on mitigating the insider threat to information systems. RAND - Conference Proceedings, August, 2000.
22. **Shuklin D. E., 2003.:** Models of semantic neuron networks and their application are in the intelligence systems: dis. . kan. tekhn. sciences: 05.13.23 / D. E. Shuklin. - X.,. 196 p.
23. **Saveliev M., 2000.:** Systems analysis and modeling of protection of information. The second regional scientific-practical seminar "Information Security-South Russia." Taganrog, rad. tech. Univ. Taganrog, pp. 136-137.
24. **Tereykovsky I., 2007.:** Neuron borders in the means of defense computer information/ I. Tereykovsky K.: PoligraphConsulting - 209 p.
25. **Voronenko P. A., 2000.:** Security. Situation in the world and in Russia // news-letter of «Jet Info». № 8 (87). P. 14-16.
26. **Voyaobuev C B., 2002.:** Systems analysis object security information. Scientific Session MIFI-2002. IX International Scientific and Practical Conference "Problems of security in a higher school) *. Collection of scientific works MIFI. Moscow, pp. 31-33.
27. **Zaegorodny V.I., 2001.:** Integrated protection of information in computer systems: the manual. Moscow: Logos, 264 p.
28. **Zegzhda P.D., 2002.:** Modern technology trends to ensure the security of computer systems. Scientific Session MIFI-2002. IX International Scientific and Practical Conference "Problems of security in higher education." Collection of scientific works MIFI. M.. pp. 40-41.

МЕХАНИЗМ АНАЛИЗА ВХОДЯЩЕГО ИНТЕРНЕТ ТРАФИКА НА НАЛИЧИЕ УГРОЗ

Александр Петров, Сергей Вельченко

Аннотация. В статье исследуется механизмы защиты АИС от внешних угроз. Показаны классификация угроз, технология прогнозирования появления внешних угроз с помощью Марковских процессов, и механизмы защиты от них. Приведен механизм отслеживания изменений в развитии угроз в виртуальной сети на базе семантической нейронной сети для обучения системы их противодействию.

Ключевые слова: внешние угрозы, защита информационной системы, Марковские процессы, семантические нейронные сети, виртуальные сети.

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Mathematical model-building of reological and thermodynamical processes in modified concrete mix at vibro impact compact method of comression

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Summary. In the article is examined the modified cementing system at vibro impact compact method of compression. It is solving the task of system's movement taking into consideration relax processes. It has been considered the interaction of the system components with each other, there have been received the formulas of movement and internal parameters characterizing movements of relaxing system.

Key words. Modified concrete mix, vibro impact compact method of compression, relax processes, phenomenological formulas of movement.

ACTUALITY OF RESEARCH AND PROBLEM DEFINITION

In comparison with the flow of Newtonian liquids the flow of modified concrete mix at compressing by vibro impact compact method has the series of peculiarities [Okorokov 1956, Polak 1986, Pilipenko 2011]. Thus, at a simple move the normal stresses appear in the modified concrete mix which is not observed in Newtonian liquids. The viscosity of modified cement systems depends not only on the applied stresses (or the velocity gradients), but also on the flow pattern. At a simple move the viscosity, as a rule, decreases, and it increases at a simple extension [Rudenko 2010, Bazhenov 2005]. At a non-stationary system movement it is also observed the series of "non classical" effects [Tomosawa 1997].

In the general case the cause of abnormal behavior can be immediately indicated and does not cause any doubt – the presence of the processes with the relax times comparable with characteristic times of system movement or exceeding them [Sawaide, Iketani 1992]. At deformation such system turns to be derived more considerably from the state of thermodynamical equilibrium the more the gradients of rate of flow are.

At very small (in comparison with the characteristic times en route) relaxation times the thermodynamical equilibrium is not locally broken during the movement by a marked way [Shayan, Quick 1992]. The presumption of a local equilibrium of a system together with the conservation laws leads to the equations of motion of Newtonian liquid. Thus, the description of the impulse movement of modified concrete mix brings to the task of the system movement taking into account the relax processes.

On the one hand, considering the modified concrete mix as the continuous medium, we can formulate phenomenological equations of the movement in the form fit for the description of relatively slow movements on the basis of the view of non-equilibrium thermodynamics and the most common concepts [Mchedlov-Petrosyan, Babushkin 1992]. And at this the view of equations of motion and, accordingly, the properties of concrete mix as the system are defined by tensorial dimension of internal parameters [Moranville-Regourd 1999, Pashchenko 1991].

On the other side, the modified concrete mix represents itself the ensemble of

interactive one to each other components. At a sequent review of the components in a moving system it is possible to get the equations of motion which are the particular case of common phenomenological equations of motion. While this relax processes are clearly considered and it becomes obvious the sense of phenomenological parameters of an equation. Whereas the cement system defines viscous ductile properties of modified concrete mix, let's consider the cement system as the continuous medium [Batrakov 1998, Punagin 2010]. Let the elements of the volume of the medium be so huge that it can be applicable macroscopic description for them.

PURPOSE AND OBJECT, MATERIALS AND RESULTS OF INVESTIGATIONS

Let's stop on the kinematics of deformed system. Let's denote by xk the point of deformed system at the moment t xk = xk(t). The tensor of the gradients of movements at the moment t against the moment t' we define by the following way

$$\lambda_{ik}(t,t') = \frac{\partial x_i(t)}{\partial x_k(t')}. \quad (1)$$

That is $\lim_{t'\to t} \lambda_{ik}(t,t') = \delta_{ik}$,

where: δ_{ik} – Kronecker symbol.

It follows from the definition of the tensor of the gradients of movements that it is true the ratio

$$\frac{\partial}{\partial t}[\lambda_{ik}(t,t')\lambda_{s\ell}(t',t)] = \\ = \frac{\partial}{\partial t}[\lambda_{ik}(t,t')]\cdot\lambda_{s\ell}(t',t) + \lambda_{ik}(t,t')\cdot\frac{\partial}{\partial t}[\lambda_{s\ell}(t',t)]. \quad (2)$$

Let's further define the local velocity $v_i = \frac{\partial x_i(t)}{\partial t}$ and the tensor of gradients of the velocity

$$v_{ik}(t) = \frac{\partial v_i}{\partial x_k} = \frac{\partial}{\partial x_k}\left(\frac{\partial x_i}{\partial t}\right) = \\ = \lim_{t'\to t}\lambda_{ik}\frac{\partial}{\partial t}\lambda_{ik}(t,t') = \lim_{t'\to t} v_{ik}(t,t'). \quad (3)$$

It can be analogically defined the other tensor of the angular velocity:

$$\omega_{ik}(t) = \lim_{t'\to t}\lambda_{ik}\frac{\partial}{\partial t}\lambda_{ik}(t,t') = \lim_{t'\to t}\omega_{ik}(t,t'). \quad (4)$$

Differentiating (2) to t, we find the ratio between the tensors of the gradients of the velocity

$$\lambda_{ik}(t,t')\,\omega_{s\ell}(t',t) = -v_{ik}\lambda_{s\ell}(t',t). \quad (5)$$

Considering the moments of time t' < t, let's insymbol t – t' = s. In this case at small s the tensor of the gradients of movements and the tensor of deformations can expanded into series near the moment of time t

$$\lambda_{si}\lambda_{jk} = \delta_{si}\delta_{jk} + (\delta_{si}v_{jk} + \delta_{jk}v_{si})s - \\ - (2v_{si}v_{jk} + \delta_{si}\zeta_{jk} + \delta_{jk}\zeta_{si})s^2 + \ldots \quad (6)$$

$$\lambda_{[si]}\lambda_{[sk]} = \delta_{[ik]} + 2v_{(ik)}\,s - \\ - 2(v_{[si]}v_{[sk]} + \zeta_{(ik)})s^2 + \ldots, \quad (7)$$

where: $\zeta_{ik}(t) = \lim_{t'\to t}\frac{\partial v_{ik}(t,t')}{\partial t}$.

In the formula (7) and the round brackets are further used for the definition of symmetrical index and square brackets are used for antisymmetric index.

The local thermodynamical state of the system at the equilibrium can be characterized by different parameters, for example, by the density ρ and the pressure p, including the temperature T. Whereas as in principal there always exists the equation of the state connecting all these values f (T, ρ, p) = 0 then for the full characteristics of the cement system in the equilibrium is enough two values out of the three indicated ones. It is acceptable at this that the system is one-component, i.e. all the process of diffusion have been excluded beforehand.

A small change of internal energy is written by the following way

$$dE = \rho T\,ds + \omega\,d\rho, \quad (8)$$

where:s – entropy density of a system;

ω – enthalpy of a mass unit.

At a uniform and rectilinear movement of a system the thermodynamical equilibrium isn't obviously broken. But if there are the gradients of the velocity and the gradients of movements then the deformed system, generally speaking, is not already in equilibrium even locally. At small external changes the inner process can be on time

to follow the change of the system state [Kaprielov, Travush, Karpenko 2006]. By other words, all relax times of the system turn to be small in comparison with the character times of system motion. This is true for small viscous liquids the equilibrium for which is able to come stable in the process of the movement. It is used (8) for the description of the change of the energy of the element of the volume.

In the process of the movement the system is defined besides the velocity only by pressure and density (except for the temperature which is constant at isothermal flows). At the flow the system remains isotropic. The consistent building of phenomenological theory of motion of such systems leads to the system of Navier-Stokes equations which describes the motion of law-viscous liquids.

In the process of faster motions some inner processes are not on time to follow external changes [Bratchun, Zolotarev, Pakter, Bespalov 2011, Pilipenko 2010]. Deforming takes place by non-equilibrium mode and the state of the system is described additionally by some inner independent variables $\xi\alpha$. We consider that the set $\xi\alpha$ fully characterizes the deviation of the system from the equilibrium. At the equilibrium $\xi\alpha = \xi\alpha 0$.

Thermodynamical functions of the system now depend additionally on the inner parameters. For example, the inner energy of the volume unit

$E = E(s, \rho, \xi\alpha)$ and, thus, the change of the density of the inner energy in the moving frame

$$dE = \rho T\, ds + \omega\, d\rho + A_\alpha d\xi^\alpha, \qquad (9)$$

where: $A_\alpha = \left(\frac{\partial E}{\partial \xi^\alpha}\right)_{s,\rho}$ – affinity of relax process;

T, ω, $A\alpha$ – functions of variables s, ρ, $\xi\alpha$.

The introduced system itself aims at the equilibrium state: $\xi\alpha \to \xi\alpha 0$. Moreover, if the deviation from the equilibrium is small, the rate of change of parameters is proportional to the deviation of the parameters from the equilibrium [Ziegler 1976]

$$\frac{d\,\xi^\alpha}{d\,t} = -\frac{1}{\tau_\alpha}\left(\xi^\alpha - \xi_0^\alpha\right). \qquad (10)$$

We consider that selected variables are the normal coordinates. The equation (10) defines the relax time corresponding to this normal coordinate. Solution of the equation (10) is given by

$$\xi^\alpha - \xi_0^\alpha \approx e^{-\frac{t}{\tau_\alpha}}. \qquad (11)$$

This function describes the system's approaching to the equilibrium.

Let stationary liquid be in the state of thermodynamical equilibrium which is broken at motion. It would appear reasonable that the rate of change of inner parameters at motion also depends on kinetic performances. In the process of deforming stoppage the inner parameters relax according to the law (11). The relaxation process also takes place at deforming and, thus, the rate of change of inner parameters is defined simultaneously by two effects [Mchedlov-Petrosyan, Babushkin 1992, Gusev, Kondrashchenko, Maslov, Faivusovich 2006]. The phenomenological theory of irreversible processes doesn't allow defining this dependence without additional concepts. It is usually limited to the first expansion terms in small gradients of the rate and small inner parameters [Ziegler 1976]. In the general case it's possible to consider that

$$\frac{d\xi^\alpha}{d\,t} = D_\alpha[\xi^\alpha, \lambda_{js}(t, t-s)\lambda_{pq}(t, t-s)]. \qquad (12)$$

The functional (12) can be introduced in the integrated form. It is necessary to account for tensor dimension of inner parameters which can be scalars, vectors or top ranks tensors. According to the tensor of deforming in linear approaching for the scalar parameter

$$\frac{d\,\xi}{d\,t} = B(\xi) + \int_0^\infty C(\xi, s)\lambda_{ii}(t, t-s)\, ds \qquad (13)$$

(in this case the rate of change of parameters is only defined by the rate and accelerations of volume change) and for the parameter – second rank tensor

$$\frac{d\xi_{ik}}{dt} = B_{ik}(\xi_{js}) + \int_0^\infty C_{ikjspq}(\xi l_n, s)\,\lambda_{js}(t, t-s)\gamma_{pq}(t, t-s)\, ds. \qquad (14)$$

Formulas (13) and (14) are written in the supposition that integral kernels C and Cikjspq are decreasing, positive, stated at $s > 0$ functions of their variables. Besides at $s \to \infty$ the functions aim for the zero faster than any other degree s.

Let integrand functions in (13) and (14) fade very quickly i.e. there's a considerable influence of the deformations close in time. We use expansions (6) and (7) and get in the first approximant

$$\frac{d\xi}{dt} = b(\xi) + c(\xi)v_{ii}, \tag{15}$$

$$\frac{d\xi_{ik}}{dt} = b_{ik}(\xi_{js}) + c_{ikjspq}(\xi_{ln})(v_{js}\delta_{pq} + v_{pq}\delta_{js}). \tag{16}$$

It can be supposed further that the changes of inner parameters are small values in which can be expanded the functions in the equations (15) and (16) depending on them. As the result of expansion we get for the scalar parameter

$$\frac{d\xi}{dt} = -\frac{1}{\tau}(\xi - \xi_0) + (\alpha_1 + \alpha_2\xi)v_{ii} \tag{17}$$

And for the tensor parameter symmetric in indexes

$$\begin{aligned}\frac{d\xi_{ik}}{dt} = &-\frac{1}{\tau}(\xi_{ik} - \xi_{ik}^0) + \\ &+\beta_1\delta_{ik}v_{ss} + \beta_2 v_{(ik)} + \\ &+\beta_3\xi_{ss}v_{(ik)} + \beta_4\delta_{ik}\xi_{js}v_{js} + \\ &+\beta_5\xi_{jj}\delta_{ik}v_{ss} + \beta_6\xi_{ik}v_{ss} + \\ &+\beta_7(\xi_{is}v_{sk} + \xi_{ks}v_{si}) + \\ &+\beta_8(\xi_{is}v_{ks} + \xi_{ks}v_{is}).\end{aligned} \tag{18}$$

The equations (17) and (18) in linear as per the tensors of the gradients of the rate and inner parameters approaching define the law of change of inner parameters at deforming.

The system of the equations of motion of continuous medium can be obtained as the consequence of the laws of conservation of mass, energy, impulse and the moment of impulse in their differential form [Loitsiansky 2003]. For the isothermal motion of one-component medium these equations after the introduction of the tensor of the stresses σik are reduced to the form

$$\frac{\partial\rho}{\partial t} + \mathrm{div}(\rho v) = 0, \tag{19}$$

$$\rho\frac{dv_i}{dt} = \frac{\partial\sigma_{ik}}{\partial x_k}. \tag{20}$$

Equations (19) and (20) have absolutely common character and are applicable to any moving medium.

At an equilibrium motion four equations – (19) and (20) modified with the equation of the state f (T, ρ, p) = 0 and rheological equation of the state or constitutive equation σik = σik(vjl, ξsq,…) are enough for the description of isothermal movement of the system the state of which at a constant temperature is described by four variables: pressure p or density ρ and three components of the rate vi.

In the elementary case we suppose that the tensor of the stresses depends only on the gradients of the rate. At this the equation of the first order for the incompressible system

$$\sigma_{ik} = -p\delta_{ik} + 2\eta v_{(ik)} \tag{21}$$

defines Newtonian liquid and the second rank equation – Reiner-Rivlin fluid [Cherny 1988]:

$$\sigma_{ik} = -p\delta_{ik} + 2\eta v_{(ik)} + 4\eta_c v_{(ik)}v_{(kj)}. \tag{22}$$

We are not limited only by the account of the gradients of the rate for the description of the expression of cement system of modified concrete mix, but we admit that the accelerations of highest orders can also enter the constitutive equation. The account of the acceleration of the first order leads to the constitutive equation of Reiner-Ericksen [Wollis 1982]

$$\begin{aligned}\sigma_{ik} = &-p\delta_{ik} + 2\eta v_{(ik)} + \\ &+4\eta_c v_{(ij)}v_{(kj)} + 2\eta_a(\zeta_{(ik)} + v_{si}v_{sk}).\end{aligned} \tag{23}$$

It is obvious that can be written also the constitutive equations of the highest orders with the accelerations of higher orders, but it is a common supposition of the local equilibrium of cement system in the process of fluid for all above mentioned equations. As the consequence of this the cement system remains isotropic at the fluid.

The situation changes if the deforming takes place by equilibrium way: to the enumerated independent variables is added m of inner variables ξα. The equations (19) and (20) should be modified by m equations of inner variables chosen in the way (17) or (18) by the equation of the system state f (T, ρ, p, ξα) = 0 and constitutive equation which should be considered in more details.

In the general way the tensor of the stresses is defined by the tensor of the gradients of movements at some moment of the time in relation to earlier moments of time and values of inner parameters at this moment of time

$$\sigma_{ik}\left(\xi^{\alpha},t\right)=\sigma\left[\xi\gamma,\lambda_{js}\left(t,t-s\right)\lambda_{pq}\left(t,t-s\right)\right]. \qquad (24)$$

We suppose that the tensor of the stresses is also defined by independent variables except for the tensor of deformation – by inner parameters which are changed at the deforming of the concrete mix. The functional (24) can be introduced by integral way (in linear) as per the tensor of deformation in approach for the scalar parameter

$$\sigma_{ik}\left(\xi,t\right)=N\left(\xi\right)\delta_{ik}+\int_{0}^{\infty}\Gamma\left(\xi,s\right)\Lambda_{ik}\left(t,t-s\right)ds \qquad (25)$$

And for the parameter – the tensor of the second rank

$$\sigma_{ik}\left(\xi_{j,s},t\right)=N_{ik}\left(\xi_{mn}\right)+ +\int_{0}^{\infty}\Gamma_{ikjspq}\left(\xi_{mn},s\right)\lambda_{js}\left(t,t-s\right)\lambda_{pq}\left(t,t-s\right)ds. \qquad (26)$$

We suppose at this that integral kernels Γ and Γ_{ikjspq} are decreasing, positive, stated at $s>0$ by the functions of their variables of times aiming for the zero at $s\to\infty$. As the functions of the inner parameters, the integral kernels can be expanded into series about their equilibrium value. The character of the dependence of integral kernels on the time is defined by the relax properties of the system. The less the time of relaxation, the quicker the functions are decreasing. If the times of relaxation are small in comparison with characteristic times of motion than the deformations close to the moment of t turn to be considerable. In the consequence of this it can be used the expansion of the tensor of the deformation in the variable s near the moment of time t. Putting expansions (7) and (6), accordingly, in (25) and (26), we got the expressions for the tensor of stresses at scalar and tensor parameters

$$\sigma_{ik}\left(\xi,t\right)=n\left(\xi\right)\delta_{ik}+\gamma\left(\xi\right)v_{(ik)}, \qquad (27)$$

$$\sigma_{ik}\left(\xi_{js},t\right)=n_{ik}\left(\xi_{ls}\right)+ +\gamma_{ikjspq}\left(\xi_{nm}\right)\left(v_{js}\delta_{pq}+v_{pq}\delta_{js}\right). \qquad (28)$$

Depending on the inner parameters the coefficients in the equations (27) and (28) are changing at the motion of system that is are not material constants. If according to the inner parameters can be made the expansion, we come to the formulas

$$\sigma_{ik}\left(\xi,t\right)=-p\delta_{ik}+\varepsilon_{0}\xi\delta_{ik}+2\left(\varepsilon_{1}+\varepsilon_{2}\xi\right)v_{(ik)}, \qquad (29)$$

$$\begin{aligned}\sigma_{ik}\left(\xi_{js},t\right)=&-p\delta_{ik}+q\xi_{jj}\delta_{ik}+\mu\left(\xi_{ik}-\xi_{ik}^{0}\right)+\\&+\zeta_{1}\delta_{ik}v_{ss}+\zeta_{2}v_{(ik)}+\zeta_{3}\xi_{ss}v_{(ik)}+\\&+\zeta_{4}\delta_{ik}\xi_{js}v_{js}+\zeta_{5}\xi_{jj}\delta_{ik}v_{ss}+\zeta_{6}\xi_{ik}v_{ss}+\\&+\zeta_{7}\left(\xi_{is}v_{sk}+\xi_{ks}v_{si}\right)+\zeta_{8}\left(\xi_{is}v_{ks}+\xi_{ks}v_{is}\right)+\\&+\zeta_{9}\left(\xi_{is}v_{sk}-\xi_{ks}v_{si}\right)+\zeta_{10}\left(\xi_{is}v_{ks}-\xi_{ks}v_{is}\right)-\\&-\left(2/3\right)\left(\zeta_{9}+\zeta_{10}\right)\xi_{ss}v_{[ik]}.\end{aligned} \qquad (30)$$

The coefficient at the last term in the equation (30) has been chosen so that at the deformation of the system as the whole the tensor of stresses would not change. The constant coefficients which are in the equations (29) and (30) are material constants characterizing the system.

The tensor of stresses with tensor inner variables can be asymmetric. At the absence of the external moments of forces the dissymmetry of the tensor of stresses is connected with rotator Brownian motion [Nigmatulin 1987].

Thus if the inner parameters characterizing the system have been known, the constitutive equation can be established with desired precision. But in the general case we cannot establish the universal connection between the tensor of stresses and the tensor of the gradients of the rate ignoring the inner parameters.

Isothermical deformation of visco elastic cement system with m inner parameters is described by the system of the equations m+4 into which number logs on the continuity equation (19), three equations of motion (20) with constitutive equation (29) or (30) and m equations describing the law of change of inner variables. Inner parameters can be excluded from the system of the equations which leads in this case to the system of a small number of the equations of a higher order. Thus, the constitutive equation written in the form of the correlation between the tensor of stresses, tensor of the gradients of the rate and their derivatives also can lead in the principle to the correct description of the motion of relax system.

The material constants of the system are defined by the correlations (18) and (30). Their number, the view of the equations of motion consistently, the properties of the system are defined by the tensor dimension of inner variables. This allows classifying the visco elastic cement systems according to the largest tensor rank of their inner parameters assigning the rank equal to the largest tensor rank of inner variables. The theory can be built at any approach.

CONCLUSIONS

On the ground of the results of the experimental theoretical investigations:

1. There has been established that whereas it is studied the modified concrete mix at vibro impact compact compression, then the study of concrete mix as the Newtonian liquid does not give full analysis of this system in the consequence of which it is necessary to consider thermodynamical non-equilibrium processes for the account of relax processes which allows to formulate the phenomenological equations of motion.

2. There have been obtained the equations of motion on the ground of the consideration of the behavior of the components in a concrete mix which are particular case for the common phenomenological equations of motion.

REFERENCES

1. **Batrakov V.G., 1998.:** Modified concretes. Theory and practice. // M.: Technoproject, 768 p.
2. **Bazhenov Yu.M., 2005.:** Modern technology of concrete.Technologies of concretes. № 1, p. 6-8.
3. **Bratchun V., Zolotarev V., Pakter M., Bespalov V. 2011.:** Physical chemical mechanics of building materials: the textbook for the students of higher schools. Edit.2, rev. and add. Makiivka-Kharkiv: Donnbas. 336 p.
4. **Cherny L. 1988.:** Relative models of continuous media. M.: Nauka. 288 p.
5. **Gusev B., Kondrashchenko V., Maslov B., Faivusovich A. 2006.:** Structure formation of composites and their properties. M.: Nauchnyi mir, ill. 560 p.
6. **Kaprielov S., Travush V., Karpenko N. and others 2006.:** Modified concretes of new generation in constructions MMDC, "Moscow-City". Part 1. Construction materials. № 10. p. 13-17.
7. **Loitsiansky L. 2003.:** Mechanics of liquid and gas. M.: Drofa. 900 p.
8. **Mchedlov-Petrosyan O., Babushkin V. 1992.:** Application of thermodynamics to concrete research. Papers of conference in chemistry and technology of concrete «New in chemistry and technology of concrete». M.: Gosstroyizdat. p. 92-103.
9. **Moranville-Regourd M. 1999.:** Portland Cement – based Binders – Cements for the next millennium. Creating with Concrete: International Conf.,: Proc. Dundee (Scotland). p. 87-99.
10. **Nigmatulin R. 1987.:** Dynamics of multiphase medium, part 1. M.: Nauka. 414 p.
11. **Okorokov S. 1956.:** To the question about mechanism of colloidation by Baykov A.A. at hardening viscous substances. Papers of conference in chemistry of concrete. M.: Promstroyizdat. p. 45-59.
12. **Pashchenko A. 1991.:** Theory of cement. K.: Budivelnik. 168 p.
13. **Pilipenko V., 2011.:** Technological peculiarities of forming of axisymmetric unreinforced concrete pipes. TEKA Commission of Motorization and Power Industry in Agriculture. V. XI_A, p. 198-206.
14. **Pilipenko V.N., 2010.:** Principles of structure formation of modified matrixof corrosion resistant concrete.. TEKA Commission of Motorization and Power Industry in Agriculture. V. XB, P. 100-104.
15. **Polak A. 1986.:** Hardening of monomineralic cementing. M.: Stroyizdat. 208 p.
16. **Punagin V., 2010.:** Properties and technology of beton for high altitude monolithic construction. TEKA Commission of Motorization and Power Industry in Agriculture. V. XB, p. 114-119.
17. **Rudenko N.N., 2010.:** The development of conception of new generation concretes. TEKA Commission of Motorization and Power Industry in Agriculture. V. XB, p. 1128-133.
18. **Sawaide M., Iketani J. 1992.:** Rheological Analysis of the Behavior of Bleed Water from Freshly Cast Mortar and Concrete. ACI Materials Journal.V. 89. No. 4. p. 323-328.
19. **Shayan A., Quick G. 1992.:** Microscopic Features of Cracked and Uncracked Concrete Railway Sleepers. ACI Materials Journal. V. 89. No. 4. p. 348-360.
20. **Tomosawa F. 1997.:** Development of a kinetic model for hydration of cement. Proc. of the X International Congress on the Chemistry of Cement. Geteborg. V. 2. p. 43-50.
21. **Wollis G. 1982.:** One-dimensional two-phase flow. M.: Mir. 456 p.
22. **Ziegler G. 1976.:** Extremal principles of thermodynamics of irreversible processes and mechanics of continuous medium. M.: Mir. 315 p.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ РЕОЛОГИЧЕСКИХ И ТЕРМОДИНАМИЧЕСКИХ ПРОЦЕССОВ В МОДИФИЦИРУЕМОЙ БЕТОННОЙ СМЕСИ ПРИ ВИБРО-УДАРНОИМПУЛЬСНОМ СПОСОБЕ УПЛОТНЕНИЯ

Владимир Пилипенко

Аннотация. В статье рассматривается модифицированная цементная система при вибро-ударноимпульсном способе уплотнения. Решается задача движения системы с учётом релаксационных процессов. Рассмотрено взаимодействие компонентов системы друг с другом, получены уравнения движения, и внутренние параметры, характеризующие движения релаксирующей системы.

Ключевые слова. Модифицированная бетонная смесь, вибро-ударноимпульсный способ уплотнения, релаксационные процессы, феноменологические уравнения движения.

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Outline of a theory of semantic information and misinformation

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Summary. The update version of semantic information theory, in which the not bona fide source of messages is considered and the absurdness of some sentences is assumed, is presented. Ternary logic is used. This logic includes along with the values of truth: "true" and "false" – also "absurd" value with respect to nonsence sentences. The quantities of semantic information and of misinformation, which are contained in messages, are defined.

Key words. Quantity of semantic information, logic of predicates, probability

INTRODUCTION

Mathematical theory of communication [1] developed in 1948 by Claude Shannon stimulated the development of the semantic theory of information. In 1952 the first work on this subject by Bar-Hillel and Carnap in a form of a report on investigations made [2] appeared. It was later published in Bar-Hillel's book [3]. It operated the Leibniz's idea of the plurality of "possible worlds" which exist because of our lack of awareness of the "real world" realities. Receiving new information, we reject some "possible worlds" which do not correspond to it and, thus, we narrow the number of possible combinations. The number of rejected "worlds" is used as a measure of the information message content.

Let us assume that we use the language system Λ_2^2, which contains two individual constants a and b, and two predicates, a one-place predicate M and a two-place predicate L. The first predicate may have the meaning "man", and the second predicate may mean "loves". We will denote the inversion $\neg M$ with the symbol W, "woman". The table 1 represents all sixteen descriptions of "possible worlds" within the specified language system.

Individual constant a may be interpreted as "Tom is a man", and the constant b like "Mary is a woman". And moreover, "Tom loves Mary" and "Mary loves Tom". Then the combination of the number 3 in the table 1 corresponds to the "real world". All other worlds are "false". It is necessary to get some semantic information contained in the sentences to understand it. Each of 16 combinations is a model of the world created by means of mathematical logic and constitutes a conjunction of four atomic statements. Bar-Hillel and Carnap called such atomic sentences (and their inversions) the *basis* sentences, similar to the system of coordinate vectors. According to the established tradition [4, 5], we denote the plurality of all "possible worlds" with a letter W.

Table 1. Descriptions of "possible worlds"

1.	$M(a) \wedge M(b) \wedge L(a,b) \wedge L(b,a)$
2.	$W(a) \wedge M(b) \wedge L(a,b) \wedge L(b,a)$
3.	$M(a) \wedge W(b) \wedge L(a,b) \wedge L(b,a)$
4.	$W(a) \wedge W(b) \wedge L(a,b) \wedge L(b,a)$
5.	$M(a) \wedge M(b) \wedge \neg L(a,b) \wedge L(b,a)$
6.	$W(a) \wedge M(b) \wedge \neg L(a,b) \wedge L(b,a)$
7.	$M(a) \wedge W(b) \wedge \neg L(a,b) \wedge L(b,a)$
8.	$W(a) \wedge W(b) \wedge \neg L(a,b) \wedge L(b,a)$
9.	$M(a) \wedge M(b) \wedge L(a,b) \wedge \neg L(b,a)$
10.	$W(a) \wedge M(b) \wedge L(a,b) \wedge \neg L(b,a)$
11.	$M(a) \wedge W(b) \wedge L(a,b) \wedge \neg L(b,a)$
12.	$W(a) \wedge W(b) \wedge L(a,b) \wedge \neg L(b,a)$
13.	$M(a) \wedge M(b) \wedge \neg L(a,b) \wedge \neg L(b,a)$
14.	$W(a) \wedge M(b) \wedge \neg L(a,b) \wedge \neg L(b,a)$
15.	$M(a) \wedge W(b) \wedge \neg L(a,b) \wedge \neg L(b,a)$
16.	$W(a) \wedge W(b) \wedge \neg L(a,b) \wedge \neg L(b,a)$

In fact, the authors of the work [2] used the idea of Shannon about information as a removed

uncertainty [1], although this idea is not expressed explicitly in their article. At the initial moment, when there is no information about the realities of the "real world", we have 16 alternatives, so the uncertainty is high. When we obtain the most possible information, we have only one option, and the uncertainty is equal to zero. According to the formula of R. Hartley [6]

$$\inf(\sigma_3) = \log_2(16) - \log_2(1) = 4\ bit\ ,$$

where: $\inf(\sigma_3)$ is the amount of semantic information contained in the message σ_3 (it is written in the third line of the table 1).

Suppose that another, less informative message, for instance: "$M(a) \vee M(b)$", came instead of the most informative message σ_3. On the basis of the information contained in this sentence, we cross off from table 1 four "possible worlds": σ_4, σ_8, σ_{12} and σ_{16}. The amount of the obtained semantic information makes then

$$\inf(M(a) \vee M(b)) = \log_2(16) - \log_2(12) = \log_2 \frac{4}{3}\ bit\ .$$

Thus, the message σ_3 has in about ten times more information than the message "$M(a) \vee M(b)$". In the case of an arbitrary message σ we have:

$$\inf(\sigma) = \log_2 \frac{1}{m(\sigma)} = \log_2 \frac{1}{1 - cont(\sigma)}\ , \qquad (1)$$

where: $cont(\sigma) \le 1$ is *the measure of the content of the message* [2, 3] (the quotient obtained by dividing the number of the descriptions of the "possible worlds", inconsistent with σ, by the total number of "possible worlds"), $m(\sigma) = 1 - cont(\sigma)$. If we know $cont(\sigma)$, then we can clearly define $\inf(\sigma)$, and vice versa. For example:

$$cont(\sigma_3) = \frac{15}{16}, \qquad cont(M(a) \vee M(b)) = \frac{4}{16} = \frac{1}{4}\ .$$

The disadvantage of the theory of Bar-Hillel and Carnap is that the logical contradiction in their concept contains an infinite amount of information, because it does not match any of the "possible worlds". This fact is counterintuitive and is known as the "Bar-Hillel-Carnap paradox".

For this reason, other theories appeared, in which the number of semantic information is determined otherwise. A.A. Kharkevich proposed to measure the value of information through changing the possibility of achieving a certain goal, arising under the influence of the received message. [7] In Y.A. Schreider's work it is proposed to estimate semantic information as the degree of changing the system of knowledge (thesaurus) of an addressee as the result of the perception of the received message. [8] Although this concept had some success, and continues to be popular even in modern times [9], the insufficient formalization of the concept of thesaurus makes this theory too vague and does not allow to subject it to mathematical analysis.

Luciano Floridi in his work [10] presented his theory of "strongly semantic information" (this concept is developed in his later articles [11, 12, 13]). In this paper he calls the theory of Bar-Hillel and Carnap the theory of "weakly semantic information". Floridi introduced the function $\vartheta(\sigma)$, which describes the difference between the message σ and the real situation. This function changes within the interval [-1.0, +1.0]. The negative values of this function describe the degree of the "inaccuracy" of the received message, and the positive functions describe the degree of its "emptiness". He also introduced the function of the "degree of the message information value".

$$\iota(\sigma) = 1 - \vartheta^2(\sigma)\ . \qquad (2)$$

The amount of the meaningless information in the message σ can be defined using the formula

$$\vartheta^*(\sigma) = \frac{\int_0^{\vartheta} \iota(\sigma) dx}{1 sbit}, \qquad (3)$$

where: $1 sbit = \int_0^1 \iota(\sigma) dx = \log_2 \frac{2}{3} = 1 bit - 1 trit\ .$

And the amount of semantic information in a message σ is defined by the formula

$$\iota^*(\sigma) = 1 sbit - \vartheta^*(\sigma)\ . \qquad (4)$$

Since the values of the function $\vartheta(\sigma)$ for logically controversial sentences are equal to "-1", then according to the formula (4) they do not contain semantic information:

$$\iota^* = 1 sbit - \frac{\int_{-1}^{0} \iota(\sigma) dx}{1 sbit} = 0\ .$$

Thus, the Bar-Hillel-Carnap paradox is solved under the new concept. However, the approach of Floridi is not notable for its clarity and simplicity typical for the classical theory. The article [14] says on this subject: "Unlike Hartley and C.E. Shannon, who tried to apply simple models of Boolean algebra for the description of

information, L. Floridi uses more complex mathematical models ...".

It should be noted, that the paradox of Bar-Hillel and Carnap is not the only problem of the theory of semantic information. One of them is related to the possibility of misinformation. The fact is that the source of the message in classical works [2, 10] is interpreted as the conscientious (*bona fide* source of information). It means that only true messages are accepted, what does not always correspond to the real situation. Another problem refers to the completeness of the description of the "possible worlds".

Let us consider a rather complex language system Λ_n^π containing n number of individual constants (objects, events or locations) and π number of predicates of different arity. To take into account all the possible relationships between the constants in the description of the possible state of the world it is necessary to use the following number of atomic sentences:

$$l = \sum_{k=0}^{n} \pi_k \frac{n!}{(n-k)!}, \qquad (5)$$

where: π_k is the number of k- place predicates in the language system Λ_n^π.

Naturally, not all l of basic sentences will make sense. For example, if in the simple language system Λ_2^2 the individual constant a is interpreted not as "Tom", but as "brick" (building material), then the expression $M(a)$ "A brick is a man" confuses. Let us assume, that it is false. Then its inversion $W(a)$ "A brick is a woman" is a false sentence as well. It leads to breaking the law of the excluded middle.

Of course, every adult knows that a woman and a man are people and a brick is not a man. Then using the method of deduction it is easy to conclude the absurdity of the sentences "A brick is a man" and "A brick is a woman". However, it should be remembered, that in the real life the most of the knowledge (especially at the initial stage) is acquired through the induction. Since often we can not know in advance (before obtaining the relevant information), which sentences make sense, and which do not, we can not exclude a priori the meaningless sentences from the descriptions of the possible states of the world.

Thus, the question arises: what truth value should be ascribed to a meaningless sentence?

THE AIM OF THE WORK

The paper presents a new version of the theory of semantic information, which consideres not necessarily a conscientious message source and in which senselessness of some atomic and molecular sentences is conceded. The theory uses the ternary logic, including, along with the traditional truth values "true" and "false", an additional value "absurd" applied to the meaningless sentences. The definition of the amount of semantic information and misinformation contained in messages is given in the work.

TERNARY LOGIC

Why do children love absurd statements so much and Lewis Carroll and other writers indulge them in this? Because such statements help to understand better, what is allowed in this world, and what is forbidden. Moreover, absurd sentences bear fascination, i.e. they are emotionally appealing [15, 16].

Having assumed the existence of meaningless sentences, let us assign them a new truth value, "*absurd*". In this case, all of the classic definitions and equivalences of binary logic (with the exception of the law of the excluded middle) remain in force. Let φ and ψ be the different sentences of ternary logic. Let us formulate five axioms that seem to be intuitively obvious.

Axioms

1. For each φ only one of three expressions: "$\varphi \equiv true$", "$\varphi \equiv false$", "$\varphi \equiv absurd$" is true, the other two are false.
2. $(\varphi \equiv absurd) \rightarrow (\neg\varphi \equiv absurd)$;
3. $((\varphi \equiv absurd) \wedge (\psi \equiv absurd)) \rightarrow (\varphi \wedge \psi \equiv absurd)$;
4. $((\varphi \equiv absurd) \wedge (\psi \equiv true)) \rightarrow (\varphi \wedge \psi \equiv absurd)$;
5. $((\varphi \equiv absurd) \wedge (\psi \equiv true)) \rightarrow (\varphi \vee \psi \equiv true)$.

Based on these axioms, we can prove the following theorems.

Theorem 1.

$((\varphi \equiv absurd) \wedge (\psi \equiv false)) \rightarrow (\varphi \wedge \psi \equiv false)$.

Proof: If $(\varphi \equiv absurd) \wedge (\psi \equiv false)$, then, based on the axioms 2 and 5 (and using the law of De Morgan), we can write: $\neg(\varphi \wedge \psi) \equiv \neg\varphi \vee \neg\psi \equiv true$. Therefore: $\varphi \wedge \psi \equiv false$.

Theorem 2.

$((\varphi \equiv absurd) \wedge (\psi \equiv false)) \rightarrow (\varphi \vee \psi \equiv absurd)$.

Proof: If $(\varphi \equiv absurd) \wedge (\psi \equiv false)$, then, based on the axioms 2 and 4 (and using the law of De

Morgan), we can write: $\neg(\varphi \vee \psi) \equiv \neg\varphi \wedge \neg\psi \equiv absurd$. Therefore: $\varphi \vee \psi \equiv absurd$.

Theorem 3.

$((\varphi \equiv absurd) \wedge (\psi \equiv absurd)) \rightarrow (\varphi \vee \psi \equiv absurd)$.

Proof: If $(\varphi \equiv absurd) \wedge (\psi \equiv absurd)$, then, based on the axioms 2 and 3 (and using the law of De Morgan), we can write: $\neg(\varphi \vee \psi) \equiv \neg\varphi \wedge \neg\psi \equiv absurd$. Therefore: $\varphi \vee \psi \equiv absurd$.

Theorem 4.

$((\varphi \equiv absurd) \wedge (\psi \equiv true)) \rightarrow (\varphi \rightarrow \psi \equiv true)$.

Proof: If $(\varphi \equiv absurd) \wedge (\psi \equiv true)$, then, based on the axioms 2 and 5 (and using the known equivalence), we can write: $\varphi \rightarrow \psi \equiv \neg\varphi \vee \psi \equiv true$.

Theorem 5.

$((\varphi \equiv true) \wedge (\psi \equiv absurd)) \rightarrow (\varphi \rightarrow \psi \equiv absurd)$.

Proof: If $(\varphi \equiv true) \wedge (\psi \equiv absurd)$, then, based on the axiom 2 and the theorem 2 (and using the known equivalence), we can write: $\varphi \rightarrow \psi \equiv \neg\varphi \vee \psi \equiv absurd$.

Theorem 6.

$((\varphi \equiv absurd) \wedge (\psi \equiv false)) \rightarrow (\varphi \rightarrow \psi \equiv absurd)$.

Proof: If $(\varphi \equiv true) \wedge (\psi \equiv false)$, then, based on the axiom 2 and the theorem 2 (and using the known equivalence), we can write: $\varphi \rightarrow \psi \equiv \neg\varphi \vee \psi \equiv absurd$.

Theorem 7.

$((\varphi \equiv false) \wedge (\psi \equiv absurd)) \rightarrow (\varphi \rightarrow \psi \equiv true)$.

Proof: If $(\varphi \equiv false) \wedge (\psi \equiv absurd)$, then, based on the axioms 2 and 5 (and using the known equivalence), we can write: $\varphi \rightarrow \psi \equiv \neg\varphi \vee \psi \equiv true$.

Theorem 8.

$((\varphi \equiv absurd) \wedge (\psi \equiv absurd)) \rightarrow (\varphi \rightarrow \psi \equiv absurd)$.

Proof: If $(\varphi \equiv absurd) \wedge (\psi \equiv absurd)$, then, based on the axiom 2 and the theorem 3, we can write: $\varphi \rightarrow \psi \equiv \neg\varphi \vee \psi \equiv absurd$.

Definition 1. We will define an equivalence in ternary logic as follows:

$$(\varphi \equiv \psi) \equiv ((\varphi \equiv true) \wedge (\psi \equiv true)) \vee \vee ((\varphi \equiv false) \wedge (\psi \equiv false)) \vee \vee ((\varphi \equiv absurd) \wedge (\psi \equiv absurd)).$$

From this definition follows, that expression $\varphi \equiv \psi$ is true only in those cases, when the values of truth of sentences φ and ψ coincide. It is false in all other cases. Sentense $\varphi \equiv \psi$ can not be absurd.

On the basis of the accepted axioms and the proved theorems it is possible to make the truth table of ternary logic (table 2), in which the sign "1" corresponds to the value of truth "*true*", the sign "0" corresponds to the value "*false*" and the sign "-1" corresponds to the value "*absurd*".

Table 2. The truth table of ternary logic

φ	ψ	$\neg\varphi$	$\varphi \wedge \psi$	$\varphi \vee \psi$	$\varphi \rightarrow \psi$	$\psi \rightarrow \varphi$	$\varphi \equiv \psi$
0	0	1	0	0	1	1	1
0	1	1	0	1	1	0	0
0	-1	1	0	-1	1	-1	0
1	0	0	0	1	0	1	0
1	1	0	1	1	1	1	1
1	-1	0	-1	1	-1	1	0
-1	0	-1	0	-1	-1	1	0
-1	1	-1	-1	1	1	-1	0
-1	-1	-1	-1	-1	-1	-1	1

THE SET OF THE POSSIBLE WORLDS

The cardinal number of the "possible worlds" set is equal to $|W| = s^l$, where s is the number of truth-values in the used logic [10]. The description of a separate world (its logical model) is the conjunction, containing l of basic sentences. The basic sentence will be denoted by the Greek letter β_{ij}, the index i denotes the number of the "possible worlds", and the index j denotes the sequence number of the sentence in a conjunction. State-descriptions are presented in the table 3.

Table 3. State-descriptions

$$\begin{array}{l}
\beta_{11} \wedge \beta_{12} \wedge \cdots \wedge \beta_{1l} \\
\beta_{21} \wedge \beta_{22} \wedge \cdots \wedge \beta_{2l} \\
\beta_{31} \wedge \beta_{32} \wedge \cdots \wedge \beta_{3l} \\
\beta_{41} \wedge \beta_{42} \wedge \cdots \wedge \beta_{4l} \\
\beta_{51} \wedge \beta_{52} \wedge \cdots \wedge \beta_{5l} \\
\beta_{61} \wedge \beta_{62} \wedge \cdots \wedge \beta_{6l} \\
\beta_{71} \wedge \beta_{72} \wedge \cdots \wedge \beta_{7l} \\
\cdots\cdots\cdots\cdots\cdots\cdots \\
\beta_{s^l 1} \wedge \beta_{s^l 2} \wedge \cdots \wedge \beta_{s^l l}
\end{array}$$

Basic sentences with the same index j consist of the totality of periodically recurring s sentences. In ternary logic the first of them asserts the truth of a certain atomic sentence (which is denoted as α_j), the second sentence asserts its falsity and the third one asserts its absurdity. Using numbers 1, 0, -1 to indicate the truth, the falsity and the absurdity of the sentence α_j respectively, we can make an image of the descriptions of the world's states as a set of pseudo-ternary codes (for convenience presented in a specular reflection). Now β_{11} indicates the sentence "$\alpha_1 \equiv true$", β_{21} indicates the sentence "$\alpha_1 \equiv false$", and β_{31} indicates the sentence "$\alpha_1 \equiv absurd$".Then the truth

values are repeated: β_{41} indicates the sentence "$\alpha_1 \equiv true$", β_{51} indicates "$\alpha_1 \equiv false$", β_{61} indicates "$\alpha_1 \equiv absurd$" and so on. In the second column of the model structure the first three sentences β_{12}, β_{22}, β_{32} state the truth of the other atomic sentence α_2, the next three sentences state its falsity and the following three sentences state its absurdity, etc. We shall call *the core of basic sentences* β_{ij} $(1 \le i \le s^l)$ the atomic sentence α_j for the fixed j. Though the core can take three values of the truth: "*true*", "*false*" and "*absurd*", all basic sentences are either true or false.

THE PROCESS OF COGNITION

Let us assign to the i-th "possible world" $(1 \le i \le s^l)$ the assessment of the probability $p_i(t)$, that for $t \to \infty$ it will be the "real world", made at the moment of time t. The time t is measured with the number of the messages received (some of them may be repeated). The messages may be both "external" and "internal". The "external" come from the outside world, the "internal" are the result of the deductive conclusion made on the basis of the earlier obtained information. Introducing probabilities into the logical system, we come to the probabilistic logic, in which multiplying of the probabilities corresponds to conjunction, and *comultiplication* corresponds to disjunction [17-22]. So we can summarize

$$p_i(t) = \prod_{j=1}^{l} p_{ij}(t) \qquad (6)$$

where: $p_{ij}(t)$ is the made in the moment of time t assessment of the probability, that for $t \to \infty$, the basic sentence β_{ij} is true.

Definition 2. The set W with the given on it probabilities $p_{ij}(t)$ will be called *thesaurus.*

At the initial moment of time, when the uncertainty is maximal, for atomic sentences presented in the conjunctions of the set W we have:

$$p_{ij}(0) = \frac{1}{s}, \qquad (7)$$

and for a separate "possible world" we have

$$p_i(0) = \frac{1}{s^l}. \qquad (8)$$

Upon the receipt of the message σ (atomic or molecular), some estimated probabilities from the general totality $p_{ij}(t)$ will change. Changes can occur in the following algorithm.

Algorithm 1. Let us denote the estimated probability, that for $t \to \infty$ the sentence σ will be true, as $p_t(\sigma,t)$; the estimated probability, that for $t \to \infty$ it will be false, as $p_f(\sigma,t)$; the estimated probability, that for $t \to \infty$ it will be absurd, as $p_a(\sigma,t)$. Let $m_t(\sigma,t)$, $m_f(\sigma,t)$ and $m_a(\sigma,t)$ be the number of the messages indicating the truth, the falsity and the absurdity of the sentence σ respectively. Then for $t > 0$ we have:

$$p_t(\sigma,t) = \frac{m_t(\sigma,t)}{m_t(\sigma,t) + m_f(\sigma,t) + m_a(\sigma,t) + m_{tf}(\sigma,t)}, \qquad (9)$$

$$p_f(\sigma,t) = \frac{m_f(\sigma,t)}{m_t(\sigma,t) + m_f(\sigma,t) + m_a(\sigma,t) + m_{tf}(\sigma,t)}, \qquad (10)$$

$$p_a(\sigma,t) = \frac{m_a(\sigma,t) + m_{tf}(\sigma,t)}{m_t(\sigma,t) + m_f(\sigma,t) + m_a(\sigma,t) + m_{tf}(\sigma,t)}, \qquad (11)$$

where: $m_{tf}(\sigma,t) = \begin{cases} m_t(\sigma,t), \text{ if } m_f(\sigma,t) \ge m_t(\sigma,t), \\ m_f(\sigma,t), \text{ if } m_t(\sigma,t) \ge m_f(\sigma,t). \end{cases}$

The variable $m_{tf}(\sigma,t)$ is used, because the sentence $\langle\langle \sigma \wedge \neg\sigma \equiv true \rangle\rangle$ is not true. If the sentence σ is basic, then using formulas (9), (10) and (11) we can directly calculate estimated probabilities $p_{ij}(t)$.

Algorithm 2. Algorithm 1 can be complicated. The process of cognition has the subjective nature. Let us suppose that the subject A at the moment t_1 has received not too many messages and does not have much trust in his assessments of probabilities. He prefers to use the estimates of the subject B, who has received much more messages and therefore has more experience. More precisely, the subject A leads a "double bookkeeping", that is, he continues to count messages and calculate probabilities according to the formulas (9), (10), (11), but "for the time being" he prefers somebody else's data. Over time, his trust in his estimates grows and he starts using his own experience more often.

The presented in this paper theory of semantic information is based on the following hypothesis.

Hypothesis. The random process of changing the estimated probabilities $p_{ij}(t)$, done according to the algorithm 1 or the algorithm 2, for $t \to \infty$ asymptotically leads to the fact that for some natural number i the following equality will be

satisfied: $\lim_{t\to\infty} p_{ij}(t)=1$ for all j over the range $(1\le j\le l)$.

The hypothesis states that the cognition is possible and is not restricted. It is clear that certain conditions are necessary to accomplish it, the received messages should be diverse and possess a certain degree of trustworthiness, and the subject of cognition should have logic abilities. We will assume that these requirements are fulfilled and the algorithm tallies.

The peculiarity of our case is that the law of the excluded middle is replaced by the law of the excluded fourth:

$$p_t(\sigma,t)+p_f(\sigma,t)+p_a(\sigma,t)=1. \qquad (12)$$

Next expressions are thus just

$$p_t(\neg\sigma)=p_f(\sigma), \qquad (13)$$

$$p_f(\neg\sigma)=p_t(\sigma), \qquad (14)$$

$$p_a(\neg\sigma)=p_a(\sigma). \qquad (15)$$

Let us suppose that σ is a molecular sentence obtained from the two sentences φ and ψ (atomic or molecular) connected by logical connectives. Formulas (17-27) on which it is possible to expect probabilities of truth ensue from formulas (12-16), to falsity and absurdity of the compound sentences by the known probabilities of truth, falsity and absurdity of the sentences φ and ψ (the sign of the argument t is omitted everywhere). If $p_a(\bullet)=0$, they are converted into regular expressions of the probabilistic logic.

$$p_t(\varphi\wedge\psi)=p_t(\varphi)\cdot p_t(\psi\mid\varphi), \qquad (16)$$

$$p_f(\varphi\wedge\psi)= \\ =p_f(\varphi)+p_f(\psi\mid\varphi)-p_f(\varphi)\cdot p_f(\psi\mid\varphi), \qquad (17)$$

$$p_a(\varphi\wedge\psi)= \\ =p_a(\varphi)+p_a(\psi\mid\varphi)-p_a(\varphi)\cdot p_a(\psi\mid\varphi)- \\ -p_f(\varphi)\cdot p_a(\psi\mid\varphi)-p_a(\varphi)\cdot p_f(\psi\mid\varphi), \qquad (18)$$

$$p_t(\varphi\vee\psi)= \\ =p_t(\varphi)+p_t(\psi\mid\neg\varphi)-p_t(\varphi)\cdot p_t(\psi\mid\neg\varphi), \qquad (19)$$

$$p_f(\varphi\vee\psi)=p_f(\varphi)\cdot p_f(\psi\mid\neg\varphi), \qquad (20)$$

$$p_a(\varphi\vee\psi)=p_f(\varphi)\cdot p_a(\psi\mid\neg\varphi)+ \\ +p_a(\varphi)\cdot p_f(\psi\mid\neg\varphi)+p_a(\varphi)\cdot p_a(\psi\mid\neg\varphi), \qquad (21)$$

$$p_t(\varphi\to\psi)=1-[p_t(\varphi)+p_a(\varphi)]\cdot[1-p_t(\psi\mid\varphi)], \qquad (22)$$

$$p_f(\varphi\to\psi)=p_t(\varphi)\cdot p_f(\psi\mid\varphi), \qquad (23)$$

$$p_a(\varphi\to\psi)=p_t(\varphi)\cdot p_a(\psi\mid\varphi)+ \\ +p_a(\varphi)\cdot p_f(\psi\mid\varphi)+p_a(\varphi)\cdot p_a(\psi\mid\varphi), \qquad (24)$$

$$p_t(\varphi\equiv\psi)=p_t(\varphi)\cdot p_t(\psi\mid\varphi)+ \\ +p_f(\varphi)\cdot p_f(\psi\mid\neg\varphi)+p_a(\varphi)\cdot p_a(\psi\mid\varphi), \qquad (25)$$

$$p_f(\varphi\equiv\psi)=1-p_t(\varphi\equiv\psi), \qquad (26)$$

$$p_a(\varphi\equiv\psi)=0. \qquad (27)$$

Let us define the uncertainty of the message recipient at the moment of time t as an entropy:

$$H(t)=\sum_{i=1}^{s^l} p_i(t)\log_s\frac{1}{p_i(t)}, \qquad (28)$$

$$H(0)=\sum_{i=1}^{s^l}\frac{1}{s^l}\log_s s^l=l. \qquad (29)$$

Definition 3. The volume of thesaurus $V_t(t)$ at the moment of time t is equal to:

$$V_t(t)\overset{Def}{=}H(0)-H(t). \qquad (30)$$

Definition 4. The change of the thesaurus volume $\Delta V_t(t)$ at the moment of time t is equal to:

$$\Delta V_t(t)\overset{Def}{=}H(t-1)-H(t). \qquad (31)$$

The value of the change of the thesaurus volume $\Delta V_t(t)$ corresponds to the definition of the amount of semantic information by Schreider [8]. The disadvantage of this definition is that in the conditions of possible misinformation (which leads to the necessity of the correction of the thesaurus, when the falsehood is exposed), the quantity $\Delta V_t(t)$ may take both positive and negative values. Also, $\Delta V_t(t)$ depends not only on the content of the message, but on the thesaurus state at moment of time $t-1$. Bar-Hillel and Carnap (together with Floridi) try to give an objective meaning to the definition of the amount of semantic information. The classical definition assumes that the recipient of information before obtaining the tested message σ is extremely naive, and the volume of his thesaurus is equal to zero (or the message content does not depend on the content of the previously received messages). We also will follow this approach.

Let us assume that the sentence σ is true. Let m be the number of the possible worlds, which do not contradict this sentence. Then the value of the uncertainty removed by this sentence is equal to $\log_s s^l/m$. However, the assumption of the truth of the sentence σ requires confirmation. If the assumption is not confirmed, there will be no removed uncertainty.

On the other hand, the ratio m/s^l can be treated as an a priori estimated probability of the truth of the sentence σ. In the case of the basic sentence this interpretation is equivalent to the formula (7), in the case of the conjunction of basic sentences it is equivalent to the formula (8).

THE AMOUNT OF SEMANTIC INFORMATION AND MISINFORMATION

In definition of the amount of semantic information and misinformation in the message we will be guided by the following principles:

- a true message has a certain amount of semantic information;
- a false message has a certain amount of misinformation;
- an absurd sentence has neither semantic information nor misinformation;
- the amount of semantic information in a true message is proportional to the value of the uncertainty, removed in the result of the receiving of this message.

Definition 5. The amount of semantic information $\inf(\sigma)$ contained in the message σ equals to:

$$\inf(\sigma) \overset{Def}{=} \lim_{t\to\infty} p_t(\sigma,t)\cdot\log_s \frac{1}{p_t(\sigma,0)}, \qquad (32)$$

where: $p_t(\sigma,t)$ is the estimated probability of the truth of the sentence σ at the moment of time t.

Definition 6. The amount of misinformation $\mathrm{mis}(\sigma)$ contained in the message σ equals to:

$$\mathrm{mis}(\sigma) \overset{Def}{=} \lim_{t\to\infty} p_f(\sigma,t)\cdot\log_s \frac{1}{p_t(\sigma,0)}, \qquad (33)$$

where: $p_f(\sigma,t)$ is the estimated probability of the falsity of the sentence σ at the moment of time t.

SOME RESULTS OF THE THEORY

Let us consider several simple examples. It is easy to ensure that a true atomic sentence has one unit of semantic information and no misinformation. A false atomic sentence has no semantic information and one unit of misinformation. Using the data of the table 2 (or table 4), we can calculate that the true sentence "$\alpha_1 \wedge \alpha_2$" ("α_1" and "α_2" are atomic sentences) has two units of semantic information. The true sentences "$\alpha_1 \vee \alpha_2$" and "$\alpha_1 \to \alpha_2$" both have $\log_3 9/5 \approx 0{,}535$ units of semantic information, and the true sentence "$\alpha_1 \equiv \alpha_2$" has one unit of semantic information.

Now we will consider tautology: $\varphi \vee \neg\varphi$. Suppose in the beginning, that sentence φ either truly or falsely (but not absurdly). Then according to a formula (19) for any t $(0 \le t < \infty)$:

$$\begin{aligned}
&p_t(\varphi \vee \neg\varphi,t) = \\
&= p_t(\varphi,t) + p_t(\neg\varphi \mid \neg\varphi,t) + p_t(\varphi,t)\cdot p_t(\neg\varphi \mid \neg\varphi,t) = \\
&= p_t(\varphi,t) + 1 - p_t(\varphi,t) = 1, \\
&p_f(\varphi \vee \neg\varphi,t) = p_a(\varphi \vee \neg\varphi,t) = 0, \\
&\inf(\varphi \vee \neg\varphi) = \\
&= \lim_{t\to\infty} p_t(\varphi \vee \neg\varphi,t)\cdot\log_s \frac{1}{p_t(\varphi \vee \neg\varphi,0)} = \log_s \frac{1}{1} = 0, \\
&\mathrm{mis}(\varphi \vee \neg\varphi) = \\
&= \lim_{t\to\infty} p_f(\varphi \vee \neg\varphi,t)\cdot\log_s \frac{1}{p_t(\varphi \vee \neg\varphi,0)} = 0\cdot\log_s \frac{1}{1} = 0.
\end{aligned}$$

If sentence φ is absurd, then

$$p_t(\varphi \vee \neg\varphi,t) = p_f(\varphi \vee \neg\varphi,t) = 0,\ p_a(\varphi \vee \neg\varphi,t) = 1.$$

In this case we get the same result:

$$\inf(\varphi \vee \neg\varphi) = \mathrm{mis}(\varphi \vee \neg\varphi) = 0.$$

Thus, tautology carries neither information nor misinformation, and absurd sentence reminds this property.

THE SOLUTION OF THE BAR-HILLEL-CARNAP PARADOX

Now we will consider contradiction $\varphi \vee \neg\varphi$. Suppose in the beginning, that sentence φ either truly or falsely (but not absurdly). Then according to a formulas (16) and (17) for any t $(0 \le t < \infty)$:

$$\begin{aligned}
&p_t(\varphi \wedge \neg\varphi,t) = \\
&= p_t(\bot,t) = p_t(\varphi,t)\cdot p_t(\neg\varphi \mid \varphi,t) = p_t(\varphi,t)\cdot 0 = 0, \\
&p_f(\bot,t) = \\
&= p_f(\varphi) + p_f(\neg\varphi \mid \varphi) - p_f(\varphi)\cdot p_f(\neg\varphi \mid \varphi) = \\
&= p_f(\varphi) + p_t(\varphi \mid \varphi) - p_f(\varphi)\cdot p_t(\varphi \mid \varphi) = 1, \\
&\inf(\bot) = \\
&= \lim_{t\to\infty} p_t(\bot,t)\cdot\log_s \frac{1}{p_t(\bot,0)} = p_t(\bot,0)\cdot\log_s \frac{1}{p_t(\bot,0)} = \\
&= \lim_{x\to 0}\left[x\cdot\log_s \frac{1}{x}\right] = 0, \\
&\mathrm{mis}(\bot) = \\
&= \lim_{t\to\infty} p_f(\bot,t)\cdot\log_s \frac{1}{p_t(\bot,0)} = \log_s \frac{1}{p_t(\bot,0)} = \infty.
\end{aligned}$$

If sentence φ is absurd, then

$$p_t(\varphi \wedge \neg\varphi,t) = p_f(\varphi \wedge \neg\varphi,t) = 0,\ p_a(\varphi \wedge \neg\varphi,t) = 1.$$

In this case we get the same result:

$$\inf(\varphi \vee \neg\varphi) = \mathrm{mis}(\varphi \vee \neg\varphi) = 0.$$

Thus, contradiction does not carry semantic information, however, if φ is not absurd sentence, contradiction carries an infinite amount of misinformation. Although this conclusion is some unexpected, he does not conflict with intuition. A

role of contradiction in logic and in science is such, that, taking its truth for a true, we destroy all bases of thought.

CONCLUSIONS

In this paper we tried to strengthen the Bar-Hillel and Carnap's theory of "weakly semantic information", which, despite the well-known paradox, is attractive for its simplicity and in the framework of which a lot of interesting results have been already received. The use of such new truth-value as "absurd" actually leads to the division of the set of all possible sentences into three classes that have fundamentally different properties. True sentences bear semantic information, false sentences bear misinformation and absurd sentences bear neither information nor misinformation. In the update version of theory the contradiction does not carry semantic information. The Bar-Hillel-Carnap paradox is explained by an illogical attempt to ascribe to false sentence a truth value.

REFERENCES

1. **Shannon C.E., 1948.:** A Mathematical Theory of Communication. Bell Syst. Tech. J., 27: 379-423, 623-656.
2. **Bar-Hillel Y., Carnap R., 1952.:** «An Outline of a Theory of Semantic Information», Technical Report No. 247, October 27, Research Laboratory of Electronics. – 49.
3. **Bar-Hillel Y., Carnap R., 1964.:** «An Outline of a Theory of Semantic Information», rep. in Bar-Hillel Y., pp. 221-274.
4. **Kripke S. A., 1963.:** «Semantical Considerations on Modal Logic», Acta Philosophica Fennica 16:83-94.
5. **Kripke S. A., 1963.:** «Semantical Analysis of Modal Logic I: Normal Modal Propositional Calculi», Zeitschrift für Mathematische Logik und Grundlagen der Mathematik 9:67-79.
6. **Hartley R.V., 1928.:** «Transmission of Information», Bell Syst. Tech. J., 7:535.
7. **Kharkevich A.A., 1960.:** At the values of information, "Problems of cybernetics", v. 4: 586-601.
8. **Schreider Y.A., 1965.:** About one model of semantic information theory, "Problems of cybernetics", v. 13: 60-68.
9. **Chursin N.N., 2010.:** Concept of thesaurus in the informative picture of the world: monograph. - Luhansk: Publ. "Knowledge". - 305 p.
10. **Floridi L., 2004.:** «Outline of a Theory of Strongly Semantic Information», Minds and Machines, 14(2), 197-222.
11. **Floridi L., 2005.:** «Is Semantic Information Meaningful Data», Philosophy and Phenomenological Research, 70(2), 351-370.
12. **Floridi L., 2006.:** «The Logic of Being Informed», Logique et Analyse, 49(196), 433-460.
13. **Floridi L., 2007.:** «In Defence of the Veridical Nature of Semantic Information», The European Journal of Analytic Philosophy, 3(1), 1-18.
14. **Tsvetkov V. Ya., 2012.:** Semantic Information Units as L. Floridi's Ideas Development, European Researher, Vol.(25), N 7: 1036-1041.
15. **Knorosov Y.V., 1973.:** To the question about the classic signaling// the Basic problems of africanystic. - M.: Science: 324-334.
16. **Muxelyshvily N.L., Schreider Y.A., 1997.:** Information and fascination in a line and indirect communication// of STI, 2, Inf. Processes and systems, № 8: 1-7.
17. **Nilsson, N. J., 1986.:** «Probabilistic logic», Artificial Intelligence 28(1): 71-87.
18. **Jøsang, A. and McAnally, D., 2004.:** «Multiplication and Comultiplication of Beliefs», International Journal of Approximate Reasoning, 38(1), pp.19-51.
19. **Jøsang, A., 2008.:** «Conditional Reasoning with Subjective Logic», Journal of Multiple-Valued Logic and Soft Computing, 15(1): 5-38.
20. **Gerla, G., 1994.:** «Inferences in Probability Logic», Artificial Intelligence 70(1–2):33–52.
21. **Norbert Chamier-Gliszczynski, 2011.:** "Modelling of Traffic Flow in an Urban Transportation System", TEKA, Commission of Motorization and Power Industry in Agriculture. – OL PAN, 2011, 11v.: 12-18.
22. **Norbert Chamier-Gliszczynski, 2011.:** "Selected Aspects of Modelling of Sustainable Urban Transportation System", TEKA, Commission of Motorization and Power Industry in Agriculture. – OL PAN, 2011, 11v.: 19-24.

НАБРОСОК ТЕОРИИ СЕМАНТИЧЕСКОЙ ИНФОРМАЦИИ И ДЕЗИНФОРМАЦИИ

Олег Погорелов

Аннотация. Представлена новая версия теории семантической информации, в которой рассматривается не добросовестный источник сообщений и допускается бессмысленность некоторых предложений. Используется трехзначная логика, включающая наряду со значениями истинности «true» и «false» дополнительного значения «absurd», применяемого по отношению к бессмысленным предложениям. Дается определение количеств семантической информации и дезинформации, содержащихся в сообщениях.

Ключевые слова. Количество семантической информации, логика предикатов, вероятность

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Estimation of frictional properties of the disc brake working elements in order to increase efficiency of brake systems of the rolling stock

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Summary. There given the estimation of integral frictional properties of the disc brake working elements in order to increase the efficiency of the brake systems of the rolling stock. There carried out the comparison of theoretical research based on molecular-mechanical theory of friction with actual data available in original sources. It shows the possibility to use the given technique necessary for prediction of the processes of interaction of the friction elements in the unit "pad – disk" of the disc brake.

Key words: efficiency of frictional brake, disc brake, molecular-mechanical theory of friction, coefficient of friction.

INTRODUCTION

Frictional brake systems, namely, disc brakes are a main means of braking, used in modern rolling stock [Asadchenko 2006, Krylov 1980, Modern Railways 2002, Schlosser 2001].

However, their use is connected with great heat loads which occur while interacting of the working elements. Due to it there happens over-heating of friction elements and it results in decrease of efficiency of brakes and wear resistance of brake pads and discs [Inozemtsev 1987, Krylov 1989, Osenin 2011].

In connection with this, improvement and increase of efficiency of the disc brake is an actual problem.

Main parameter which defines the efficiency of brake devices is a brake force used for regulation speed of motion of the rolling stock up to its stop which is directly proportional to the force of friction of frictional elements of the mechanical brake [Inozemtsev 1987, Krylov 1989].

The force of friction in the contact of frictional elements of the disc brake is directly proportional to the friction coefficient between them [Ehlers 2002, Inozemtsev 1987, Kombalov 1983, Osenin 1997]:

$$F = f \cdot P, \tag{1}$$

where: F – force of friction;

f – coefficient of friction;

P – force of pressing the elements of friction (normal load).

The coefficient of friction is an integral value which depends on potential frictional properties of interacting elements and conditions of their combined showing in the process of braking [Khebda 1989, Kombalov 1983, Kragelsky 1978, Kragelsky 1984, Osenin 2009].

Thus, the main idea of this paper is estimation of integral frictional properties of the working elements of the disc brake aimed at the increase of their friction coefficient and increase of the efficiency of disc brake systems of the rolling stock.

RESULTS OF RESEARCH

To estimate integral frictional properties of the disc brake we use the technique of calculation of the friction coefficient based on molecular-mechanical friction theory [Kragelsky 1977, Kragelsky 1984, Mikhin 1978] (direct friction assignment) taking

into account specific character of the work of frictional brake systems of the rolling stock. There considered so called external friction under which relative replacement of the friction bodies in the tangent direction is not accompanied with breakdown of integrity of the material and its deformation below thin surface layer can be neglected.

According to up-to-date idea, general force of external friction consists of the sum of two components: molecular and deformation ones [Kragelsky 1978, Kragelsky 1984]. It should be noted that those components of the friction force are interconnected. Arithmetic addition while determining general force of friction can be used as a first approximation.

To calculate friction force it is necessary to know the type of deformation in the contact zones and geometrical outlines of unevenness. Deformation in the zones of actual contact is determined by mechanical properties of the surfaces which exist in frictional interaction (brake disc – pad), value of the load and microtopography of the surface.

Dependencies obtained with the help of the spherical model of the rough surface are given below [Kragelsky 1978, Kragelsky 1977, Kragelsky 1984]. Calculations [Kragelsky 1978] show that in the zone of introduction of unevenness, the use of spherical model of single unevenness while determining contour area of contact gives the error not more 10% and while determining the coefficient of friction (for plastic deformation) the error does not exceed 7%. The application of the given model brings to the following conclusions:

1. If it is assumed that the relationship between the contact area and convergence of the spherical model of the rough surface is determined by the curve of the support surface of the real body [Kragelsky 1984] and to take into account the fact that the area of contact is formed due to single contact spots, average sizes of the model and real body coincide then in that case the distribution of unevenness peaks by the height for a real body and spherical model are described by the identical function.

2. The identical contact areas, identical loads and identical forces of friction while sliding are in conformity with identical value of convergence of the real surface of the spherical model of unevenness of the rough surface. While contacting solid bodies introduction of more solid sections into less solid ones takes place and the deformation of more solid sections is insignificant, in this case it is possible to take one of them as absolutely solid while considering interaction the bodies. The contact of the surfaces is discrete. Taking into account the above, the sequence of the calculations is the following:

1. The value of contour pressure (for the unit of friction brake disc – pad) is determined.

This value depends on the parameters of the roughness of the interconnecting surfaces and those belonging to more solid surface are considered to be determining. Average height of the wave H_x (because real working surfaces of the frictional brakes, namely, disc ones of the rolling stock are wave [Kragelsky 1984]) and the height of the rough layer of the unevenness R_{max} are considered to be more solid. If the roughness is not great ($R_{max} < 0,1 H_x$), the waves are considered to be smooth and can be used for calculation of the dependence which are made in accordance with Hertz formulas. If the roughness is great ($R_{max} \geq 0,1 H_x$) it is necessary to take into account the mutual influence of microprotrusions which are placed on the peaks of the waves. This phenomena brings to considerable increase of the area of contact in comparison with the values which are obtained with the help of Hertz formulas. Calculation formulas for the given cases are considered below [Kragelsky 1984, Mikhin 1978].

$$\left.\begin{aligned} n_x \leq 3, \quad P_c &= \frac{0,36}{(\Theta_\Sigma R_x)^{2/3}}\left(\frac{N}{n_x}\right)^{1/3} \\ n_x > 3, \quad P_c &= 0,45 P_a^{0,14}\left(\frac{H_x}{\Theta_\Sigma{}^2 R_x}\right)^{0,43} \end{aligned}\right\} \quad R_{max} < 0,1 H_x$$

$$P_c = \frac{1}{2,4 K_x} P_a^{\delta/(3+\delta)}\left(\frac{H_x}{2\Theta_\Sigma{}^2 R_x}\right)^{0,5\nu/(3+\delta)}, \quad R_{max} \geq 0,1 H_x, \tag{2}$$

where: N and P_a - normal load and nominal pressure in the contact of the brake disc and pad; R_x - height of the wave of more solid surface; K_w, K_x, δ - constants which depend on the type of deformation of the surface microprojections which are in contact (their value are given in [Kragelsky 1978]); Θ_Σ - elastic constant of the material for two surfaces which are deformed:

$$\Theta_\Sigma = \frac{1-\mu_1}{E_1} + \frac{1-\mu_2}{E_2},$$

where: μ, E - Puasson coefficient and modulus of elasticity of the corresponding material of the friction pair (here and henceforth index ”1”

characterizes the material of the brake disc, and index "2" characterizes the material of the brake pad).

2. The type of deformation in the zone of contact is determined.

Elastic contact takes place in case of the value of contour pressure answers to the condition [Kragelsky 1984]:

$$P_c \le \frac{2{,}4^{(2\nu+1)/2}\,\nu(\nu-1)\,k\,HB^{(2\nu+1)}(1-\mu^2)^{2\nu}}{5\,E^{2\nu}\,\Delta^{\nu}}, \quad (3)$$

where: $\Delta = \frac{R_{\max}}{r\,b^{-\nu}}$ - dimensionless complex parameter of roughness, here r – radius of rounding of the peak to single inequality;

b, ν – parameters of degree approximation of the support curve of the friction surface;

HB – Brinell hardness of the corresponding friction surface;

k – constant of integration which depends on ν [Kragelsky 1977].

Elastic contact is considered as elastic nonsaturated and elastic saturated (in dependence on the type of deformation and the degree of saturation in the zone of contact).

Elastic nonsaturated contact takes place when the contour pressure determined by (2) does not exceed the value obtained by (3) and in addition the condition is being carried out:

$$P_c \le \frac{0{,}08\,\Delta^{0{,}5}E}{(\nu\,b^{1/\nu})^{(\nu+0{,}5)/(\nu-1)}(1-\mu^2)}. \quad (4)$$

Elastic saturated contact takes place under contour pressures, which exceed the values, obtained by the formula (4) but not more those which are determined with the help of (3).

Plastic contact takes place in the case if the condition is carried out for the contour pressure:

$$P_c \ge 5{,}4^{\nu}\,\frac{HB^{(2\nu+1)}(1-\mu^2)^{2\nu}}{2\,E^{2\nu}\,\Delta^{\nu}}. \quad (5)$$

Saturated and nonsaturated plastic contact can be observed under the plastic deformations in the zone of contact of solid bodies.

Nonsaturated plastic contact takes place when there are contour pressures which are determined by the formula (6) and the condition (5) is to be carried out.

$$\frac{14{,}5}{\Delta^2}\left(\frac{HB(1-\mu^2)}{E}\right)^4 \le \frac{P_c}{HB} \le \frac{0{,}5}{(\nu\,b^{-\nu})^{\nu/(\nu-1)}}. \quad (6)$$

Plastic saturated contact takes place when there are contour pressures which exceed the values found in accordance with formula (6).

Calculation p_c according to the formula (2) and analysis of the given value showed that interaction of pad and disc of the frictional brake is realized under the conditions of elastic nonsaturated contact.

3. Expediency of application of the given equations for fulfilling the condition of external friction is determined. The condition (7) [Kragelsky 1978] is to be true:

$$P_c \le \frac{HB}{2^{(\nu+1)}\,\Delta^{\nu}}\left(1-\frac{6\,\tau_n}{HB}\right)^{\nu}, \quad (7)$$

where: τ_n - tangent lines of voltage which happen on the boundary of distribution of contact surfaces as a result of intermolecular interaction [Kragelsky 1984].

Value τ_n can be evaluated theoretically taking into account influence of temperature and availability of "third" body in the zone of contact in accordance with the technique which is given in [Kragelsky 1977].

Obtained calculations confirm the validity of the chosen procedure.

4. Calculation dependencies on the coefficient of external friction (maximum theoretical value) is being determined. For the case of elastic nonsaturated contact [Kragelsky 1978]:

$$f = \frac{2{,}4\,\tau_0\left(1-\mu^2\right)r^{0{,}5}}{E\,h^{0{,}5}} + \beta + \frac{\alpha\,h^{0{,}5}}{k\,\nu\,(\nu^2-1)\,r^{0{,}5}}, \quad (8)$$

where: τ_0, β - frictional parameters (shear resistance under the conditions of extrapolation of normal pressure to zero and the coefficient of strengthening of adhesion bond [Kragelsky 1984] which define molecular component of the friction coefficient;

α - coefficient of hysteresis losses under simple stretching-compression (its value for various materials is given, for example, in [Kragelsky 1978]);

h – convergence of contacting surfaces.

To check rightfulness of application of above equalities there are many experimental data in the reference book [Bogdanovich 2005, Starchenko 2006, Wukolov 2005, Zander 2001] and there is comparison of these data and the data obtained with the help of calculations according to above dependencies.

Steel 45 – polycarbonate (for showing interaction of metal and nonmetal frictional

materials which are used in the systems of frictional brakes of the rolling stock) and steel 45 – steel 45 (the case when both elements of the friction pair are metal) are taken as the pair of friction disc – pad. Metal roller and flat planes are considered as brake disc and pad. The surfaces of metal pairs of friction answered to 8-th grade of roughness of the surface (Ra = 0,63); frictional parameters: $\nu = 2$, b = 1, r = 116 mkm, nominal area of the contact made $2 \cdot 10^{-4}$ m^2, $\Delta = 9{,}6 \cdot 10^{-2}$, R_{max} = 4,5 mkm, β = 0,06 (experimental and calculation parameters which correspond to steel surface are shown). Relative linear speed of sliding 0,34 m/s, temperature in the zone of friction did not exceed 55^{0}C. Nominal pressure in the contact changed within the limits of 50…500 kPa. Corresponding physico-mechanical properties of the materials are taken from the reference book [Kombalov 1983, Kragelsky 1978, Kragelsky 1977, Kragelsky 1984].

The results of comparison of the calculations and experiments are given in fig. where there are the following symbols. The curves 1 and 2 answer to the case steel disc - pad of polycarbonate (here and henceforth a full line – experiment, a dotted line – theory); the curves 3 and 4 – steel disc – steel pad. The curve 5 – theoretical evaluation of the average coefficient of friction for a frictional joint – a brake disc and two pads made of different materials (steel 45 and polycarbonate).

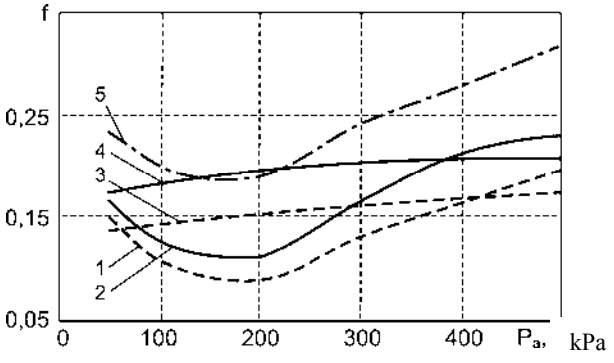

Fig. Comparison of theoretical and experimental values of the friction coefficients for a frictional unit brake disc – pad in dependence on nominal contact pressure

CONCLUSIONS

Considering obtained results it is possible to make the following conclusions:

1. One of the ways of efficiency increase of frictional brake systems is prognosis of influence of integral frictional properties of the disc brake on the characteristic of friction and wear of working elements of the brake and development of the recommendations necessary for their improvement.

2. Prognosis of friction characteristic and wear of the elements of the frictional brake in dependence on the factors can be performed on the base of molecular-mechanical theory of friction. They describe the processes in the field of contact of solid bodies and which at present have a high degree of approbation and universally recognized.

3. Force interaction of the elements of the disc brake of the rolling stock is realized under the conditions of elastic nonsaturated contact of microunevenness placed on the surface of the block and a wheel.

4. Maximum divergence of experimental and theoretical results does not exceed 20%. It gives the possibility to use molecular-mechanical theory of friction for satisfactory description of the mechanism of friction of metallic and nonmetallic (in particular polymer) materials, which act according to the scheme of the frictional unit – disc brake of the rolling stock.

REFERENCES

1. **Asadchenko V.R., 2006.:** Automatic brakes of the rolling stock: Training appliances for the students of the transport educational institutions. – M.; Route, 392 p.
2. **Bogdanovich P.N., Galai E. I., 2005.:** Estimation of tribotechnical characteristic of composition materials for brake blocks under low speed of sliding // Vestnik VNIIZT, №2, P. 21 – 24.
3. **Ehlers H.-R. et al., 2002.:** Potential and limits of opportunities of the block brake. Glasers Annalen, № 6/7, P. 290-300.
4. **Inozemtsev V.G., 1987.:** Brakes of the rolling stock. Questions and replies. 3-edition. – M.: Transport, 207 p.
5. **Khebda M., Chichinadze A.V., 1989.:** Reference book on tribotechnology. V.1: Theoretical principles. – M.: Machine-building, 400 p.
6. **Kombalov V.S., 1983.:** Evaluation of tribotechnological properties of the contacting surfaces. – M.: Science, 136 p.
7. **Kragelsky I.V., Alisin V.V., 1978.:** Reference book: Friction, Wear and Lubrication – M.: Machine-building, B. 1, 400 p.
8. **Kragelsky I.V., Dobichin M.N., Kombalov V.S., 1977.:** Principles of the calculations friction and wear. – M.: Machine-building, 526 p.
9. **Kragelsky I.V., Mikhin N.M., 1984.:** Machine friction units. – M.: Machine-building, 280 p.
10. **Krylov V.I., Krylov V.V., Efremov V.N., Demushkin P.T., 1989.:** Reference book: Brake equipment of the rolling stock. - M.: Transport, 487 p.
11. **Krylov V.I., Klykov E.V., Yasentsev V.F., 1980.:** Rolling stock brakes. - M.: Transport, 272 p.

12. **Mikhin N.M., 1978.:** Calculation dependencies of molecular-mechanical theory of external friction // Theory of friction, wear and the problem of standartization. –Bryansk, P. 44–54.
13. Modern Railways, 2002, № 641, P. 54 - 56.
14. **Osenin Yu.I., Marchenko D.N., Shvedchikova I.A., 1997.:** Frictional interaction of the wheel and rail. – Lugansk: VUGU Publishing, 226 p.
15. **Osenin Y., Sergienko O., 2009.:** An ifluence of geometrical characteristics of frictional elements on the effectiveness of disk brake. // TEKA Commission of Motorization and Agriculture. – Liblin, Polska Akademia nauk Oddzial w Lubline, Vol. IX., P. 285 – 289.
16. **Osenin Y., Sosnov I., 2011.:** Mathematical modeling unstationary friction interaction of working elements disc brake locomotive // TEKA Commission of Motorization and Agriculture. – Liblin, Polska Akademia nauk Oddzial w Lubline, Vol. XIIB, P. 111 – 120.
17. **Schlosser W., Aurich S., 2001.:** Modern brake systems // Glasers Annalen, № 8, P. 273 – 277.
18. **Starchenko V. N., Gurin V. A., Bikodorov V. P., Shapran E. N., 2006.:** Frictional materials on the base of carbon-asbestos fibres for brake devices. // Railways of the world, №2. [electronic resource] – regime of access: http://www.css-rzd.ru/ZDM/2006-02/06008-1.htm.
19. **Wukolov L. A., Zharov V. A., 2005.:** Comparative characteristic of brake blocks of different suppliers // Vestnik VNIIZT, №2, P. 16–20.
20. **Zander C.P., 2001.:** Ceramic-metal brake block on powerful locomotives // Glasers Annalen, № 4, P. 157–165.

ОЦЕНКА ФРИКЦИОННЫХ СВОЙСТВ РАБОЧИХ ЭЛЕМЕНТОВ ДИСКОВОГО ТОРМОЗА С ЦЕЛЬЮ ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ТОРМОЗНЫХ СИСТЕМ ПОДВИЖНОГО СОСТАВА

Наталия Погребнова

Аннотация. В работе выполнена оценка интегральных фрикционных свойств рабочих элементов дискового тормоза с целью повышения эффективности тормозных систем подвижного состава. Проведено сопоставление теоретических исследований, выполненных на основе молекулярно-механической теории трения, с фактическими данными, имеющимися в литературных источниках, которое свидетельствует о возможности использования данной методики для прогнозирования процессов взаимодействия элементов трения в узле «накладка – диск» дискового тормоза.
Ключевые слова: эффективность фрикционного тормоза, дисковый тормоз, молекулярно-механическая теория трения, коэффициент трения.

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Research of the automatic control system of belt conveyor on the technical basis of the industrial controller schneider electric

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S u m m a r y . The results of the studies of complex system of automatic control of processes of the transportation and the crushing of the ore been presented. The principles of control been based on the measurement of temperature field on the zone of the friction. The efficiency of the approach confirmed by the results of theoretical and experimental research of the control system based on industrial controllers Schneider Electric.

K e y w o r d s . Industrial controllers, belt tension control, mathematical models of distributed parameters.

INTRODUCTION

One of the common problems in using mining equipment is a high level of equipment's accident rate, associated with wear and tear of equipment, as well as using out-dated automated process control systems (APCSs) that have exhausted their lifetime and currently their tasks cannot perform.

The implementation of advanced automatic control systems (ACS TP) on the basis of industrial controllers enables you to programmatically perform a main part of the logical schema control that previously technically implemented at the hardware level, in the form of electric circuits.

A perfect example of using of APCSs conveyor line based on modern industrial microcontrollers is control system for a conveyor line of the Crushing Plant CrP-3 of the mining-concentrating plant "SevGOK" [1].

The development of automatic control systems of the belt conveyors began almost from the time of the first applications of belt conveyors.

Thus, the authors of [2] formulated the requirements for automatic control lines conveyors back in the 60's of the last century.

Assignment of tasks to different levels of the hierarchy in terms of automated control theory is discussed in [3]. The study is important for task of the low level, which lies at the base of the whole pyramid of hierarchy of control problems. It is the task of control the individual aggregates or the processes. The production cost, depending on the nature of the technological process, is the only reasonable criterion functioning of each technological object.

This paper will focus on the implementation of requirements [2] to control for the belt conveyor. The control system, among other things, will help increase lifetime of the conveyor belt, the preservation of its properties [4].

In this paper, to prevent emergency of slip belt on the pulley and its excessive wear is offered use a belt tension control. To implement the developed control method necessary to use a mathematical model with distributed parameters. Based on this model will be generated the model of the optimal control in accordance with the principles, discussed in [5].

The main cause of all these problems is connected with the parameters of the ore, which transported. These parameters define the requirements for the formation of traction factor, and physical processes in the friction pair of conveyor belt-pulley during transportation of the material. The main parameter - is mass per unit length of the transported material. So the work done by VS Volotkovsky, reflected the following

results. On belt conveyors with the length from 467 to 1870 m, area of stripped bottom cover varies from 15 to 25%. This is caused by the appearance of slip bands and large values of the stresses in the bottom plate of the tape when it interacts with the driving drum [6, 7]. Increased loading conveyor, weak belt tension results in increase in arc of operative slipping that increases belt wear and may cause emergency slipping. In the case of slipping, in adhesion zone of belt and pulley the temperature rises and reaches 300-350 °C within 15 minutes of operating [8]. In the case of operative slipping there are losses of energy by overcoming friction. It results in temperature change in the zone of the contact pulley-belt.

The problem of temperature change has been studied by the following authors: M.A. Malutin, L.I. Popov, V.G. Piletsky and others [9, 8, 10]. To create a system of automatic control of friction couple drive pulley-belt is proposed to develop a mathematical model of temperature distribution on the arc circumference (as an object of control). In this case, the thermal field of arc of contact can change through the tension of the conveyor belt or speed of pulley rotation.

The problem of conveyor take-up control has been studied by the authors [11, 12, 13, 14, 15, 16, 17], who deduced that the level of belt tension is determined by the material loading level, as well as size of the pieces of ore, conveyer belt durability or its term of exploitation. Control of the station of the pull for conveyor has been determined out as function of measuring tension, as well as depending on load distribution between the drive pulleys and also according to the total conveyor maintenance costs. The study of the dynamic properties of the conveyor with automatic take-up and terms of system operability has been carried out by the authors [18]. Determination of the dynamic properties of belt conveyor as controlled system during conveyor start-up has been carried out in [19].

Study of the dynamic properties of the automatic belt tension control is necessary to obtain information on indicators of the quality of regulation, to get the results of the stability of modes with automatic conveyor belt tension control during transportation of raw materials.

In the process of improving the control also analyzed the possibility of using fuzzy control of conveyor and the research of belt transport system based on PLC [20, 21]. Modeling of control processes of the transport system [22] was carried out in the laboratory automation controller-based firm Schneider Electric (Krivoy Rog Technical University). In forming models were used as classical approaches, and methods of intellectual analysis, as, for example, in [23].

OBJECTS AND PROBLEMS

In this paper on the basis of existing ore dressing control system of the crushing plant CrP of the “CGOK” PJSC the author puts forward the implementation of an integrated conveyor line APCS using the developed software and technology based on PLC TSX 37-22 Schneider Electric industrial controllers.

Based on the results of the analysis of existing industrial controllers can use to implement hardware and software solutions designed automatic control system based on PLC TSX 37-22 Schneider Electric industrial controller.

After tests the software and algorithmic support of the automatic process control transportation of ore in the lab need to move to testing under industrial conditions at the crushing plant of the “CGOK” PJSC.

And these tests have been carried out under industrial conditions by two directions:

tests of software, validation algorithm of the control with inspection sensors for technological process control;

carrying out control actions (change of belt tension and of cargo weight).

During production tests at the crushing plant of the “CGOK” PJSC the following results have been obtained: software, which was developed and which based on graphic language of step logic Ladder (LD), operates if sensors used in APCS are hooked up. In-process of the study of the control algorithm, the control system (OBCS) ore beneficiation makes signal collection and processing provided by sensors (belt speed, cargo weight on belt). Weight control has been carried out by conveyor scales VTK4-2, mounted on K-2 conveyer of (1-2) primary and secondary crushing. For belt speed control a frequency type sensor was used, which is frictionally bound with bottom-run. During the testing the temperature control with the Mikron M90-V infrared thermometer of the area frictional interaction of the belt and drive pulley has been carried out. To hook up the sensors to the main controller gear, integrated analog inputs for Mikron M90-V, for sensor of belt load and for frequency speed sensor have been used.

The principle of operation of scales is based on the transformation of the value of the mass of material present at the weighing station conveyor

to an electrical DC signal proportional to the consumption of material. The transformation is based on strain gauge signals and signals of speed tape sensor. Total value of handling material is defined by current consumption integration by BOI-3V microcontrollers.

Thus, having integrated APCS system under development into the operational ore beneficiation control system (OBCS), receive an integrated automatic ore reduction and beneficiation process control system at the crushing plant. Modern equipment of the test of belt stretching (tension) is based on strain-gauge transducer, which operates with electronic modules meant for integration into industrial network communications. As a belt tension transducer Meradat K-20 tension and compression gauge transducer is recommended for use. The gauge is located between idler pulley with tripper and conveyor take-up pulley system.

Upon the tests at the first stage positive results have been obtained.

For the second stage tests it was necessary to perform the preliminary calculations for finding the range of controlled variable regulation. When the conveyor testing was being carried out during the preventive maintenance, it was possible to change only the tension and belt mass per unit length while ore reduction process reaches the desired capacity.

Table 1. Conveyor pulling calculation results

Cargo weight per unit length with rated capacity, kg/m	425
Belt mass per unit length, kg/m	56
Minimum carrying run pull, N	37600
Minimum bottom run pull, N	12860
Total pulling factor	10,4
Maximum carrying run pull, N	404400
Total drive power, kW	974
Take-up cargo weight, kg	5000
Cargo weight per unit length with rated capacity, kg/m	425
Belt mass per unit length, kg/m	56
Minimum carrying run pull, N	37600
Minimum bottom run pull, N	12860
Total pulling factor	10,4
Maximum carrying run pull, N	404400
Total drive power, kW	974
Take-up cargo weight, kg	5000

For basic data the rated technical specifications of the K-2 conveyer of (1-2) primary and secondary crushing are used.

Upon the calculations of conveyor pulling units according to a simplified circuit (track configuration) the following results presented in Table 1 have been obtained.

Dynamic belt tension change when the conveyer is started up empty (no-loaded) and under load is presented in fig.1.

Thus, according to obtained results it is worth noting that under the conveyor maintenance the belt tension specified by truck type take-up is overestimated and composes $1{,}078 \cdot 10^5$ N and can be provided to reduce to 49 kN.

When the conveyer is started the conveyor take-up by reeving system (pulley system rate is 4) creates tension equals 431200N. Maximum climbing point of belt against driving pulley equals 404,4 kN, and subject to dynamic component (see fig. 1) equals 448500N. Thus, when the conveyer is started up empty, upon which the dynamic force is 44,065 kN (see fig. 1b), take-up tripper does not move out of location.

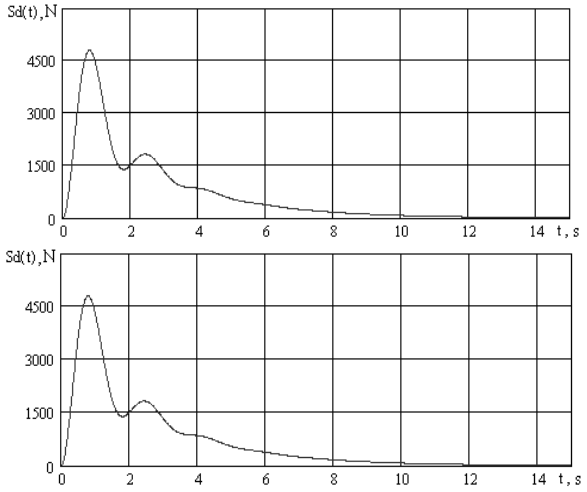

Fig. 1. Dynamic belt tension change when the conveyer is started empty – a; under load – b

Conveyor-drive power is also overestimated, installed power is 1200 kW, and design power is 974 kW. Such reserve power is useful only for engines in order to limit overloading as pulling factor of drive pulleys, following the calculations, doesn't ensure specific margin.

Design value of total pulling factor is 10,4 but recommended value is 5,22 on one drive pulley with the diameter of 2000 mm, wrap angle of 270 grad and adhesion coefficient of 0,35.

As a result, the range from 3000 kg to 11000 kg for belt tension control is adopted.

During the tests belt ore value-tonnage and its speed have been displayed by ore beneficiation control system (OBCS) v0.04. The system displays the current handling cargo capacity on the conveyor within an hour at 5 minute intervals and during the changeover at 1 hour intervals, in

tabular format and diagrammatically. The process received results are depicted in fig. 2.

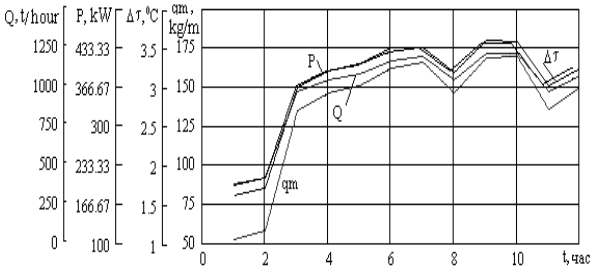

Fig. 2. Consumed conveyor capacity and its behavior, variation of belt mass per unit length and lining temperature increment during the changeover on K-2 conveyer of the crushing plant

According to the results it is worth noting that conveyor capacity falls short of rated capacity and during the changeover changes in a broad range. Based on the results of the current capacity belt ore value-tonnage and its behavior during the changeover have been obtained (see fig. 2). Consumed conveyor capacity and its behavior during the changeover are depicted in Fig. 2.

Conveyor drive power consumption behavior is proportionally with ore handling capacity behavior that is due to belt turning force variation by pulley driving. As a result of load growth the frictional interaction of belt and drive a pulley increase that is evident as heat emission in wrap angle. Turning force value (pulley belt pressure) is corrected by belt tension conveyor control. For heat losses control temperature measurements have been performed by Mikron M90-V infrared thermometer. Thermometer readings were recorded in parallel with the existing system.

Belt tension change has been carried out by change of conveyor take-up cargo value, within the range from 3000 kg to 11000 kg. According to obtained results tension change expressed as percentage.

During the testing the conveyor has been started up for several times with various weight values on conveyor take-up, at the same time temperature measurements of drive pulley lagging have been carried out. Measurement results are depicted in fig. 3 - characteristic curve 1. In that Figure Characteristic curve 2 is depicted, obtained upon calculations.

Thus, according to obtained results it is worth noting marginal differences in measured and rated values but the temperature trend through the reduce of belt tension is identical.

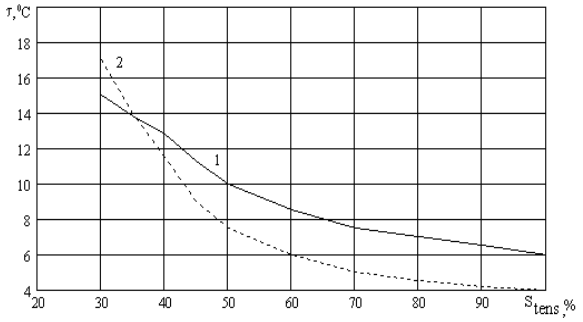

Fig. 3. Variation of pulley lagging temperature when the conveyer is started at various belt tension values:1- experimental characteristic; 2- rated characteristic

When starting up the conveyor the temperature measurements of dynamic pulley lagging have been carried out. The received results are depicted in fig. 4. Characteristic curve 1 reflects testing data. Characteristic curve 2 reflects data, obtained by calculations where the emergency takes place.

According to the testing results, measured during the changeover, i.e. capacity, mass per unit length, consumed capacity, temperature change calculations have been performed, more specifically its increment within an hour of conveyor operating at current capacity. The results are depicted in fig. 3. The received results reflect the capacity losses due to drive conveyor take-up friction, which are evolved as heat and define the arc size of operative slipping at the current conveyor starting up. According to the results it is worth noting that conveyor operates not on the excess (rated) capacity, drive pulley behavior is set and friction losses are minimum, which means that the wearing of pulley lagging and belt nonworking surface has been kept to a minimum

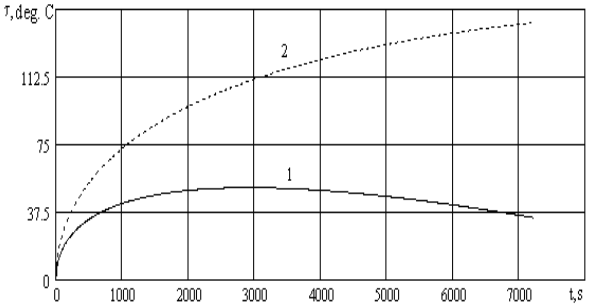

Fig. 4. Variation of pulley lagging temperature when the conveyer is started in steady state operation by regular conveyor start-up -1 and emergency operation -2

Industrial test data carries the following readings. Thus, at starting-up the traction load increase has been stated, with temperature raise to

+15 deg. C at ambient temperature +4 deg. C. In steady-state operation during the ore handling the temperature rise composed 3,6 deg. C. Measurement uncertainty composes 1%. The signal processing time suggested to use by transducer is ≤ 100 ms.

Conveyor start-up control with friction drive heating temperature prevents from emergency drive pulley slipping. At the same time it can eliminate the possibility of damage of the belt nonworking surface, pulley lagging as well as fire emergency, thereby eliminating the possibility of conveyor shut down. The test results have corroborated that during the belt tension control the drive power consumption upon handling by reduction in belt resistance varies.

Drive friction couple efficiency is evaluated by pulley efficiency. Raise of temperature in the friction engagement results from consume power losses. By regular conveyor operation power losses compose 150 – 300 W, the efficiency variation as a result of belt tension change is small - 0,974÷0,977. If as a result of environmental impacts and other factors the friction power losses increase a hundredfold then efficiency will significantly change 0,4÷0,9 under the belt tension change.

CONCLUSIONS

The developed software according to controlled quantities enables to specify technological process state, equipment condition and its operation: startup, steady state, and shutdown. The rational process operation selection is based on algorithm of automatic adaptive control system with modifiable structure.

REFERENCES

1. Automatic control system of UTS at the crushing plant. http://www.omron.com.ua/iIntroduction/sistema-avtomaticheskogo-upravleniya-cptr-drobilnojj-fabriki
2. **Volotkovsky S.A., Fursov V. D., 1960.:** Conveyor belt line control automation in ore mines and quarries, Izvestiya vuzov. Journal of Mining Science, №12, pp.117-128.
3. **Kolesnik V.V., Korobtsov A.A., 1993.: C**ontinuous flow process technology, as automatic control object, Automatic adaptive control systems, №1, pp. 70-77.
4. **Golubenko A., Marchenko D., 2008.:** Features of diagrams of phases and anomaly of structures of dynamic systems during degradation of their properties. TEKA Commission of motorization and Power Industry in Agriculture, №8, V.III, pp. 77-81.
5. **Rapoport E.Ya., 2003.:** Structural Modeling of Distributed-Parameter Objects and Control Systems, Vysshaya Shkola, Moscow, 299p.
6. **Volotkovsky V.S**., **1976.:** Application and wearing of conveyor belt on long-haul installations, Treatise of Institute of Mining Engineering: Ministry of Iron and Steel Industry SSSR, Publ. 50, Sverlovsk, pp.70-76.
7. **Morev V.I., Zavgorodniy E.H., 2008.:** Service life of the conveyor belts under fatigue delamination, Izvestiya vuzov. Journal of Mining Science, №12, pp. 65-66.
8. **Piletsky V.G., 1999.:** The research of thermal signal of movable belt after conveyor shutdown, Miing electromechanics and automatics, №2(61), pp.220-224.
9. **Malutin M.A., Popov L.I., 1972.:** The research of contact temperature of belt drives, Izvestiya vuzov. Journal of Mining Science, №2, pp. 115-119.
10. **Troschilo V.S., Piletsky V.G., 1999:** The mine ribbon conveyors technical condition instrumental diagnosing substantiation, Miing electromechanics and automatics, №2(61), pp. 200-204.
11. **Andreev A.V., 1963.:** Friction drive, M., MASHGIZ, 109 p.
12. **Bilichenko N.Y., Popov S.I., 2009.:** Automatic conveyor take-ups operation, Dnepropetrovsk Mining Institute, Scientific and technical conference data on exploitation of mineral deposits, T.56, pp.54-61.
13. **Dyakov B.A., Kotov M.A., 1995.:** Conveyor belt drive pulley behaviour. Research data / Mining Institute named after Skochinsky / 26, 116p
14. **Nazarenko V.M., 1975.:** New decisions on heavy belt conveyors control, Izvestiya vuzov, Journal of Mining Science, №8, pp.89-97.
15. **Nazarenko V.M., 1986:** Operational conditions of friction pulley of adjustable speed drive of belt conveyors, Izvestiya vuzov, Journal of Mining Science, №10, pp.57-63.
16. **Novikov E.E., Smirnov V.K., 2003.:** Belt conveyor theory for large-sized rocks, Kiev, Scientific Thought, 184p.
17. **Kurganov I.D., 2004.:** Automatic adaptive belt tension control systems, "Ore mining", Krivoy Rog, KTU, №86, pp. 155-159.
18. **Liberman Y.L., Gorbunova L.N**., **2001:** Stipulation of device operability conditions for automatic takeup, Izvestiya vuzov. Journal of Mining Science, №5, pp. 76-79.
19. **Nazarenko V.M., Sokotnyuk Y.A**., **2006.:** Belt conveyor transfer functions as a controlled system, Izvestiya vuzov. Journal of Mining Science, №1, pp. 110-114.
20. **Leehter Yao, 1995.:** Fuzzy control of belt conveyor in the manufacturing process, Industrial Automation and Control: Emerging Technologies, 1995, International IEEE/IAS Conference on, pp.748 – 754.
21. **Wu Li, Yang Zheng, Dong Xinfa, 2010.:** The design and research of belt transport system based on PLC, Advances in Energy Engineering (ICAEE), 2010. International Conference, pp. 120 – 124.
22. **Porkuryan O.V., Kurganov I.D., 2010.:** Algorithm realization concept of belt conveyor automatic control system based on PLC TSX 37-22 Schneider Electric industrial controllers, "Ore mining", Krivoy Rog, KTU, №93, pp.135-139.

23. **Krzysztof Necka, 2011.:** Use of DATA MINING techniques for predicting electric energy demand, TEKA Commission of motorization and Power Industry in Agriculture, V.XIC, pp. 237-245.

ИССЛЕДОВАНИЕ СИСТЕМЫ АВТОМАТИЧЕСКОГО УПРАВЛЕНИЯ ЛЕНТОЧНЫМ КОНВЕЙЕРОМ НА ТЕХНИЧЕСКОЙ БАЗЕ ПРОМЫШЛЕННЫХ КОНТРОЛЛЕРОВ SCHNEIDER ELECTRIC

Ольга Поркуян, Игорь Курганов

Аннотация. Представлены результаты исследований комплексной системы автоматического управления технологическим процессом дробления и транспортирования руды. Разработаны принципы управления на основе измерения температурного поля. Эффективность похода подтверждена результатами теоретических и экспериментальных исследований системы управления на базе промышленных контроллеров Schneider Electric.

Ключевые слова. Промышленные контроллеры, контроль натяжения ленты, математические модели с распределенными параметрами.

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Physicochemical characteristics of bond and friction between the modified concrete and sliding formwork for the construction of high-rise buildings

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S u m m e r y . The article presents the research results of the interaction between formwork and freshly-mixed concrete. It is established that there is a significant bond and friction between the concrete and the sliding formwork at the moment of its rise.
K e y w o r d s : concrete, formwork, bond.

INTRODUCTION

The development of modern housing construction, considering sharp price rise and shortage of land parcels in large cities, is directed toward the construction of high-rise buildings. This practice is widely known in the urban construction of civilized countries. Economics of high-rise residential buildings has a number of important advantages in comparison with the usual buildings. There is practically no alternative to such development of housing construction in large cities [Holland T.C. 1998, Zollo R. F. 1997]. However, the development of high-rise construction requires a special approach to the choice of basic material, creating the framework and the most important construction elements of buildings [Акгоid T.M.B. 1980, Czernin W. 1998, Derucher K. M. 1989].

It is doubtless that heavy-weight concrete is this construction material [Hughes B. P., Gregory R. 1982, Reading T. J. 1987]. The uniqueness of the constructed residential buildings determines a complex of high operational requirements for this material [Vladimir Punagin 2010; Natalya Rudenko 2010]. First of all, they include high strength, resistance of heavy-weight concrete in various operating conditions, low radioactive background and the most possible durability at a relatively high economy of the selected material.

RESEARCH OBJECT

The existence of a significant bond and friction between the concrete and the sliding formwork at the moment of its rise was established experimentally. Negative consequences caused by the high friction and bond are also well-known. However, the nature of these phenomena has not been carefully studied yet and, in our opinion, the reason of it is the complexity of physicochemical phenomena and processes observed in the zone of contact of concrete with the formwork [Morinaga S. 1973, Schiller K. K. 1991, Willis J. R. 1982].

Concrete and sliding formwork, by analogy with the classical glue compounds, can be figuratively represented as the contact pair, where concrete acts as a glue (adhesive) and the formwork as a solid (the substratum). Their bond should be regarded as a result of mechanical anchor, adhesion, cohesion and shrinkage. The first three factors increase the bond and shrinkage reduces it.

The mathematical model of the bond in the general view is as follows:

$$\begin{aligned}\sigma_n = {} & f(a)+f(k)+f(m)+f(y)+f(ak)+ \\ & +f(am)++f(km)\pm f(ay)\pm f(ky)\pm f(my)\end{aligned}, \quad (1)$$

where: σ_n – normal bond (tear force is perpendicularly to the plane of contact);

a – adhesion;

k – cohesion;

m – mechanical anchor (mechanical constituent);

y – shrinkage.

The impact of shrinkage on the bond can be fixed on technological and physical-mechanical level. Its value depends on the technological factors (mixture workability, terms of hardening), as well as the mineralogical composition of the cement matrix of concrete [Hanehara S., Yamada K. 2008, Sawaide M., Iketani J. 1992].

Mechanical anchor of concrete is determined by the surface roughness and porosity of the formwork and reveals mainly at the technological level.

RESULTS OF EXPERIMENTAL RESEARCH

It is established that various rough surfaces are moistened in different ways. The presence of unevenness (roughness) on hydrophilic surfaces leads to the reduction of the contact angle of Θ and, consequently, to the improvement of moistening rough hydrophilic surfaces in comparison with the smooth ones. On the contrary, roughness of hydrophilic surfaces increases the contact angle and worsens moistening. For this reason, the increase of roughness of hydrophilic formwork materials, such as steel, causes growth of bond of concrete. To reduce the negative consequences of this phenomenon we should strive to use steel formwork with pre-treated surfaces (grinding, polishing).

In our opinion, the assessment of formwork material should take into account not only its nature and roughness , but also the area of roughness. In particular, the increase of the distance between $x_o > x_{кр}$ and certain technological parameters of concreting lead to possible wetting and adhesion of concrete all over the unevenness surface or of the most part of it. Then due to sharp increase of the actual contact area the bond abruptly grows.

Roughness configuration, i.e., the shape and size of protrusions and cavities, also plays an important role for mechanical anchor. If large, but smooth asperities increase the bond only due to the increase in the actual contact area, the hook-shaped ledges and hollows when $x_o > x_{кр}$ simultaneously play the role of micro-anchors with the effect of microlacing contacting surfaces, that increases bond.

Technological factors (mixture workability, modes of compaction) also have a certain influence on mechanical anchor, as well as adhesion and bonding in whole. In the process of intensive compaction of the modified concrete in its zone of contact with the formwork, on the one hand, sharply decreases the viscosity of the mixture as adhesive, on the other hand – there is a heightened pressure in its joint layers. This increases the probability of penetration of the adhesive in the pores of the formwork and leads to a qualitative filling of surface asperities of the formwork, increasing the area of actual contact and, as a result, the bond. For a contact pair concrete - formwork the probability of mechanical anchor is great.

However, its importance should not be overestimated. Practical implementation of this component is only available in combination with other factors, such as adhesion. In our opinion, the mechanical anchor cannot be considered as a «dry lacing» of contacting bodies. Physical-chemical interaction of adhesive microvolumes with microareas of substratum surface asperities, i.e. in the points of microcontacts mechanical component is manifested through the adhesion.

The contact angle of moistening Θ may serve for the indirect characteristics of adhesion. It is established that the higher the moistening, i.e., the more cos Θ, the higher the adhesion, and vice versa.

The bond value of modified concrete with the formwork to a large extent depends on the cohesion of the adhesive, i.e. cement system. Cohesion depends on the degree of modification of the cement, the mineralogical composition, terms of setting and conditions of hardening.

It is established experimentally that the higher the strength of concrete, the greater the bonding between the concrete and formwork. Thus, the nature of the dependence of bonding on concrete strength other conditions being equal is determined by cohesion.

Adhesion and cohesion are two interrelated aspects of a process of a seam-contact formation. The kinetics of their growth over time reflects the processes of formation of structure of the adhesive (cohesion), and intermolecular interactions of contacting surfaces. At later terms, on the contrary, cohesion prevails over the adhesion. Here, apparently, there is an impact of shrinkage, which is less in a volume than in the contact zone.

In practice there are three cases of formwork separation (shift) depending on adhesion and cohesion ratio. The first one – plane separation (shift) coincides with the plane of the contact, adhesion is less than cohesion ($a<k$). This

separation (shift) is called adhesion. In this case the surface of the formwork is clean, the surface of the concrete is smooth. The second one - plane separation (shift) is held in the volume of concrete. In this case, the adhesion is much more than cohesion ($a>k$); separation (shift) is cohesive. In this case the surface is covered with cement crust, and the concrete becomes too rough. The third one - plane of separation partially coincides with the plane of contact, partially is held in the volume of concrete. It takes place at $a \approx k$. This separation (shift) is mixed. In this case there is partial increase of the cement crust on the formwork surface, and the surface of the concrete has a small not entire roughness. This type of separation (shift) in practice is observed most frequently.

Obviously, adhesion is the most important component of bonding concrete to the formwork.

In accordance with the adsorption theory of adhesion [Guzeyev E. A., Piradov K. A. 1998], adhesion is considered to be a surface phenomenon and is determined by the interaction Van-der-Waltz forces between the molecules of contacting objects. Manifestation of intermolecular forces is possible at approaching the contact surfaces on the distance of $5 \cdot 10^{-10}$ м. The main conditions of adsorption interaction are the maximum possible convergence of the contacting objects, the formation of the highest continuity of contact; the best moistening of the substratum surface with adhesive; the value of polarity of contacting objects.

The process of formation of contact between the concrete and formwork can be relatively divided into three stages.

On the first stage, as a result of intense compaction of the concrete mix there is an increasing convergence of contacting surfaces (concrete and formwork) at a distance of $5 \ldots 10 \cdot 10^{-10}$ м. It is quite possible, as the pressure rises in the contact zone, contributing to the destruction of the films on the surface of formwork (in particular, the film lubrication destroys) and removing of adsorbed bubbles of air on it. On the other hand, the viscosity of adhesive (cement system) is sharply reduced with vibration, this also contributes to the maximum convergence of the contacting surfaces.

The second factor is the continuity of contact. Considering the peculiarities of the contacting surfaces and conditions of technology, it can be asserted that the contact of modified concrete with the formwork has a pointed character.

The second stage is conventionally installed from the moment of termination of the mechanical impact (vibration) till the beginning of intensive structure formation.

Polarity of the contacting objects plays an important role in the implementation of intermolecular interaction at this stage, apart from the proper convergence. It is established that convergence of two polar or non-polar objects their intermolecular interaction is more, than of the objects, one of which is polar, and the other is non-polar.

It is difficult to establish the effect of polarity for the real conditions of a pair concrete - formwork, as long as the adhesive (concrete) is a multi-component conglomerate, and the surface of the framework is covered with various films. Despite this, during the construction of formwork for the deck such material should be chosen, which polarity would not correspond to the polarity of the adhesive.

The third stage of the adhesion seam is characterized by intensive structure formation. It is established, that this stage has two phases. Coagulation structure is formed on the first of them, and first hearths of crystallization structure appear. It is proved, that at the beginning the formation of hearths is more intensive on a solid surface, i.e. the formwork, than in the volume of concrete. As a result by the moment of shift adhesion becomes more cohesive, that leads to rapid accretion of shields with cement crust.

At the second stage in the zone of contact it is hardened neoplasms at the expense of transition coagulation-crystallization structure into crystallization-coagulation. At the same time with this hardening in joint layers of adhesive materials arise shrinkage tension, reducing adhesion.

The essence of the developed by S.S. Voyutskiy [Voyutskiy S. S. 1975] diffusion theory of adhesion consists in the following. When approaching the adhesive and the substratum at a distance, close to the size of the molecules, as a result of Brownian motion in the surface layers of contacting objects is the interpenetration of molecules (groups of molecules), i.e., their diffusion. The result is a durable contact seam between two dissimilar objects.

Manifestation of the diffusion components of such a type in the contact zone of concrete with the formwork is unlikely because of the hardness of the substrate and the small energy potential of the adhesive.

The process of adhesive microparticles penetration in the pores of the formwork, which is

observed during the vibration compaction of concrete mixture, can be conditionally called macro-diffusion. The result is an increase in the mechanical anchor [Singh B. G. 1998, Sontige C. D., Hilsdorf H. 1993].

It is obvious that macro-diffusion appeares not only at the moment of vibration compaction, and will not end with its termination. In the period setting of this process continues as a result of penetration of microparticles growths in the pores and unevenness of formwork, especially this process intensifies when laying of the modified concrete mixture.

Macro-diffusive process in the zone of contact of concrete with the formwork is one-sided, i.e. it is accomplished on the side of the adhesive as a more mobile component.

Developed by B.V. Deryagin [Deryagin B. V., Krotova N. A. 1979] electrical theory of adhesion explains the interaction of two contacting bodies as a result of the formation of the double electric layer on the surface.

In real conditions the electric double layer can be of ordered or mosaic structure. According to the Deryagin's data, the risk of double electrical layer is higher in contact dielectric with the conductor and with intense friction of contacting surfaces.

In the zone of contact of concrete with metal formwork the appearance of a double electric layer, it is quite probable, as contact material (concrete) with metal at the intense friction (vibration compaction).

In the liquid phase of the modified concrete as adhesive materials at all stages of the formation of the contact (compaction, setting, hardening) contains the hydroxyl group HE is; in addition, in the zone of contact are ions of Ca^{2+}, Al^{3+}, $Al(OH)_4^-$, SiO_4^{4-}, O^{2-}. The surface of the steel, not having the products of corrosion, is characterized by the presence of hydroxyl groups OH^-, free electrons and ions Fe^{2+}. As a result of ion bond becomes complicated: the positive ions Fe^{2+} are donors for hydroxyl groups of the liquid phase of concrete, while the ions Ca^{2+}, Al^{3+} have arisen as a result of the transfer of electrons hydroxyl groups, which are on the surface of the steel. The result is a double electric layer of mosaic structures, various parts of which have different charges.

Therefore, the objective prerequisites for the emergence of in the zone of contact of concrete with the formwork of electric components of adhesion can be considered theoretically possible.

The absence of outer signs of electrization in violation of contact, i.e. when the formwork is shifted, in our opinion, is explained by the following: steel formwork has a very low ohmic resistance, as a result of the possibility of the formation in the zone of contact of surface electric charge is insignificant; the rate of rise of formwork so small that the electrons have time to flow down from the separated surfaces; presence of moisture in the contact zone does not contribute to the formation of surface charges. Therefore, for the moving formwork probability of electrical components is practically equal to zero. For other cases, for example, at immediate separation of plastic formwork and concrete products, hardened when drying infrared rays, it is much higher.

On Deryagin's opinion, every interaction at the molecular level (adsorption, electric) should be considered as a chemical bond.

The liquid phase of concrete as the adhesive is a strong alkaline environment, so the appearance of new formations in the zone of contact as a result of chemical interaction of concrete with the material of the deck is quite possible.

It is established by research [Anpilov S. M. 2005; Chernyavsky V. L. 1983] that the chemical interaction of cement stone can be also observed in metal with the formation of so-called intermetallic layer.

The result of chemical interaction of concrete and polymeric protective films can be explained by a relatively rapid destruction of such films on formwork panels and forms.

The force of friction $F_{тр}$ and normal pressure $P_н$ relation at «dry» friction can be expressed as follows:

$$F_{тр} = \varphi \cdot P_н, \tag{2}$$

where:φ – coefficient of friction.

When lifting, moving of formwork in the contact zone is the place of the complex interaction between the contacting surfaces, including, along with the «dry» friction adhesive interaction, i.e. the bond. This is just a generalized Deryagin's law, and the dependence takes the form

$$\begin{gathered} F_{тр} = \varphi \left(P_н + F_o\right), \\ F_o = \sigma_n \cdot S, \end{gathered} \tag{3}$$

where: F_o – the strength of adhesion interaction of contacting surfaces, H;

σ_n – normal adhesion, MPa;

S – he contact area of the concrete formwork, $м^2$.

Adhesive component is observed not only at the moment of sliding formwork shift, but also in the process of its calm rise. In this case, apparently, the forces of the so-called non-contact adhesion

take place. It becomes apparent on the surface areas, not adjoined directly, but located at intermolecular attraction radius distance from each other.

Thus, the generalized Deryagin's law of friction applies to practically all aspects of interaction of concrete with sliding formwork and in the best way reflects the regularities of interaction between those contacting surfaces.

There are real preconditions for the display of adsorptive, diffusive, electrical and chemical processes in real conditions of a contact pair concrete - formwork. Nevertheless, the technological conditions of contacting of concrete and formwork are so diverse (existence of various films on formwork, the degree of its roughness and porosity, different modes of vibration compaction, the characteristics of cements, mix rheology), and the mutual influences of different physical-chemical processes and phenomena in the contact zone are so complex that it is practically impossible to give a definite answer about the initial cause of adhesion.

Apparently, many factors and physical-chemical phenomena interconnected with each other are responsible for the adhesion, and, consequently, for the bond of concrete to the formwork. Therefore, the adhesion of concrete to the formwork should be considered as a multiple-factor phenomenon. Its mathematical model can be presented as following

$$a = f(A) + f(D_м) + f(E) + f(Ch), \quad (4)$$

where: A – adsorption component;

$D_м$ – the same, macro-diffusive;

E – the same, macro-diffusive;

Ch – the same, chemical.

The solution of the question about the nature and value of adhesion (bond) is possible at profound analysis of physical-chemical processes and surface phenomena occurring in the contact zone of concrete with the formwork. The complex of these processes and phenomena correlating with the identification of prevalent factors in this case should be taken into account to develop technological recommendations aiming reduction of bond and friction between the concrete and formwork.

CONCLUSIONS

1. It is established, that in monolithic constructions formation many factors and physical-chemical phenomena interconnected with each other are responsible for the adhesion, and, consequently, for the bond of concrete to the formwork. Therefore, the adhesion of concrete to the formwork should be considered as a multiple-factor phenomenon.

2. It is established that various rough surfaces are moistened in different ways. The presence of unevenness (roughness) on hydrophilic surfaces leads to the reduction of the contact angle of Θ and, consequently, to the improvement of moistening rough hydrophilic surfaces in comparison with the smooth ones. On the contrary, roughness of hydrophilic surfaces increases the contact angle and worsens moistening. For this reason, the increase of roughness of hydrophilic formwork materials, such as steel, causes growth of bond of concrete. To reduce the negative consequences of this phenomenon we should strive to use steel formwork with pre-treated surfaces.

REFERENCES

1. **Акroid T.M.B. 1980.:** Ultimate loabs in rock and concrete // Engineering. - Vo1. 189. - № 4908. - P. 146-159.
2. **Anpilov S.M. 2005.:** Formwork systems for monolithic construction. – M.: ASV. – 280 p. (In Russian).
3. **Chernyavsky V.L. 1983.:** Increase of concrete anticorrosion properties. – Kiev: The Builder, 88 p. (In Russian).
4. **Czernin W. 1998.:** Einige Bemerkungen uber Verhalten der Zementen bei Damfbehandlung // Betonstein – Zeitung. – Jg. 84. - № 3. - S. 98-103.
5. **Deryagin B.V., Krotova N.A. 1979.:** The adhesion of solids – M.: Publishing house of the USSR Academy of sciences, 245 p. (In Russian).
6. **Derucher K.M. 1989.:** Composite materials: Testing and Design – New Orleans - Philadelphia, 697 p.
7. **Hanehara S., Yamada K. 2008.:** Rheology and early age properties of cement systems // Cement and Concrete Research. - Vol. 38, No l. - P. 175-195.
8. **Holland T.C. 1998.:** High-Performance Concrete: As High as It Gets // The Concrete Producer. - - Vol. 16, No 7, July. - P. 501-505.
9. **Hughes B.P., Gregory R. 1982.**: Concrete Subjected to High Rates of Loading in Compression // Mag. Concr. Res. — V. 24. – N 78. – P. 25-36.

10. **Guzeyev E.A., Piradov K.A. 1998.:** Mechanics of reinforced concrete destruction. - M.: New age, – 190 p. (In Russian).
11. **Morinaga S. 1973.:** Pumpability of concrete and pumping Preasure in Pipelines // Proceeding of RILEM Seminar. – Leeds, England, – P. 109-121.
12. **Punagin Vladimir. 2010.:** Properties and technology of concrete for high altitude monolithic construction. TEKA Commission of Motorization and Power Industry in agriculture, Vol. XB, p. 114-119.
13. **Reading T.J. 1987.:** Shotcrete as a construction material // Shotcreting. – Publication SP-14. – ACI. – P. 98-118.
14. **Rudenko Natalya. 2010.:** The development of conception of new generation concretes. TEKA Commission of Motorization and Power Industry in agriculture, Vol. XB, p. 128-133.
15. **Sawaide M., Iketani J. 1992.:** Rheological Analysis of the Behavior of Bleed Water from Freshly Cast Mortar and Concrete // ACI Materials Journal. - Vol. 89. - No. 4. - P. 323-328.
16. **Schiller K.K. 1991.:** Mechanical Properties of Non-Metallic Brittle Materials // Cement and Concrete Research. - Vol. 2. - P. 35-42.
17. **Singh B.G. 1998.:** Specific surface of aggregates related to compressive and flexural of concrete / B. G. Singh //J.A.C.I. - Vo1. 29. - № 10. - P. 897-907.
18. **Sontige C.D., Hilsdorf H. 1993.:** Fracture Mechanism of Concrete Under Compressive Loads // Cem. and Concr. Res. – V.3. – N4. – P. 363-388.
19. **Voyutskiy S.S. 1975.:** Colloid chemistry. – L.: Chemistry, – 513 p. (In Russian).
20. **Willis J.R. 1982.:** Elasticity Theory of Composites // Mechanics of Solids / Ed. H. G. Hopkins and M. J. Sewell: Pergamon Press. – P. 653-686.
21. **Zollo R.F. 1997.:** Fiber-reinforced Concrete: an Overview after 30 year of Development // Cem. Concr. Com. - Vol. 19. – P. 107-122.

ФИЗИКО-ХИМИЧЕСКИЕ ОСОБЕННОСТИ СЦЕПЛЕНИЯ И ТРЕНИЯ МЕЖДУ МОДИФИЦИРОВАННЫМ БЕТОНОМ И СКОЛЬЗЯЩЕЙ ОПАЛУБКОЙ ПРИ ВОЗВЕДЕНИИ ВЫСОТНЫХ ЗДАНИЙ

Владимир Пунагин

Аннотация. В статье представлены результаты исследований взаимодействия опалубки и свежеуложенного бетона. Установлено наличие значительного сцепления и трения между бетоном и скользящей опалубкой в момент ее подъема.
Ключевые слова: бетон, опалубка, сцепление.

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Features of project analysis of the project portfolio of regional educational space

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S u m m a r y . Peculiarities of the project analysis of the regional space educational project portfolio (such as evaluation in terms of strategic objectives of the region and critical human resources) have been discovered.
K e y w o r d s . Region, strategy, education, profit, project, project analysis.

INTRODUCTION

The characteristic features of today within states are the processes of globalization and decentralization at the state level, which possible due to the implementation of e-technologies in all spheres of life [Brudno 2011]. This led to the fact that competition between countries turned into competitions between regions of different countries [Regional 2012] and within individual countries [Zaitseva 2007].

The competition takes place in different directions of struggle: starting from income investments to the region to fight for high qualified specialists and consultants, who involved for working in the region [Competitiveness 2012, Dvorkovich 2012]. One of the competition aspects is also a struggle in sphere of higher education. It is on the background of interstate support of educational spaces, such as Eurasian [Abdraimov 2009]. This leads to the fact that in Ukraine on the background of the demographic crisis [Libanova 2008, Tsapok 2009] certain regions catastrophically quickly lose young people who leave places where they were born, graduated from high school to get higher education in more socially prestigious metropolitan regions and other states. This process happens without paying attention to the fact that in the regions that they are leaving, exist very powerful educational establishments with long history, prestigious professions and specialists in these spheres are required in this region. This appears to be a major problem for the regions because in the era of the knowledge economy regional development is impossible without creative and competent specialists [Ramazanov 2011]. Strong regional education market can help to solve this problem.

OBJECTS AND PROBLEMS

Today the research of regional education market is not given enough attention in terms of their systematic study. But there is enough scientific publications which contained some aspects of the problem. So, in publication [Regional 2008] a comparative analysis of regional markets of educational services in Lviv region of Ukraine and the West Pomeranian region of Poland has shown the need to "develop an educational regional strategy ... that comply with the main provisions of the Lisbon strategy and the Bologna process". The author of publication [Yurchuk 2011] determined the most prospective action of the regional authorities in contemporary education services. Today, some works include new management technologies among which there are alternative management models as informal, project, integrative [Soloviev 2012]. Among questions that should be solved there are finding of rational combination of project and process management educational regional complexes and

systems [Lipovetsky 2010]. The applications of certain methods (including matrix portfolio analysis Boston Consulting Group [Murashko 2012]) of strategic planning for regional higher education are considered. But works, that are devoted to target investigation of regional educational space management tools, are almost absent.

PURPOSE

Therefore, the purpose of the article consists in the development of tools for initialization phase to form the project portfolio of regional educational space.

RESULTS OF INVESTIGATION

A lack of competent teachers can be considered the main problem of modern educational regional spaces in Ukraine. To the competent teaching staff will be referred teachers who have not only the formal qualification required features (education, degree, academic rank, publications, manuals, etc..), but can show up and present products of their mental activity that have been implemented in the real economy and thus something fundamentally changed in the world. For example, a new technology has been introduced, fundamentally new equipment has been successfully created, a new software product has been used and a new mechanism of management has been developed and put into practice etc. Other words competent - is the teacher who has managed to introduce his new knowledge in the vital activities of socio-economic systems at any level and size [Rach 2010].

In addition, the lack of teaching staff in region leads to the fact that one and the same teacher is working at the same time in different educational establishments. This fact is inherent both in the capital educational space and educational spaces of cities that are equal to the capital. The number of students per volume licensed Doctor or Professor is one of the basic indicators, which is a prerequisite for providing the high qualified educational services [State 2012]. And for the major regional education areas which investigate as a holistic education, this figure exceeds normative value – 25 students per doctor, a specialist in the relevant specialty.

The solution of the situation considers in the creation of a holistic, powerful, attractive regional educational space based on the cluster integration mechanism in which teachers are regarded as the only available high qualified resource for any student of this space. Therefore, the local educational space in relation to the existing model should have fundamentally another model as the holistic system. Using the approach described in publication [Rossoshanskaya 2000], we are offering to consider a regional educational space (I) as an element of is more integrated system – region (fig. 1). In this model, a separate element is the specialist (II), which was prepared for the regional labour market (IV). However, his training is based on the priorities of the region (III).

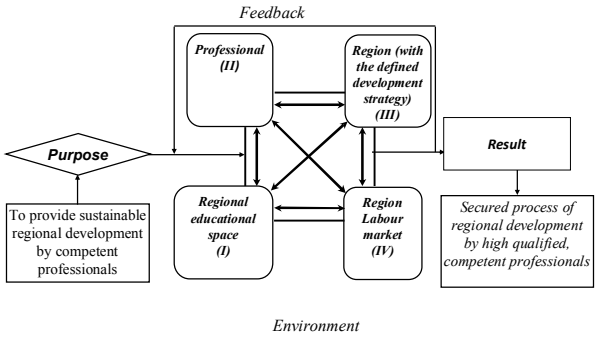

Fig. 1. System model ensuring sustainable development of the region by competent professionals based on functioning holistic regional educational space

This model is substantially correlated with the modern model of innovative development – triple helix [Itskovits 2010] and its modernized variant for Ukrainian conditions [Rach 2011]. Based on this model, a regional educational space except educational projects as a mandatory condition for its normal functioning should implement scientific and economic projects (classification, which is given in [Kolyada 2011]). Implementation of such or similar model implies the existence of information, organizational and economic levers of management [Maksimov 2010]. However, as shown in the work [Borzenko-Miroshnichenko 2008] transition to project-oriented management of regional educational space involves the formation and implementation of the educational project portfolio.

Prior to converting the model into reality the region and model elements readiness should be evaluated before its implementation. The tools of project analysis are used in project management methodology for the evaluation of individual projects [Verba V.A. 2000]. But existing tools of project analysis are not quite adequate for such

task. They require appropriate improvements. In publication [Rach 2012] a new approach to project analysis has been developed. This approach and the model shown at Fig. 1 are based on using model which includes four components. This gives hope to find opportunities and reveal peculiarities of the project analysis of the project portfolio of regional educational space.

Traditionally expertise of separate project involves evaluation by seven aspects: technical, environmental, commercial, financial, economic, social, and institutional [Rach 2012]. A separate range of expertise is the risk analysis in each of the following aspects. Also according to the model of system project analysis listed aspects are the connections between elements which interaction determines the success of the project.

Model of system project analysis of the project portfolio of regional educational space is shown at fig. 2. It is based on the fact that the essence of project analysis aspects is defined the essence of connections between elements of the system model. Lets investigate in detail these connections.

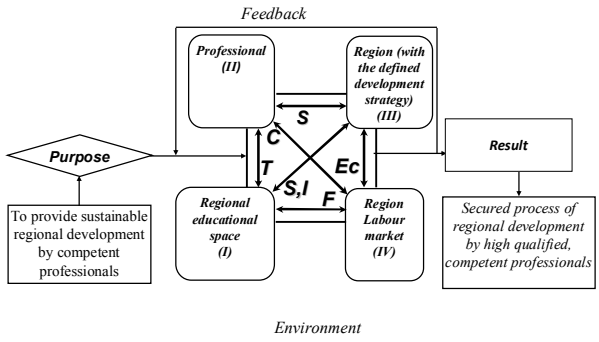

Fig. 2. Model of system project analysis of the project portfolio of regional educational space

Accentuated the role and importance of human resources in educational projects leads primarily consider the relationship between the strategic goals of sustainable development in the region and created there the regional educational space. This relationship in the expertise of the project portfolio can reveal institutional and social aspects (S, I at fig. 2). The essence of the institutional aspect of the expertise is to response the question – what degree of facilitate the environment the project portfolio.

Principle of manning labour resources to realize the project portfolio based on qualification, managerial and administrative capacities of all members of the cluster are requiring special attention in a regional education space. This condition is primarily concerned with study projects of portfolio which are associated with the preparation of the bachelors in normative disciplines. Quality staffing these projects must comply with the principle of historicity. Teach the following courses, such as higher mathematics, philosophy, history, foreign language and others have to departments with extensive experience of reading such disciplines, supported by scientific and practical results. Overall rating may be taken as one of the methods to define leading teachers. Such rating have to take into account the formal parameters (experience, seniority, number of teaching and scientific research, etc.) and objective indicators of two kinds. The first group is determined by students, for example, the logic and understandability the presentation of the material, clarity of speech, personal characteristics, and so on. This group of objective indicators will reduce the risk students perception the content of the discipline. The second group – are indicators of competence, which have been outlined above, and reveal the extent of implementation of own scientific investigations of the teacher to socio-economic systems. External constraints of such planning labour resources of the educational project portfolio are the norms of labour legislation and requirements of licensing and accreditation approved by the Ministry of Education, Youth and Sports of Ukraine.

According to the social aspect high qualified specialist as the main product of the educational project portfolio affects the spiritual component of life in the space. Group of educational level indicators of the population assess the direct influence, but the social effect can be determined by level indicators of cultural activity, crime, etc.

Connection between element "professional" and "region labour market" reflects the commercial aspect of project analysis (C at fig. 2). It answers the question of the existence of demand for the project product – professionals. The priority projects should be such educational projects for graduates of each is guaranteed demand at the region labour market. The main evaluative indicator in this aspect is the level of demand for professionals of the proper specialties, prepared by summarized needs of businesses in the region. In order to provide the quality of education in accordance with the requirements of specific customers (enterprises of the region) they should be actively engaged in the process of curricular content and monitoring of educational projects.

Similarly, there is the principle of selection of economic and research projects to the portfolio.

Note that the consumer must receive projects product features of the highest quality. For example, fully prepared for implementation an innovation, based on proven scientific and practical developments, etc. During the project expertise in the commercial aspect these indicators should be formalize.

The financial aspect (F at fig. 2) reflects the connection between the regional educational space and region labour markets. Educational projects have no financial gain. However, portfolio estimation should be carried out on the base of balance criterion. It means rational combination in the project portfolio commercial (for example, education of foreign students) and non-commercial projects (aimed at priority perspective directions of development of individual businesses and the region as a whole or of the regional educational space).

Expertise in economic aspect (Em at fig. 2) provides for the establishment influence of products of the realized project portfolio on the economy of the region, positioning the portfolio according to the criteria of economic attractiveness and effectiveness. Thus, this aspect reveals the essence of connection between elements of "region" and "region labour market". This evaluation for the educational project portfolio may be carried out on the basis of indicators of economic activity in the region, in which the contribution made by high-quality human resources, implemented research-based innovations.

The essence of the technical aspect (T at fig. 2) project analysis reveals the connection between professional and regional educational space. Today effective educational technologies exist in sufficient amount. For example, during the classes most teachers combine visual and audio means of conveying information due to modern computer technology. The basis of the current and final evaluation means assigned educational taxonomies, which allow establishing not only knowledge level but also formed competence. Along with this, the level of material and information educational projects support needs the mandatory assessment. In some cases, old material and technical basis, the fixed assets may adversely affect the process of creating the educational projects portfolio product (for example, lack of heating in an audience, outdated software and computer equipment, etc.). Existence of the sole regional educational network goes at the forefront for regional educational space in the model which is at consideration.

Such a system look at the project analysis of the regional educational space project portfolio allows us to estimate connections between the elements, which interact and determine the regional development be the high qualified professionals.

CONCLUSIONS

Result of this investigation consist of the following:

Evaluation in terms of strategic objectives of the region and critical human resources are the discovered peculiarities of the project analysis of the regional space educational project portfolio.

The essence of connections between elements of the system model project analysis of the project portfolio of the regional educational space has been determined.

REFERENCES

1. **Abdraimov B.J., 2009.:** Interuniversity cooperation as key to the development of general educational space: Eurasian dimension. Information and Analytical Center. Electronic Resource. Access mode: http://www.ia-centr.ru/expert/4223.
2. **Borzenko-Miroshnichenko A.Y., 2008.:** Regional education management of according to the paradigm of public administration: project-oriented view. Project Management and Production Development. Lugansk: Publ. V. Dahl SNU. № 3 (27), pp. 87-92.
3. **Brudno A., 2011.:** Competition between regions – one of the main springs of e-government in all countries. Gosbuk. Electronic Resource. Access mode: http://www.gosbook.ru/node/18105.
4. Competitiveness of the region, 2012.: Electronic Resource. Access mode: http://www.concretica.ru/publications/single/article/92/266.
5. Dvorkovich predicts surge in regional investment activity and growing competition between regions for investment, 2012.: Electronic Resource. Access mode: http://www.finmarket.ru/z/nws/news.asp?id= 3095778.
6. **Itskovits H., 2010.:** Triple helix. University-enterprise state. Innovation in action. Tomsk: Publishing TUCSR, 238 p.
7. **Kolyada O.P., 2011.:** Portfolio planning the development strategy realization of higher education: diss. PhD. Lugansk, 222 p.
8. **Libanova E., 2008.:** Prediction demographic development of Ukraine for the period up to 2050. Svitoglyad. № 3, pp. 48-51.
9. **Lipovetsky O.G., 2010.:** Common mechanisms for managing educational complexes and region systems. Public Administration: Theory and Practice. Kyiv. National Academy of Public Administration under the President of Ukraine. № 2. Electronic Resource. Access mode: ttp://www.academy.gov.ua/ej/ej12/txts/10logksr.pdf.

10. **Maksimov V., Galgash R., Synytsa L. 2010.:** Information and organizational-aspects of innovative development management of regional enterprises. TEKA Commission of Motorization Power Industry in Agriculture, XD, p. 184-189.
11. **Murashko M.I., Nazarko S.O., 2012.:** Adaptation matrix methods to the terms of strategic regional high school development. Efficient economy. Dnipropetrovsk. Dnipropetrovsk State Agrarian University. № 11. Electronic Resource. Access mode: http://www.economy.nayka.com.ua/ index.php?operation=1&iid=204.
12. **Rach V.A., Borzenko-Miroshnichenko A.Y., 2012.:** Project analysis: tutorial. Lugansk/ Publ. V. Dahl SNU, 223 p.
13. **Rach V.A., Ignatova E.V., 2010.:** Methodology of systematic approach and scientific research: textbook. Lugansk. Publ. V. Dahl SNU, 210 p.
14. **Rach V.A., Medvedva E.M., Rossoshanskaya O.V., Evdokimov A.V., 2011.:** Innovation development: the triple helix model in the context of the system vision. : Materials XVI International Scientific Conference Problems and prospects of innovative development of the economy, Alushta, 12-16 september. Simferopol. IT Ariano, pp. 157-163.
15. **Ramazanov S., Kalinenko N., Rakova L. 2011.:** The use of IT-technologies in student employment using a competence based approach. TEKA Commission of Motorization Power Industry in Agriculture, V.XIA, p. 207-215.
16. **Rossoshanskaya O.V., 2000.:** Features planning projects on the base of system model. Project Management and Production Development. Lugansk: Publ. V. Dahl SNU. № 1(1), pp. 57-62.
17. Regional competitiveness: from competition between municipalities to raising the region's competitiveness, 2012: Electronic Resource. Access mode: http://www.citystrategy.leontief.ru/world/ linda.htm.
18. Regional market of educational services in Poland and Ukraine: a comparative analysis, 2008.: Project "Regional market of educational services". Electronic Resource. Access mode: http://www.csr.co.ua/ pdf/projekt_oswiata_poski_ukrainy_ua.pdf, 8 p.
19. **Soloviev Y., 2012.:** Conceptual Foundations of modernization of education management. Electronic Resource. Access mode: http://osvita.ua/school/ manage/general/1725.
20. State requirements for accreditation of specialty of higher establishment, 2012.: Order of the Ministry of 13.06.2012 № 689, which is registered in the Ministry of Justice of Ukraine on July 4, 2012, № 1108/21420.
21. **Tsapok S., Biduk V, 2009.:** Modern trends in economic development, and their incorporation in the regional social policy. Regional Economics. № 4, pp. 133-139.
22. **Verba V.A., Zagorodnih O.A., 2000.:** Project analysis: textbook. Kyiv. Kyiv National Economic University, 322 p.
23. **Yurchuk L., 2011.:** Development of a regional education market in conditions of formation of public education management system. Dnipropetrovsk. Dnipropetrovsk Regional Institute of Public Administration of the National Academy of Public Administration under the President of Ukraine. № 2(9). Electronic Resource. Access mode: http://www.nbuv.gov.ua/portal/soc_gum/Dums/2011_2 /11ylmsuo.pdf.
24. **Zaitseva P.I., 2007.:** Features of interregional competition in Russia. The problems of the modern economy, Moscow. № 4 (24).

ОСОБЕННОСТИ ПРОВЕДЕНИЯ ПРОЕКТНОГО АНАЛИЗА ПОРТФЕЛЯ ПРОЕКТОВ РЕГИОНАЛЬНОГО ОБРАЗОВАТЕЛЬНОГО ПРОСТРАНСТВА

Валентин Рач, Алина Борзенко-Мирошниченко

Аннотация. Выявлены особенности проведения проектного анализа портфеля проектов регионального образовательного пространства: оценка с точки зрения приоритетных стратегических целей региона, критичность трудовых ресурсов.

Ключевые слова. Регион, стратегия, образование, портфель, проект, проектный анализ.

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Innovative management models of viable and stable development of technogenic region in crisis

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S u m m a r y . In modern conditions of instability, systematic crises and global transformations the problem of developing methods and technologies for analysis, modeling, forecasting and decision making for stable development of viable socioeconomic systems has become the most important. In the paper there has been proposed models and control technologies of viable, stable and safe development of systems based on the type social–ecological–economical and humanitarian subsystems integrated object and subject oriented approach.
Key words: social, ecological and economic systems, object-subject-oriented approach, management.

INTRODUCTION

Currently the issues of civilization ecological and safe development have become the first point of scientific researches and public consciousness. Humanity has come to that point when modern civilization have often called technogenic–exploitative one has reached its dead-lock when it is necessary to take serious actions to review its basis, make conscious choice of another spiritual-ecological development strategy. The humanity has to refuse from some thinking stereotypes and forward innovational development vector for mind sphere's formation (noosphere, according to Vernadsky V.I.).The formation of noosphere-ecological imperative is related to the establishment of the society capable to provide co-evolutional development of socio-natural integrity, which is the most actual nowadays.Steady and safe development is impossible without cultural–spiritual development of the person itself. New model of civilization development has to have deep humanist social orientation by implementing non- traditional social, ecological and demographic imperatives. Such approach towards noosphere perception requires new development model, which should be based both on rational intellectual approach to ecosystem assessment and rely on its spiritual-cultural components. If the intelligence is the activity optimization mechanism on the way to noosphere than spiritual moral criteria are its assessment characteristics as the spirituality is opposite to the issues of material nature, not to rational or irrational aspects.

That is why taking into account current conditions of instability and crises the issue of assessment, modeling, forecasting and solutions taking methods and technologies development becomes more and more up-to-date. These human-dimensional systems are characterized by the complexity of their structure and action, synergy, nonlinearity and have a lot of "NOT" and "MANY" factor characteristics. Moreover, another important problem lies at the research of the systems having integral peculiarities – i.e. the systems having social–ecological–economical and humanitarian subsystems in their structure (SEEHS) as the systems of future (noosphere type systems). Local manufacturing systems and regional level economical activity units such as technonegic manufacturing companies and systems (TMS) are the systems of SEEHS type.

The management and solution taking methods and models on units oriented approach basis have been traditional employed for these issues research and resolution. Though, some recent scientific researches and scientific schools with the accent on the importance and necessity have proved the need of behavioral dynamics and

management subject taking into account for such tasks resolution by means of subject oriented and reflexive approaches [Lefevr 2003, Lepsky 2009, Lepsky 2010].

This research offers management models and technologies of region TMS viable and steady development as the system of SEEHStype on integral unit and subject–oriented approach basis. It offers conceptual, synergetically generalized dynamic model which takes into account various uncertainties types and the option of non-linear dynamic model of management subjectbehavioral and solutions taking model – i.e. the model of solution taking person (STP) and others.

The peculiarity of management solution taking processes during current conditions of general social-economical, ecological, social humanitarian and system crisis, the conditions of necessity and importance of society structures steady and viable development lies at the necessity of taking into account the influence of uncertain factors and review all possible consequences of alternatives choice. That is why the development of models and informational management and solutions taking technologies on the conditions of uncertainty, risks, destabilization and crises is of big practical importance. The aforementioned models and technologies provide structuring and processing of information about resolved problem and partially fill informational gap of apriori data the manager has. Though, the recommendations on management and solutions taking obtained with the help of formal models should be taken into account only in cases when the offers, lying in the basis of such models, correspond to uncertainty actual nature and source. It is necessary to understand the essence and variety of uncertainty factors and related risk and danger notions, influencing the organization.

It is worth mentioning that the development and research of integrated economical mathematical models (EMM) and the usage of informational and innovational technologies at ecological and economical management of such socially and ecologically oriented units as TMS is up-to-date issue as well [Ramazanov 2004, Voronkova, Ramazanov, Rodionov 2004, Evtuh, Shevchenko, Ramazanov 2005, Ramazanov, Pripoten 2006, Ramazanov 2008, Evtuh, Shevchenko, Ramazanov 2009, Ramazanov, Nadion, Kryshtal, Stepanenko, Timashova 2009, Ramazanov, Aptekar 2010]. Such approach is fully confirmed by the opinion of a lot of well-known scientists about steady development concept. The steady development concept has appeared due to uniting of three main models and points of view (triune model): economical, social and ecological one. Mostly this model is the continuation of noosphere concept about "obligatory coordination of economical, ecological and human development to keep human life quality and safety, environment condition and social progress on steady level, taking into account the needs of each individual", formed by VernadskyV.I. Theory and practice confirms that VernadskyV.I. theory has turned out to be necessary platform for the development of triune concept of steady ecological social economical development and the construction of integral model of "socially oriented ecological economics" and "knowledge economics" – i.e. the model of "intelligent society" – the highest form of society development based on knowledge and innovational technologies [Ramazanov 2004, Evtuh, Shevchenko, Ramazanov 2005, Ramazanov, Pripoten 2006, Evtuh, Shevchenko, Ramazanov 2009, Ramazanov, Nadion, Kryshtal, Stepanenko, Timashova, 2009, Ramazanov, Aptekar 2010]. It is worth mentioning as well that according to the opinion of internationally approved specialist in the sphere of economical competition research - M. Porter "the counties with the most strict environment protection legislation have the highest economical indices". This means that M. Porter disproves common opinion about strict ecological policy negative influence over the country competitiveness. That is why the share of social ecological safety is very important at GDP. In the conditions of society's further transfer to the sixth and especially the seventh technological economical development stages it is significantly important to take into account social-humanitarian aspect, reflexive and subject oriented approaches and other during integral models and technologies creation. The present article is devoted to the study of the aforementioned methodological issues.

OBJECTS AND PROBLEMS

Find below some signs and definitions: environment (environment - surrounding nature, ecosphere) - En; economics (economic – economical system) - Ec; social sphere (social – social system) - So, appropriate synergetic peculiarities of their integration model are the following: viable – i.e. ecological–economical surrounding - En+Ec; social oriented (equitable) economical system - So+Ec; social-ecological (bearable– acceptable, reasonable) system -

So+En; system (concept) (sustainable) development – makes: So+ En + Ec (fig. 1).

The notion of sustainability (steadiness, viability) supposes the capacity of the system to function on the conditions close to equilibrium on the conditions of steady external and internal disturbing actions. The system functioning and development complications factors are the following: external and internal threats, dangers, crises, uncertainties, instabilities and other "NON" and "MANY" factors together with new informational and innovational technologies and others [Evtuh, Shevchenko, Ramazanov 2005]. The development of social ecological economical monitoring, management and efficient solution taking integrated system for the solution ofTMS economy socio–ecologization, particularly for the decrease technogenic companies manufacturing activity negative influence over environment and maintain social infrastructure on the conditions of economic reforms.

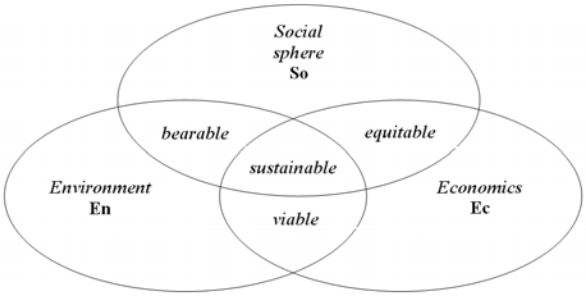

Fig. 1. Integral system diagram

This research is devoted to the issue of TMS social-ecological economical management, functioning at current conditions of instability and uncertain surrounding. Innovative integrated intellectual informational system of TMS ecological economical monitoring, modeling and management. The system basis lies at the developed concepts; complex of non-linear models, solutions taking methods and EEM; integral criteria (economical, ecological, social, technological transport and others); the idea of "five plus"with integral management model of social economical, ecological and social humanitarian system, taking into account the range of factors: *<Ec, En, So, CM; S, IT; I>*; both endogenous and exogenous and two conclusions - "useful" and "harmful" ones; based on mixed informational base: determined, scholastic, multiple and unclear information forSEEHS TMS and other.

Specific attention is paid to the issues of informational, innovational technologies and EEM TMS economical mathematical modeling processes usage. This research mentions the following important innovational instruments and technologies for set tasks' solution: modern methods, models and informational technologies for assessment and synthesis of management and solution taking systems, forecasting, management methods, anti-crisis management innovational technologies and TMS safe management innovational instruments. The issue of integration at modeling, management and solutions taking is the most important fundamental issue of economics and science in general [Ramazanov 2004, Ramazanov, Pripoten 2006, Ramazanov 2008, Ramazanov, Nadion, Kryshtal, Stepanenko, Timashova 2009, Ramazanov, Aptekar, 2010].

THE DECISION OF THE TASK

The conceptual model of integral ecological-economic, social humanitarian management of complex system on the conditions of uncertainty, instability, "NON" and "MANY" factors and other can be presented in the form of the following theoretical- multiple range:

$$IS := \langle \langle E_c, E_n, S_o, \mathrm{H}_u \rangle; \\ \langle X_I, Y_I, F_I, G_I, K_I, \Omega_I \rangle, R_I, U_I, E_I, T \rangle, \quad (1)$$

where: $\langle E_c, E_n, S_o, \mathrm{H}_u \rangle$ - makes an integral range of systems' main set, where Eclies for economics (economical system); En lies for surrounding (ecosphere); So lies for social sphere (social system); H_u - lies for humanitarian components of the model. The range $\langle X_I, Y_I, F_I, G_I, K_I, \Omega_I \rangle$ consists of the commonly known components for each aforementioned system. $R_I = \langle R_c, R_n, I_n, \tau_{II}, R_S ... \rangle$ - lies for the range of resources, where R_c and R_n lie for economic and ecological resources; I_n lies for investments; τ_{II} lies for informational and innovational potential; R_S lies for the source of provision of the security from the complex of threats, risks and other.

General scheme of system sustainable and socio-humanitarian development integration model can be presented in form of symbol called "Integrator", which is commonly used at cybernetics (fig. 2). Fig. 2 uses the following definitions: E_c – economical system, E_n –

ecological system, S_o – social system, H_u – humanitarian system; $S = E_n \oplus E_c \oplus S_o \oplus H_u$ - integral "4 united" system; $X(t,r)$ – the condition of integral system S; in the space of variables $(t,r) \in [T \times R^3]$; X_o – the condition of S system at initial period of time t_o; W – various disturbing variables (factors) of external surrounding.

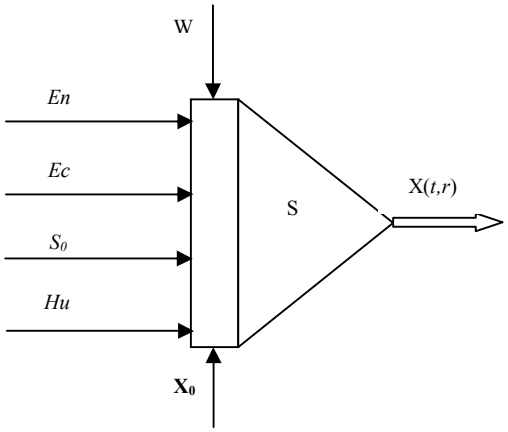

Fig. 2. System development integration model scheme

It is worth mentioning that for ecological economical modeling and management the following symbols have been used: $Y = \langle Y^{Ec}, Y^{En} \rangle$ lies for TMS overall output, where Y^{Ec} lies for efficient set(i.e. "efficient output"), and Y^{En} lies for pollution set (i.e. "harmfuloutput"); X lies for the TMS set of possible conditions; $F = \langle F^{Ec}, F^{En} \rangle$ lies for TMS model reflection; $H = \langle H^{Ec}, H^{En} \rangle$ lies for observations (measurements) general operator; G lies for targeted set; K lies for generalized criterion of management and solutions taking; Ω lies for limitations set; R lies for resources set (i.e. TMS controlled input); $U = \langle U^{Ec}, U^{En} \rangle$ lies for EEM set (the set of managing influences); E lies for the set of uncertain disturbances (both external and internal ones – i.e. additive and multiplied ones). Particularly it goes about the set of scholastic, uncertain, multiple or mixed uncertainty; T lies for time interval of TMS functioning and development. The symbol of "Ec" and "En" appropriately mean economic and ecological variables [Ramazanov 2008].

So the task of TMS EEM lies at the definition of efficient generalized U на management vector based on TMS dynamic ecological–economic model, providing the task fulfillment on the set generalized ecological economical criterion and limitations taking into account the conditions of uncertainty and risks.

Particularly, the synergetic model of non-linear complex ecological-economical system (EES) dynamics management taking into account scholastic and chaotic behavior has been presented in form of differential equation system:

$$\partial x_i / \partial t = \left[\lambda_i \xi_i(t) x_i(t) \left[X^0 \pm \sum_{j=1}^{n} a_{ij}(t) \prod_{k=1}^{j} x_k(t) \right] + \sum_{l=1}^{3} d_{il} \frac{\partial^2 x_i}{\partial r_l^2} + w_i \right] + \quad (2)$$

$$+ b_i u_i(t), \; i = \overline{1,n}, \qquad \bar{x}_i(0) = x_{i0},$$

where: $X(t,r) = (x_1(t,r), x_2(t,r), ..., x_n(t,r))$ – lies for social ecological economical system condition vector (particularly TMS), where $\{x_{i0}\}$ lie for initial conditions vector coordinates; $\langle \xi_i, w_i \rangle$ lies for scholastic, multiplicative, additive disturbing components of the model; $\{a_{ij}(t)\}$ lies for matrix elements defining non stationary model components; $\{u_i(t)\}$ lies for managing influences vector coordinates; $\{b_i(t)\}$ lies for management vector coefficients; $\{d_{il}\}$ lies for diffusion coefficients – i.e. the coefficients taking into account the effect of such spread (distribution); X^0 lies for maximum value of n-dimensional vector $X(t,r)$, where r lies for 3- dimensional vector; λ_i lies for measurement responsible for system chaotic behavior, and $t \in [0, T]$ lies for time interval of system functioning and development. Moreover, such model allows taking into account both risk and security level have their own dynamics and are scholastic processes.

The generalization of integral system diagram at fig. 1 is 4 unite integrated noosphere model ("civilization model") of system development which is social–humanitarian and ecological economical system, presented at figure 3. Figure 3 shows the following system components (sub systems): 1–Economics, 2–Ecology, 3– Social sphere, 4– Humanitarian sphere together with appropriate integrated (synergetic) peculiarities:1.2– "Viability" (ecological-economical),1.3– «Justice» (socially oriented),1.4– «Culturology orientation» (humanitarian-economical), 2.3 –«Acceptability» (social-ecological), 2.4– Humanitarian-ecological, 3.4– social–humanitarian. More refined peculiarities of integrated system such as 1.2-1.4, 1.2-2.3, 2.3-3.4, 1.4-3.4 and others require further review, assessment and definition.

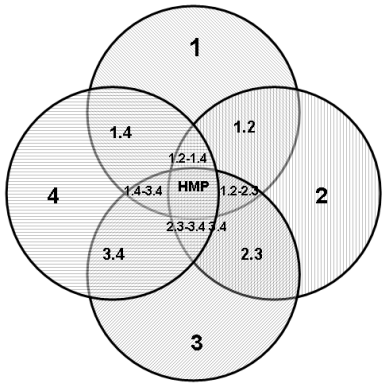

Fig. 3. 4 unite integrated system development diagram

This means that the system (model, concept) of sustainable development is an integration, and NDM can be defined as noosphere development model ("civilization model") and the set of (1.4-1.2), (1.2-2.3), (2.3-3.4), (1.4-3.4), defining the system having integrated peculiarities.

Integrated social-ecological-economic model can be presented at general (block) form:

$$\begin{cases} \dot{X}_1 = f_1(X_1, X_2, X_3, P_1, \xi_1), \\ \dot{X}_2 = f_2(X_1, X_2, X_3, P_2, \xi_2), \\ \dot{X}_3 = f_1(X_1, X_2, X_3, P_3, \xi_3). \end{cases} \quad (3)$$

where: $X = (X_1, X_2, X_3)$ lies for united vector of social-ecological–economical system conditions (SEESC) such as TMS, where $X_1 = X_1(t)$ lies for economic variables vector; $X_2 = X_2(t)$ lies for ecological variables vector (pollution vector); $X_3 = X_3(t)$ lies for social variables vector; $P = (P_1, P_2, P_3)$ lies for aggregate vector of SEESC measurements (internal system and external ones); $\Xi = (\xi_1, \xi_2, \xi_3)$ – lies for the vector of external uncertain random variables. And $X_1 = \langle K_1, L_1, I, \tau, C \rangle$, $C = (C_1, C_2, C_3, C_4)$ lies for the vector of some variables for consumption (expenses), C_1 lies for social consumption changes (i.e. salary and other related expenses), $C_3 = C_E$ lies for ecology expenses, $C_3 = C_s$ lies for security expenses, $C_4 = C_i$ lies for the amount of investments for innovational and informational technologies.

The generalized scheme of integrated hierarchic unit and subject oriented management system and ST is presented at figure 4.

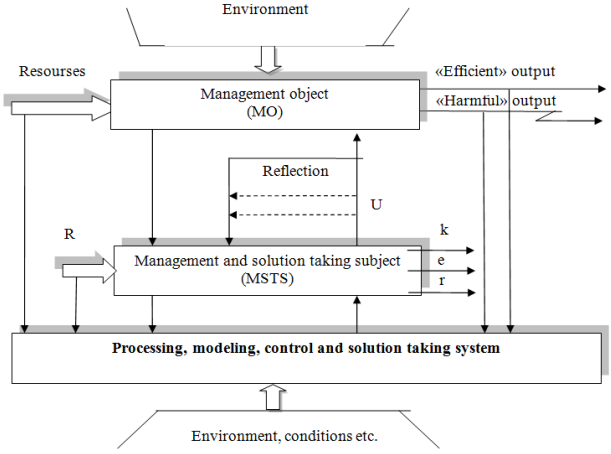

Fig. 4. Unit and subject oriented management and ST scheme

Subject oriented management and solution taking (SOM and ST) at figure 4 is presented in block "management subject and ST", where k, e, r lie for appropriate modes where k lies for cognitive variables, e lies for emotional psychological variables, in the aggregate defining behavioral dynamics of the person taking the solution.

Generalized model of STP cognitive emotional dynamics as a complex integrated system. The subject or the person taking the solution as organism and person is an open system which self organizes and develops and has the set of non-linear and unpredictable behavioral process. That is why formal mathematical methods of non-linear science allow adequate description, assessment and modeling of solution taking processes.

This research reviews one of the options of STP behavioral dynamics partial description during the process of efficient solutions taking. Moreover, it is necessary to take into account both ST cognitive and emotional element. That is why in this research it is worth mentioning the following. Human and rather highly developed animals' psychic forms the models of environment. This fact is common at modern behavioral science. Various authors have called these models cognitive schemes (Levin K.) or cognitive schemes (Tolman E.) at various periods of time. We will employ general scientific term – "model", which is currently employed at cybernetic and synergetic (non-linear dynamics). Though, even with adequate model the process of optimum solution taking and unit management might turn to be quite complex. That is why human psychic has simplified mechanism of situation assessment and solution taking, called "emotions". Emotions assess the situation not on all existing criteria, but only on some which are the most for psychic

bearer (i.e. in accordance with modes). Accordingly, the emotions can launch behavior which is not optimum for the aforementioned situations but some other which is probably "commonly used" during evolutional process at the same situations. Taking into account the above considerations the emotions are treated like psychic (cybernetic) mechanism of STP behavioral management, assessing the situation on some set of measurements (own set for some specific emotion) and launches appropriate behavioral program (for some type of emotions).

The dynamics of interaction and inter-influence processes (i.e. the dynamics of synergetic processes) of cognitive and emotional modes (group of significant measurements or variables) between themselves and emotional and cognitive modes with each other can be described as the equation system of Lotki-Walter type.

The generalized form of this model is presented in the following way (2):

$$\dot{x}_i(t)=\lambda_i^s x_i\left[\mu_i(R)-\sum_{j=1}^{n}\beta_{ij}(R)x_j(t)\right]+\eta_i(t)x_i(t),\ i=1,...,n, \quad (4)$$

where: $x_i \geq 0$ – lies for activity i -st mode (the quantity of i -st population in ecology); n lies for the amount of interacting modes (population); $\mu_i(R)$ lies for the increment of i -mode; R - lies for the set of resource variables such as available information and other available types of resources; $\beta_{ij}(R)$ lies for the elements of matrix interaction; $\mu_i(t)$ lies for multiplicative noise, which is present at the system for i -mode; λ_i lies for specific time defining the process (setting speed); s =-1,0,1,2. Depending on the measurements correlation this model demonstrates great behavioral variety. In case of more-less symmetrical correlations i.e. $\beta_{ij}=\beta_{ji}$ shows multi stability phenomena i.e. the system can display two or more steady conditions. The implementation of one of them is defined by initial conditions. In case of non–symmetric connectives heterocyclic and related cycles, steady heterocyclic channels and dynamic chaos [Rabinovich, Muezinolu 2010].

It is interesting to remember the researches where peculiar dynamic chaos, when scholastic (random) occurs only during the shifts between metastable conditions, the shift order is steady. This transitional dynamics restored from the point of view of sequence cognitive modes maintenance in the circle can be interesting solely for the display and understanding of various thinking processes. Such dynamics opens new perspectives for studying complex processes of subject behavioral dynamics.

Cognitive and emotional modes are closely connected to each other. Nevertheless it is natural to consider that the modes of one family are connected to each other stronger than with the modes of other family. We can consider that one family models the dynamics of other without destroying it. Particularly the cognitive modes support emotional balance and emotions induct or suppress (in case of being negative) intellectual activity. By bearing this in mind it is natural to describe the interaction of emotions and cognitive activity with the help of related subsystems of equations of 4th type. Taking into account the s dynamics of the resources for which the emotional and cognitive modes fight there should be three subsystems: emotions modes, cognitive modes and resources (attention, memory, energy). The role of attention should be specifically highlighted. The attention selects those objects among presented by sensor informational system, which are currently considered to be the most crucial for information assessment and making the correct behavioral strategy. The experiments prompt the efficiency of various mental processes support by means of attention are defined by the competition between various objects of attention. In order to simplify further description let's consider that the description of the competition for attention does not require the specific modes specification, that is why we are able to limit with the review of competition fight for the attention "in general" for emotions: $\overline{B}=\sum_{i=1}^{M}B_i$ and "in general" of cognitive modes: $\overline{A}=\sum_{i=1}^{N}A_i$ [12].

Then our basic equations can be presented in the following form

$$\frac{d}{dt}A_i(t)=\lambda_A^{-1}A_i(t)\left[\sigma_i(I,B,D)R_A-\sum_{j=1}^{N}p_{ij}(D)A_j(t)\right]+ \quad (5)$$
$$+A_i(t)\eta(t),\quad i=1,....,N,$$

$$\frac{d}{dt}B_i(t)=\lambda_B^{-1}B_i(t)\left[\zeta_i(S,A,D)R_B-\sum_{j=1}^{M}\xi_{ij}(D)B_j(t)\right]+ \quad (6)$$
$$+B_i(t)\eta(t),\quad i=1,....,M,$$

$$\frac{d}{dt}R_A(t)=\lambda_{R_A}^{-1}R_A(t)[\overline{A}- \quad (7)$$
$$-(R_A(t)+\phi_A(I,D)R_B(t))],$$

$$\frac{d}{dt}R_B(t)=\lambda_{R_B}^{-1}R_B(t)[\overline{B}- \quad (8)$$
$$-(R_B(t)+\phi_B(S,D)R_A(t))].$$

Here A_i and B_i lie for indispensable variables, corresponding to cognitive and emotional modes, the general intensity of which is defined as $\widetilde{A}$ and $\widetilde{B}$ appropriately, and A and B lie for vector presentation of variable. Both types of activity receive signals from external surrounding: the information I and characteristics of emotional influence S (in case of negative emotions it goes about stress), D goes for the level of taken energetic means (e.g. some preparations). The measurements λ_A^{-1} and λ_B^{-1} are peculiar times of conscious and emotional activity. Like at (4), $\eta(t)$ goes for multiplicative noise. The variables R_A and R_B characterize the dynamics of resources, the attention first of all; the coefficients ϕ_A and ϕ_B define the intensiveness of fight for attention from the point of emotions and thinking.

The emotional and cognitive processes of STP brain can differ significantly based on dynamic peculiarities. It goes both about the divergence about time parameter τ (the emotional reaction is much faster) and behavioral character. In most cases the cognitive activity can be regarded as transitional process depending on the set goal. Steady heterocyclic channel can be regarded as mathematics form of such process.

The dynamics of the emotions can be much more variable. These can be irregular pulsations (strange attractor), transitional regimes reminding the cognitive ones, recurrent dynamics which corresponds with cyclic mood fluctuations and finally long term equations-clinical case of deep depression or constant over agitation.

The dependence of increments σ_i and ζ_i from AandB accordingly describes direct influence of cognitive process activity over emotions and the influence of the emotions over thinking. This might be for example the things, agitating or slowing the emotions actions for cognitive processes or the emotions' suppression due to the development of correct behavioral strategy in case of stress or over agitation.

CONCLUSIONS

B this research reviews the issue of innovational modeling in case of integral object and subject oriented approach at TMS management as the system of SEEHS type. This research offers conceptual integrated model, generalized synergetic model of dynamics taking into account the uncertainty (scholastic and chaotic factors) together with the option of non-linear behavioral model of management and solution taking object. Further researches require the development of the range of specific models of the solution of object and SOM and ST in the systems of SEEHS type.

REFERENCES

1. **Lefevr V., 2003.:** Refletion. M.: Kogito-center, 496 p.
2. **Lepsky V.E., 2009.:** Subject oriented approach towards innovational development. M.: "Kogito-center" Publishers, 208 p.
3. **Lepsky V., 2010.:** Reflexive active surroundings of innovational development. M.: "Kogito-center" Publishers, 255 p.
4. **Ramazanov S., 2004.:** The models of ecological–economical management of manufacturing system at instable external surrounding. Monograph, Lugansk: ENU after V. Dalh Publishers, 384 p.
5. **Voronkova A., Ramazanov S., Rodionov O., 2004.:** Modeling of management of the company competitiveness: ecological-organizational aspect. Monograph, Lugansk: ENU after V. Dalh Publishers, 368 p.
6. **Evtuh N., Shevchenko G., Ramazanov S., 2005.:** The dynamics of development of social-cultural values of the country on the conditions of globalization: synergetic analysis. Collected research articles «Person spirituality: methodology, theory and practice». – 4th edition, Lugansk: ENU after V. Dalh Publishers, p.93– 97.
7. **Ramazanov S., Pripoten V., 2006.:** Methods and informational technologies for company management on the conditions of instability. Monograph, Lugansk: ENU after V. Dalh Publishers, 216 p.
8. **Ramazanov S., 2008.:** The instruments of the company ecological–economical management. Monograph, Donetsk: "South-East" LLC, 351 p.
9. **Evtuh N., Shevchenko G., Ramazanov S., 2009.:** Synergetic analysis of culture and spirituality development on the conditions of system crisis. Collected research articles «Person spirituality: methodology, theory and practice». – 4th edition, Lugansk: ENU after V. Dalh Publishers, p. 4-14.
10. **Ramazanov S., Nadion G., Kryshtal N., Stepanenko O., Timashova L., 2009.:** Innovational technologies of anticrisis management of economic systems. Monograph, Lugansk-Kiev, ENU after V. Dalh Publishers, 584 p.
11. **Ramazanov S., Aptekar M., 2010.:** The models of ecological–economical management of technogenic manufacturing company on the conditions of instability. Scientific practical journal "Intellectual systems at manufacturing", Izhevsk: ISTU, № 1(15), p. 52-66.
12. **Rabinovich M., Muezinolu M., 2010.:** Non-linear dynamics of brain: emotions and intellectual activity. UFN, vol.180, № 4, p. 371-387.
13. **Panteleev G., Ramazanov S., Krivosheev K. 2010.:** Information system of spatial contrast sensitivity diagnostics in ophthalmology. TEKA Commission of

Motorization and Power Industry in Agriculture, V. XD, p.220-225.
14. **Ramazanov S., Sokolova Y., Tavanuk T. 2010.:** Nonlinear modeling of the electrohydraulic watching drive. TEKA Commission of Motorization and Power Industry in Agriculture, V. XC, p.234-241.
15. **Ramazanov S., Levasheva L., Stepanenko O., Timashova L., Zakrzewski J. 2011.:** Innowacyjna technologie zarządzania antykryzysowego. Monografiya. Warszawa-Lugansk-Kiev, p. 368.
16. **Ramazanov S., Kalinenko N., Rakova L. 2011.:** The use of IT- technologies in student employment using a competence based approach. TEKA Commission of Motorization and Power Industry in Agriculture, V. XI A, p. 207-215.
17. **Ramazanov S. 2011.:** Object + subject driven approach in the management of technological production system under uncertainty. Journal of Volodymyr Dahl East-Ukrainian National University, № 2(156). P.1, p. 251-258.
18. **Ramazanov S. 2011.:** Management model viable and sustainable development in the context of global transformations and crises. Materials of the second round of the Ukrainian scientific-practical conference "Ukraine: East-West - the problem of sustainable development." Lviv, p. 153-156
19. **Ramazanov S., Istoimin L., Dubanov A. 2012.:** Modeling socio-economic systems: Theory and Practice: Monograph. ND - "YNZHEK" p. 522-537.522-537.
20. **Ramazanov S. 2012.:** Integrated innovation model for sustainable development of the world communityJournal of Volodymyr Dahl East-Ukrainian National University, № 2(173), p. 7-12.
21. **Ramazanov S., Burbelo O., Vitlinsky V., others. 2012.:** Risks, security, crisis and sustainable development of the economy: methodology, models, methods of management and decision-making. Monograph. Lugansk, 948 p.

ИННОВАЦИОННЫЕ МОДЕЛИ УПРАВЛЕНИЯ ЖИЗНЕСПОСОБНЫМ И УСТОЙЧИВЫМ РАЗВИТИЕМ ТЕХНОГЕННОГО РЕГИОНА В УСЛОВИЯХ КРИЗИСОВ

Султан Рамазанов

Аннотация. В современных условиях нестабильности, систематических кризисов и глобальных преобразований проблема разработки методов и технологий для анализа, моделирования, прогнозирования и принятия решений для устойчивого развития жизнеспособной социально-экономической системы становится весьма актуальной. В работе предложены методы, модели и технологии управления жизнеспособным, стабильным и безопасным развитием системы в зависимости от типа социо-эколого-экономической и гуманитарной подсистем с использованием интегрированного объектно- субъектно-ориентированного подхода.

Ключевые слова: социо-эколого-экономические системы, объектно-субъектноориентированный подход, управление

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Dynamic model of the competition in regional market of e-commerce enterprises

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Summary. Dynamic model of competition in market of e-commerce enterprises to evaluate conditions of market competitive and appropriate reasoned decision-making during the management of competitiveness level is considered. The model had been tested for to reach equilibrium and steady state. Testing of the model was carried out on the example of the regional market of e-commerce enterprises in Lugansk (Ukraine).

Keywords: dynamic model, steady state, online-shop, competitive environment, competitiveness, e-commerce.

INTRODUCTION

Assessment and management of enterprise competitiveness is a complex process [1, 3, 4, 14, 15, 16]. A person who makes decisions in the management of competitiveness should base their decision on a comprehensive in-depth analysis of the market, which is the competitive struggle, evaluating the competitiveness of the investigated companies and other players in the market, and also available information on industry trends, macroeconomic performance in country, changes in market demand, and so on [2, 3, 13, 20, 21]. E-commerce scope in Ukraine is developing very rapidly. This form of business is already familiar to many businesses and consumers. In the context of research and competitiveness of their enterprises management had been important and needed to analyze the competitive environment of the market, and identify major regularities and prospectives of its functioning and development.

THE OBJECTS OF RESEARCH

Problems of controlling the competitiveness of the enterprises had been researched by such foreign and domestic scientists of economic as: M. Porter, I. Ansoff, A. Dajan, P. Druker, B. Karloff, F. Kotler, M. Meskon, F. Rodgers, R. Yoterman, A. Hoskina, I. Shumpeter, V. S. Andrianov, G. A. Azoev, E. A. Gorbashko, M. I. Gelvanovski, A. P. Gradov, M. G. Dolinskij, V. Zhukovski, U. Kormnov, I. V. Lipsich, A. Seleznev, R. A. Fathutdinov, A. U. Udanov, N. S. Yashin, U. B. Ivanov, N. A. Kisim, A. N. Tishenko, A. E. Voronkova, T. S. Maksimova and others. Nevertheless, nowadays there is not only single approach to the system of controlling the competitiveness of the enterprise, but also a single definition of the essence of competitiveness of enterprise and competition, as a motive force of social and economic development for society [1, 2]. Having analyzed the works of leading economists in this field, it is possible to make a conclusion that each of them is doing an accent on one or another constituent of competitive activity in a greater or less measure, and some of them are defending the systematic approach in controlling the competitiveness, taking into the account all factors [5, 10, 17].

The purpose of this research is to develop a dynamic model of competition in the market of e-commerce enterprises to evaluate competitive conditions of the market and appropriate management make informed decisions on the management of competitiveness level.

THE RESULTS AND THEIR ANALYSIS

For modeling of market besides information about all the players the data on the total volume of goods (services) offered on the market, and which is effective demand of consumers are necessary. E-commerce enterprises, such as online shops can be characterized as trading enterprises, because they offering market certain goods at a certain price. Volume of goods (in terms of money), offering the enterprises at the market in each period t is denoted as $X(t)$. Accordingly, the volume of goods that offer all the other players in the market during the time period t denoted as $Y(t)$. The total volume of demand for goods in the market is denoted as $S(t)$.

A volume of goods offered by the investigated company and all others on the market depends on the levels of competitiveness of the enterprises in the market. Let the competitiveness of the investigated company as $k_x(t)$, and it directly affects on $X(t)$, and also changes in space of time t. Similarly, the average level of competitiveness of other players in the market will determine as $k_y(t)$. Both are integral indexes for multiple component indicators that characterize the enterprise competition. It is logical that the competitiveness of all other firms use average of integrated competitiveness indicators, because the market is as strong and weak competitors. If the research is interesting behavior of any particular competitor, it would be appropriate to discharge its individual strategy by some indicators, such as $k_z(t)$ and $Z(t)$.

As limits of the model we introduce performance limitations of upper and lower limits of the volume of goods offered by the investigated enterprise and all other at the market. The lower boundary of the volume of goods offered on the market by investigated enterprise f_x and other players in the market f_y, define the minimum thresholds of offerings on the market, in which companies can operate with regard to their financial capabilities and common sense. That is the work of companies that offers on the market less than this rate of the volume of goods is unprofitable and uneconomical. Upper limits F_x and F_y characterize that depend level of the investigated company and the market, respectively, if they had, in spite of an increase in market supply, begin to bear financial losses due to lack of competitiveness. So we have a situation where the company receives consumer's orders more than serviceable due to a greater level of dissatisfaction with some consumers and the competitiveness of enterprises falling. Both upper and lower bounds are not constants, and depend on the particular circumstances operation of the investigated enterprise and the market.

In light of the above designations may define "motive force" of change in sales of goods for $X(t)$ and $Y(t)$:

1. Advantages of enterprises that determine the level of competitiveness in the market, respectively, for the investigated company (1) and the other players in the market (2):

$$\left(k_x(t)-k_y(t)\right)*X(t), \quad (1)$$

$$\left(k_y(t)-k_x(t)\right)*Y(t), \quad (2)$$

considering that the growth rate of enterprise competitiveness are proportional of the volume of goods growth in the market.

2. Terms of rational volume of proposals in the market that do not lead to financial losses (3, 4):

$$\left(F_x-X(t)\right)*\left(X(t)-f_x\right), \quad (3)$$

$$\left(F_y-Y(t)\right)*\left(Y(t)-f_y\right). \quad (4)$$

3. The balance of supply and demand in the market (5):

$$\left(S(t)-X(t)-Y(t)\right). \quad (5)$$

Among the indicated parameters the level of competitiveness is the management factor for the investigated company (6) and other enterprises in the market (7) in each period of time:

$$\dot{k}_x(t)=-\alpha_1\dot{X}(t)+\beta_1\dot{Y}(t), \quad (6)$$

$$\dot{k}_y(t)=-\alpha_2\dot{Y}(t)+\beta_2\dot{X}(t), \quad (7)$$

where: α_1, α_2 - the coefficients that reflect the level of response to the volumes of investigated enterprise's goods changing on a market;

β_1, β_2 - the coefficients that reflect the level of response to the volumes of other competitor`s goods changing on a market.

Then the system of equations of the state of e-commerce enterprise`s market would have the following form (8).

In order to bring the system to the relative units divide all the components for $S(t)$ and denoted $x(t)=\frac{X(t)}{S(t)}$, and $y(t)=\frac{Y(t)}{S(t)}$. These attitudes from an economic point of view describing the share of enterprises in the market, which is very necessarily factor in the analysis the state of competitiveness on the market. Thus, the system of equations (8) will be rewritten as (9).

$$\begin{cases} \dot{X}(t) = a_1\left(k_x(t) - k_y(t)\right)X(t) + b_1\left(F_x - X(t)\right)\left(X(t) - f_x\right) + c_1\left(S(t) - X(t) - Y(t)\right), \\ \dot{Y}(t) = a_2\left(k_y(t) - k_x(t)\right)Y(t) + b_2\left(F_y - Y(t)\right)\left(Y(t) - f_y\right) + c_2\left(S(t) - X(t) - Y(t)\right), \\ \dot{k}_x(t) = -\alpha_1\dot{X}(t) + \beta_1\dot{Y}(t), \\ \dot{k}_y(t) = -\alpha_2\dot{Y}(t) + \beta_2\dot{X}(t), \\ X(0) = X_0, Y(0) = Y_0, k_x(0) = k_x^0, k_y(0) = k_y^0, \end{cases} \quad (8)$$

where: a_1, a_2 - the coefficients that reflect the rate of change in demand formed by the balance of the competitiveness levels;

b_1, b_2 - the rate of reaction on the ratio of the volume of supply and the limits of rational proposals;

c_1, c_2 - the coefficients of reaction to balance of supply and demand on the market;

$a_1, a_2, b_1, b_2, c_1, c_2, \alpha_1, \alpha_2, \beta_1, \beta_2 > 0$.

$$\begin{cases} \dot{x}(t) = a_1\left(k_x(t) - k_y(t)\right)x(t) + \overline{b}_1\left(\dfrac{F_x}{S(t)} - x(t)\right)\left(x(t) - \dfrac{f_x}{S(t)}\right) + c_1\left(1 - x(t) - y(t)\right), \\ \dot{y}(t) = a_2\left(k_y(t) - k_x(t)\right)y(t) + \overline{b}_2\left(\dfrac{F_y}{S(t)} - y(t)\right)\left(y(t) - \dfrac{f_y}{S(t)}\right) + c_2\left(1 - x(t) - y(t)\right), \\ \dot{k}_x(t) = -\overline{\alpha}_1\dot{x}(t) + \overline{\beta}_1\dot{y}(t), \dot{k}_y(t) = -\overline{\alpha}_2\dot{y}(t) + \overline{\beta}_2\dot{x}(t), \\ x(0) = x_0 = \dfrac{X_0}{S_0}, y(0) = y_0 = \dfrac{Y_0}{S_0}, k_x(0) = k_x^0, k_y(0) = k_y^0, \overline{b}_1 = b_1S(t), \overline{b}_2 = b_2S(t), \\ \overline{\alpha}_1 = \alpha_1S(t), \overline{\alpha}_2 = \alpha_2S(t), \overline{\beta}_1 = \beta_1S(t), \overline{\beta}_2 = \beta_2S(t). \end{cases} \quad (9)$$

A system of equations (9) is stable, because the second part of the first two equations need to decrease the volume of supply of goods in the market for technical reasons, and the third component of the same equations require a decrease the volume of the supply of goods in the market due to excess supply in the market of consumer demand. So get such balanced economic system where the volume of goods offered now on the market, and its share in the market cannot grow boundlessly, and have fairly reasonable economic limitations.

The next step will conduct the testing of the proposed model for the analysis of state of the competitive the regional e-commerce enterprises market to track the prospects of development of separate enterprises and market segments. As the players model will take the investigated company (Online shop Bomond), the cluster of the leading companies on the market besides the investigated company (Magazon, Dumping, Zakaz), and all other players in the market. The leader`s cluster of the market selecting to a separate strategy is logical from the point of view that the enterprise in the market stand out for a higher level of competitiveness, and averaging their performance on average for the market would not be objective. Define the basic parameters of the model in accordance the information that we know about the market (table 1).

Table 1. Parameters of dynamic model for the regional market

Variable	Value	Justification
1	2	3
S	4500 thousands of UAH	Total monthly volume commodity market in the Luhansk region defined by the statistical and expert ways
F_1	800 thousands of UAH	The upper limit of the supply of goods volume in the market an investigational enterprise, which is defined by experts on the basis of organizational, financial and macroeconomic indicators in consideration of the current capabilities of the enterprise
F_2	2200 thousands of UAH	Similarly, the upper limit of the supply of goods volume on the market in total the market leaders besides the investigated company
F_3	4500 thousands of UAH	Similarly, the upper limit of the supply of goods volume on the market in total all the other enterprises besides the market leaders
f_1	200 thousands of UAH	Lower boundary of the supply of goods volume in the market of investigated enterprise, which is defined by the rationality of the functioning
f_2	600 thousands of UAH	Lower boundary of the supply of goods volume in the market of leaders in the market (besides the investigated companies), which defined by the rationality of the functioning

1	2	3
f_3	1200 thousands of UAH	Lower boundary of the supply of goods volume in the market of all the other enterprises (besides the market leaders), which defined by the rationality of the functioning
$x(0)$	0,07	The share of the supply of goods volume of the investigated company, determined by the expert and the statistical ways
$y(0)$	0,25	The appropriate supply of goods volume of the other three market leaders besides the investigated company
$z(0)$	0,8	The respective share of the proposals of goods volume all other firms in the market
$k_x(0)$	3,409	The integral indicator of competitiveness of the investigated company
$k_y(0)$	3,257	The average level of competitiveness of the market leaders (except for the investigated company)
$k_z(0)$	2,570	The average level of competitiveness of other enterprises in the market (besides the market leaders)

As is seen from (table 1), the amount of parts of supply of goods volumes in the market of online shopping of electronics and computer equipment greater than one, indicating a super saturation of the market and is fully consistent the state of affairs in real life. All the factors that affect the "sensitivity" of model`s behavior (a_1, a_2, a_3, b_1, b_2, b_3, c_1, c_2, c_3, α_1, α_2, α_3, β_1, β_2, $\beta_3 > 0$) were chosen by experiments and the available information about the "aggressive" behavior of various players. Results of the model testing that conduct as graphs of levels of competitiveness and parts of supply of goods volumes had shown in (fig.).

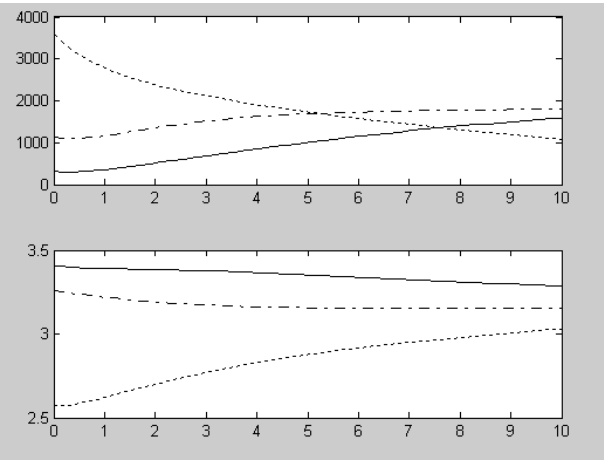

Fig. The results of testing of dynamic model of competition in the regional market

Let us analyze the results of the model and make the appropriate conclusions, that together with the other data will help in making informed management decisions by the person concerned. The first thing that can be noted from these graphs - the model balances the excess of supply in the market, which is reflected in the redistribution of the parts such a way that they are roughly equal in total level of market volume. Thus, given the initial levels of competitiveness of all three "players" of the model, the market leaders and the investigated companies improves its market positions over time, and all other enterprises lose. This comes with a small decrease in levels of competitiveness of the investigated companies and market leaders, and a substantial increase in the other market players. This suggests that at a time when market leaders will begin to "select" the market, it will become a push all other small players in the market to struggle for keep the position. This will be encourage them to an increase the competitiveness through the introduction of competitive advantage. This implementation of model cannot unequivocally say that with time on the market will be observe this situation and that the market leaders just will improve its positions and all the other players lose, or even some of them completely leave the market. This model helps us to understand the market trends while maintaining the current levels of competitiveness and the the coefficients of reaction to the behavior of other players. That is due to the effect of enterprises to the degree of reaction to changes the market, they can change the character of the market developing. This could be achieved through regular monitoring of the market, competitors, and their actions in the market. Using this model, an expert should be carried in each interval of time, which is defined for the management process of the e-commerce enterprise competitiveness.

CONCLUSIONS

As part of this research a dynamic model of competition in the e-commerce enterprises market to evaluate the competitive conditions of the market and to make informed decisions for managing the level of competitiveness has been developed. The developed model verified on the stability, and results have shown that regardless of the initial data and the nature of the conduct competing entities in the market their trajectories with a certain amount of time iterations come to the steady state. Approbation of the model

conducted on the example of the regional market of e-commerce enterprises in Lugansk (Ukraine).

REFERENCES

1. **Azoev G., 1996.:** Competition: analysis, strategy and practice. - Moscow: Centre of Economics and Marketing. – 208 p.
2. **Dyubanov A., 2010.:** Information model of the competitiveness of enterprise controlling / A. Dyubanov // Polish Academy of sciences branch in Lublin. TEKA: Comission of motorization and power industry in agriculture, Volume XD, - Lublin. – p. 122-128.
3. **Dyubanov A.S., 2010.:** Competitiveness of the enterprise / Materials of XV all-Ukrainian scientific-technical conference "The problems of economic cybernetics". - Evpatoria: Kotova O.V.. - 250 p.
4. **Fatkhutdinov R.A., 2005.:** Management of competitiveness of the organization. – 2nd., corr. and add. – Moscow: PH “Ecsmo”. – 544 p.
5. **Hayek F., 1992.:** The road to serfdom. / Translate from English. M Gnedovskiy. - Moscow: Economics. – 176 p.
6. **Ivanov Y.B., Orlov P.A., Ivanova O.Y., 2008.:** Competitive advantage: evaluation, formation and development: (Monograph) / Kharkov: PH "INZHEK". – 352 p.
7. **Korobov Y., 1996.:** Theory and practice of competition. - Saratov. – 96 p.
8. **Kotler F., 2001.:** Marketing management. / Translate from English. - L. Volkova, J. Kapturevsky. - Moscow, St. Petersburg.: Peter. – 752 p.
9. **Krayuhin G., 1995.:** The method of analysis of enterprises in market economy conditions. SPb. - 346 p.
10. **Maksimova T., Shapran E., 2010.:** Approach to diagnostics of marketing complex of industrial enterprise / T. Maksimova, E. Shapran // Polish Academy of sciences branch in Lublin. TEKA: Comission of motorization and power industry in agriculture, Volume XB, - Lublin. – p. 5-11.
11. **Malyarets L.M., 2004.:** Construction of general indicators to assess the competitive advantages / "Kyiv politechnical university”: Science #1. - Kyiv. - p. 432-438.
12. **McConnell C., Brue S., 1995.:** Economics: principles, problems and politika. / In 2 Vols, Translate from English. I. Morozov. - Tallinn: Referto. - 400 p.
13. **Piddubna L.I., 2007.:** Competitive economic systems: theory, mechanism of regulation and management: (Monograph). - Kharkov: PH "INZHEK". – 368 p.
14. **Porter M., 2000.:** Competition. / Translate from English. - Y. Zablotsky. - Moscow: Publishing House "Williams". – 495 p.
15. **Porter M., 1993.:** International competition. / V. Schepinina. - Moscow: International Relations. - 896 p.
16. **Porter M., 1997.:** Competitive strategy: techniques for analyzing industries and activities of competitors. / Translate from English. – A. Oleynik, R. Skilsky. – Kiev, Framework. - 584 p.
17. **Shevchenko L.S., Torkatyuk V.I., Kizim N.A., Shutenko A.L., 2008.:** Competitive firm diagnosis: concept, content, methods: Monograph / Kharkov: PH "INZHEK". – 240 p.
18. **Schumpeter Y., 1982.:** Theory of economic development (the study of entrepreneurship, profits, capital, credit, interest, and the cycle conditions). / Translate from German V. Avtonomova, etc. - Moscow: Progress. – 455 p.
19. **Tishchenko A.N., Ivanov Y.B., Kizim N.A. , 2007.:** Formation of the competitive position of enterprises in a crisis: (Monograph) / Kharkov: PH "INZHEK". – 376 p.
20. **Voronkova A.E., 2004.:** Strategic management competitive potential of the enterprise: diagnosis and organization. Monograph. - 2 nd pub., stereotype. - Lugansk: PH Volodymyr Dahl EUNU. – 320 p.
21. **Voronkova A.E., Ramazanov S.K., Rodionov A.V., 2005.:** Simulation of enterprise competitiveness: eco-organizational aspect: Monograph. - Lugansk: PH Volodymyr Dahl EUNU. – 368 p.

ДИНАМИЧЕСКАЯ МОДЕЛЬ КОНКУРЕНЦИИ НА РЕГИОНАЛЬНОМ РЫНКЕ ПРЕДПРИЯТИЙ ЭЛЕКТРОННОЙ КОММЕРЦИИ

Султан Рамазанов, Леонид Истомин, Алексей Дюбанов

Аннотация. В этом исследовании авторами предложена динамическая модель конкуренции на рынке предприятий электронной коммерции для оценки конкурентного состояния рынка и соответствующего принятия аргументированных решений для управления уровнем конкурентоспособности предприятия. Разработанная модель проверена на устойчивость. Апробация модели выполнена на примере регионального рынка предприятий электронной коммерции в городе Луганск (Украина).

Ключевые слова: динамическая модель, устойчивое состояние, конкурентоспособность, конкурентная среда, электронная коммерция, интернет-магазин.

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Production of copper powder from electrolysis waste products

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Summary. The maximum value of hydrostatic pressure that is corresponding to the maximum value of erosion activity of acoustic field has defined. The technology for comminution of waste powder obtained during manufacturing of copper powder by electrolysis has been developed. The properties of electrolytic copper powder PMS-B treated in the ultrasonic field presented. A comparative analysis of structure and properties of copper powder before and after dispersion has been executed.

Key words: electrolytic copper powder, ultrasonic dispersion, ultrasonic device.

INTRODUCTION

The basic operations of production of the electrolytic copper powder are electrolysis, filtering for electrolyte removal, flushing, stabilisation, flushing, drying, comminution, sieving, mixing, control and packaging of powder. The waste powder with a particle size that is out of standard requirements sent on recasting in the metallurgical department [Kiparisov, Libenson 1980, Shatt 1983, Ryabicheva et al., 2010, Stoyanov, Shenkman 2010].

The remelting operation takes great expenses of electric power and considerable losses of material at all stages of the multioperation process. Therefore, development of recycling technologies of copper wastes which eliminating remelting operation is of great importance [Ryabicheva et al., 1998, Albano-Müller 1999, Ryabicheva, Tsirkin 2004, Kulu et al., 1999, Kiparisov et al., 1993]. Implementation of ultrasonic dispersion ensures high dispersity of powders of any hard materials. The highly efficient method is ultrasonic dispersion with application of increased hydrostatic pressure into the working chamber [Kiparisov, Libenson 1980, Agranat et al., 1987, Nikitin et al., 2011, Letunovskii et al., 1971].

OBJECTS AND PROBLEMS

The dispersion technology of any material depends on acoustic field parameters (frequency of ultrasonic oscillations source, amplitude of emitter displacement), physical and chemical properties of a fluid (density, saturation vapour pressure, chemical composition) and ambient conditions (hydrostatic pressure, temperature).

The hydrostatic pressure and temperature are making the most significant impact on dispersion process and cavitation damage.

The main purpose of this work is determination of hydrostatic pressure into the working chamber for ensuring the maximum erosion activity of acoustic field and investigation of its influence on changing the chemical, physical and technological properties of powder [Agranat et al., 1974].

Hydrostatic pressure in the working chamber of ultrasonic generator USVD-6 corresponding to the maximum value of erosion activity of acoustic field has defined on a basis of the ultrasonic cavitation theory. The erosion activity criterion of a single cavity was implemented for estimating of erosion activity of the acoustic field according to this theory [Agranat et al., 1974]:

$$\chi = \frac{R_{max}^3}{R_{min}^3 \Delta t f}, \qquad (1)$$

where: f - is the frequency of ultrasonic vibrations; Δt - is the collapsing time within a

cavitation pocket is changing of its radius from maximal R_{max} to minimal R_{min}.

The value of χ is always much higher then 1. The impact of acoustic field to substance is the more intensive, the higher value of erosion activity criterion. Simple and quite precise formulas for calculation of the maximum and minimum radius and collapsing time are using in engineering calculations for working fluids with viscosity values no more then 10^7 Pa·s [Agranat et al., 1974]:

$$R_{max} = \frac{0,4}{f}\left(1-\frac{P_0}{P_A}\right)\left(\frac{P_A}{\rho}\right)^{1/2};$$

$$R_{min} = \frac{1,2P_{\Pi}\left(1-\frac{P_0}{P_A}\right)(\rho P_A)^{-1/2}}{\left(2,9\frac{P_0}{P_A}-3,4\frac{P_0^2}{P_A^2}+3\frac{P_{\Pi}}{P_A}+0,6\right)f}; \quad , \quad (2)$$

$$\Delta t = \frac{0,36}{f}\left(1-\frac{P_0}{P_A}\right)\left(2,9\frac{P_0}{P_A}-3,4\frac{P_0^2}{P_A^2}+0,6\right)^{-1/2}.$$

where: P0 - is the hydrostatic pressure; PA = ρcwA - is the acoustic pressure; ρ - is the fluid density; c - is the sound velocity into the fluid; w - is the angular frequency; A - is the generator displacement amplitude.

After substitution expressions (2) in (1) the equation (1) may be written in the following way:

$$\chi = \frac{8,14\left(P_A-P_0\right)^{5/2}\left(0,2P_A+P_0\right)^{7/2}}{P_A^3P_{\Pi}^3}, \quad (3)$$

where: P_{Π} - is the saturation vapour pressure of fluid.

As appears from expression (3), a value of the erosion activity criterion χ for the given fluid defined by values of hydrostatic (P_0) and acoustic (P_A) pressures. The efficiency of ultrasonic impact is gradually increasing while growing of hydrostatic pressure [Agranat et al., 1974]. Supersonic waves are oscillating the cavitation bubbles. The size of bubbles increases and they are blasting with liberation of considerable quantity of energy while growing of hydrostatic pressure [Vasylkiv et al., 2005].

The extremum of function $\chi = \varphi(P_0)$ has found for hydrostatic pressure by calculating of relation P_0 and P_A which attaching a maximum value to criterion χ:

$$\frac{d\chi}{dP_0} = \frac{4,07}{P_A^3P_{\Pi}^3}\left(P_A-P_0\right)^{3/2}\left(0,2P_A+P_0\right)^{5/2}\left(P_A-2P_0\right)=0. \quad (4)$$

The calculations have provided for the following conditions - acoustic field parameters: frequency of ultrasonic oscillations 20 kHz (converter PMS15A-18 with 4 kilowatts output of generator USVD-6, power supply USG 2-10 [Kiparisov, Libenson 1980, Agranat et al., 1974, Letunovskii et al., 1971, Vasylkiv et al., 2005, Matsera et al., 1971]); amplitude of emitter displacement A = 2 μm. Physico-chemical properties of working fluid: saturation vapor pressure P_{Π} = 0.0023 MPa; density ρ = 1000 kg/m3; chemical composition is trisodium phosphate Na3PO4·12H2O with adding of surface-active substances with concentration of 20 kg/m3 and 5 kg/m3, respectively [Keller et al., 1977]. Ambient conditions: temperature of working fluid was 40°C [Hickling 1966]; hydrostatic pressure into the working chamber has been changed from 0.1 to 0.45 MPa. The results of calculations are presented on fig. 1.

The analysis of function $\chi = \varphi(P_0)$ has shown that maximum value of erosion activity criterion χ = 2.748.106 is corresponding to hydrostatic pressure of 0.22 MPa.

The acoustic field parameters presented above, physical and chemical properties of working fluid, temperature and calculated value of hydrostatic pressure equal to 0.22 MPa were used for ultrasonic dispersion of copper powder PMS-B with average particle size of 100 μm.

The working chamber of generator USVD-6 has filled with 2.5 cm3 of copper powder and aqueous solution of trisodium phosphate Na3PO4·12H2O with adding of surface-active substances and tightened. The pressure of 0.22 MPa created into the chamber by working gas. The volumetric ratio of hard phase to the fluid was equal to 1:4 [Agranat et al., 1974]. A necessary temperature into the working chamber has been ensured by means of regulation the water supply through the cooling jacket. The dispersion time was 20 minutes [Matsera et al., 1971]. The powder was unloaded into the container with perforated bottom and blown through by air at overpressure of 0.5 MPa during 5 minutes. The drying of powder has been conducted into the electric furnace with protective atmosphere at the temperature of 110°C.

Chemical, physical and technological properties of copper powder PMS-B GOST 4960-75 with average particle size of100 μm and copper powder dispersed by acoustic field have been defined using standard techniques. The content of copper was defined according to GOST 139381-

78; the oxygen content was fixed by weight loss of a powder portion after calcination into a hydrogen atmosphere; the granulometric composition was determined by GOST 18318-73; the bulk density was defined using GOST 199146-74; the compactibility was established pursuant to GOST 25280-82; the tap density was found by GOST 25279-82; the flowability was established in accordance with GOST 20899-75; the shape of particles has identified using optical microscope MIM-7; the microhardness has measured by microhardness-testing machine PMT-3; the picnometric density was determined according to the method presented in the paper [Kiparisov, Libenson 1980].

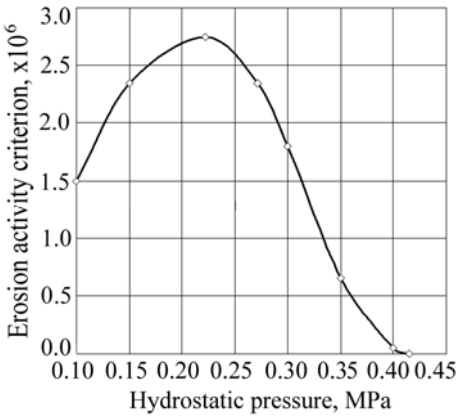


Fig. 1. Dependence of the erosion activity criterion on hydrostatic pressure

The oxygen content in the dispersed powder decreased from 0.10 to 0.08 % and the iron content remained constant (table 1).

Table 1. Chemical composition of copper powder PMS-B, %

Powder	Mass part		
	Cu	Fe	O
	Not less	No more	
Standard	99.5	0.02	0.10
Particle size >100 μm			
Dispersed	99.5	0.02	0.08

Decreasing of the oxygen content appeared due to destruction of non-uniform fragile oxide films that are suspended in the working solution at ultrasonic dispersion of powder. The interaction of powder particles with walls of working chamber is practically absent and powder pollution by extraneous substances, specifically by iron, is almost impossible. The percentage of dispersed powder with particle size less then 100 μm grew on 40 % according to results of comparative analysis (table 2). Internal stresses are appearing into material at ultrasonic impact and leading to diffusion-dislocation mechanism of fracture of plastic materials [Stepanov 2000, Anchev, Skakov 1974].

The fracture mechanism of destruction of plastic samples stipulated by formation of cluster from edge dislocations of one sign near the free surface, grain boundaries and surface of antinode of standing supersonic wave at the expense of dislocation climb from volume [Anchev, Skakov 1974]. The destruction occurs when the dislocation density into cluster reached of critical value. Particles of plastic metals are usually destroying on 3-6 parts during approximately 100 seconds [Stepanov 2000, Anchev, Skakov 1974].

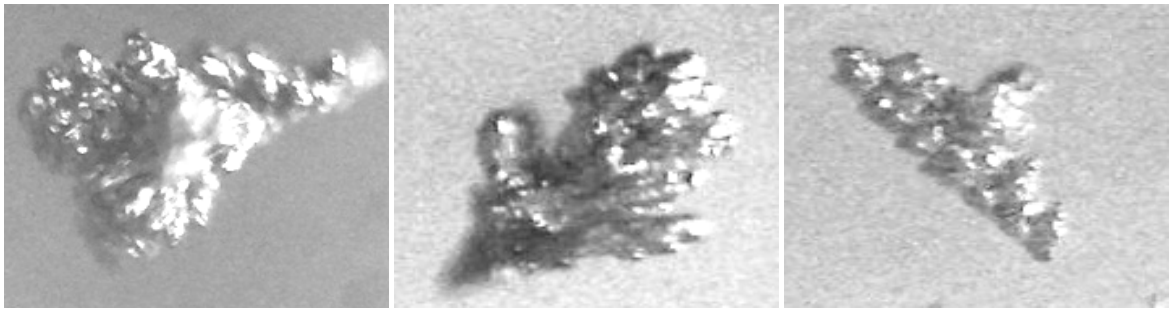
Table 2. The granulometric composition of copper powder PMS-B

Powder	Granulometric composition					
	Content of particles, %, with size, mm					
	>0.224	<0.224	<0.140	<0.100	<0.063	<0.045
Standard	0,1	1	5-15	35-45	25-35	10-25
Particle size >100 μm	-	50-55	30-45	-	-	-
Dispersed	-	15-30	25-30	20-25	10-20	5-10

The dispersed powder demonstrated the highest bulk density, tap density and plasticity (table 3) due to powder parts have a smoothed surface (fig. 2). The pelletization of particles and cleaving of sharpen edges because of mutual friction and collisions of particles have taken place simultaneously with the dispersion process [Agranat et al., 1974].

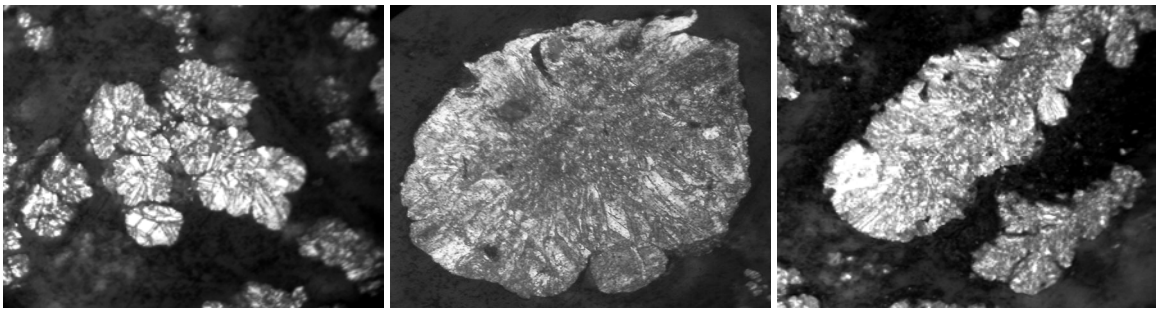
Table 3. Properties of copper powder PMS-B

Powder	Bulk density, g/cm^3	Picnometric density, g/cm^3	Microhardness, kg/mm^2	Tap density, g/cm^3	Flowability, s
Standard	2,5	8,74	84	3,0	40
Particle size >100 μm	2,47	8,77		2,9	37
Dispersed	2,89	8,72	93	3,6	31



a b c

Fig. 2. The shapes of particles of PMS-B copper powder:
a – is the standard powder; b - is the powder with particle size >100 μm; c – is the dispersed powder, ×90



a b c

Fig. 3. The microstructure of copper powder PMS-B:
a – is the standard powder; b - is the powder with particle size >100 μm; c – is the dispersed powder, ×500

Furthermore, the ultrasonic impact leads to curing of surface defects in hard-phase systems due to considerable reduction of diffusive limitations [Tyapunina, Naimi 1999].

A slight decreasing of picnometric density of dispersed powder (table 3) observed due to presence of numerous imperfections and microcracks [Shatt 1983, Agranat et al., 1974].

The microstructure of powder particle before processing consists of small equiaxial grains in the middle part and much bigger grains directed from the centre to periphery (fig. 3, a). Such microstructure is the results of peculiarities of manufacturing process [Kozhanov et al., 1988]. The amount of large not equiaxial grains in a peripheral part of particles (fig. 3, c) was diminished gradually after dispersion. All bared butts between grains are wedging out at ultrasonic impact that leads to structural failure that characterised by development of the main crack at the grain boundaries [Agranat et al., 1974].

The mutual collisions of particles and increasing density of dislocations at the grain boundaries during dispersion leads to increasing of microhardness of particles, as the result of hardening [Matsera et al., 1971, Anchev, Skakov 1974], and takes an influence on declining the compactibility of copper powder (fig. 4).

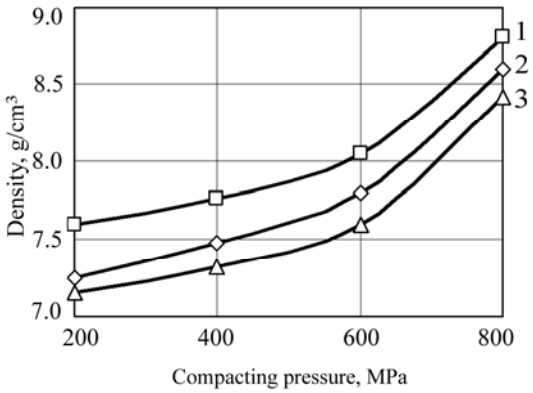


Fig. 4. The dependences of density of copper powder PMS-B from compacting pressure:
1 – is the standard powder;
2 - is the powder with particle size >100 μm;
3 – is the dispersed powder.

The areas of supersaturation of vacansions are appearing at ultrasonic dispersion of crystals near the grain boundaries and free surface. The condensation of redundant vacansions leads to formation of prismatic dislocation loops. The dislocation climb of edge dislocations from volume to crystal surface, grain boundaries and to a surface of antinode of standing wave are taking place at ultrasonic dispersion. The gradual increase in

dislocations density (usually on 1-2 order) near free surface, grain boundaries and to a surface of antinode of standing wave observed as the result of such processes [Tyapunina, Naimi 1999, Polotskii, Bazeliuk 1970].

CONCLUSIONS

The value of hydrostatic pressure in the working chamber equal to 0.22 MPa has determined on a basis of ultrasonic cavitation theories for the following conditions: the ultrasonic oscillations frequency of 20 kHz and amplitude of emitter displacement 2 μm that allows production of dispersed powder.

The production technology of comminution of powder wastes that are appearing during production of copper powder by electrolysis that including powder dispersion on ultrasonic generator USVD-6, unloading from the working chamber, air blowing at overpressure and drying in furnaces into a protective atmosphere has been developed.

The percentage of fractions with particle size less then 100 μm in the dispersed powder increased on 40 % at processing of the electrolytic copper powder PMS-B in ultrasonic field during 20 minutes. The properties of powder produced by the proposed technology are meeting the requirements of standards.

REFERENCES

1. **Kiparisov, S.S., Libenson, G.A., 1980.:** Powder Metallurgy, Metallurgy, Moscow.
2. **Shatt, W., 1983.:** Powder Metallurgy. Sintered and Composite Materials, Metallurgy, Moscow.
3. **Ryabicheva, L., Tsirkin, A., Usatyuk D., 2010.:** "Warm Deforming of Copper Porous Powder Billets", TEKA Kom. Mot. i Energ. Roln. – OL PAN, 10B, pp. 134-140.
4. **Stoyanov A., Shenkman G., 2010.:** "Manufacturing Technology of Complicated Shape Parts of Sintered Metal Powders", TEKA Kom. Mot. i Energ. Roln. – OL PAN, 10B, pp. 220-226.
5. **Ryabicheva, L.A., Nikitin, Y.N., Tsirkin, A.T., Markov, V.L., 2004.:** "The Production Technology of Copper Powder from Wastes of Current Conductors", Metalloobrabotka, No. 3, pp. 40-42.
6. **Albano-Müller, L., 1999.:** "Powder metallurgy in Europe: Challenges For Future Growth (PM98, Granada)", Powder Metallurgy and Metal Ceramics, Vol. 38, Issue 1-2, pp. 108-112.
7. **Ryabicheva, L.A., Tsirkin, A.T., 2004.:** The Production Technologies of Materials From Industrial Wastes, Volodymyr Dahl East-Ukrainian National University, Lugansk.
8. **Kulu, P.A., Arensburger, D.S., Tymanok, A.P., 1999.:** "Secondary Metals as Raw Materials for Powder Metallurgy", Powder Metallurgy and Metal Ceramics, Vol. 38, Issue 1-2, pp. 1-6.
9. **Kiparisov, S.S., Padalko, O.V., Levinskii, Yu.V., Ésikman, V.L., 1993.:** "Resource-Saving and Nature-Preserving Potential of Powder Materials and Technology; Use in the Area of Processing of Secondary Resources", Powder Metallurgy and Metal Ceramics, Vol. 32, Issue 6, pp. 465-467.
10. **Agranat, B.A., Dubovin, M.N., Havskii, N.N., 1987.:** The Bases of Physics and Techniques of Ultrasound, Metallurgy, Moscow.
11. **Nikitin, Yu.N., Shevchenko, A.V., Grebenik, L.A., Dobridneva, A.I., 2011.:** "Technological Properties of Electrolytic Copper Powder Processed in Ultrasonic Field", Volodymyr Dahl East Ukrainian National University, Lugansk, pp. 217-222.
12. **Agranat, B.A., Bashkirov, V.I., Kitajgorodskij, Y.I., Havskii, N.N., 1974.:** The Ultrasonic Technology, Metallurgy, Moscow.
13. **Letunovskii, V.V., Androsov, V.N., Petrovskii, É.A., 1971.:** "Preparation of Mixtures of Tungsten Carbide and Cobalt by Means of Ultrasonic Vibrations", Powder Metallurgy and Metal Ceramics, Vol. 10, Issue 3, pp. 244-246.
14. **Vasylkiv, O.O., Sakka, Y., Skorokhod, V.V., 2005.:** "Features of Preparing Nano-Size Powders of Tetragonal Zirconium Dioxide Stabilized with Yttrium", Powder Metallurgy and Metal Ceramics, Vol. 44, Issue 5-6, pp. 228-239.
15. **Matsera, V.E., Pugin, V.S., Dobrovol'skii, A.G., Nikitin, Yu.I., Pogorelyi, B.V., Strashinskaya, L.V., Gornostaev V.F., 1971.:** "Ultrasonic Comminution of Refractory Compound Powders", Powder Metallurgy and Metal Ceramics, Vol. 10, Issue 12, pp. 948-952.
16. **Keller, O.K., Kratish, G.S., Lubnitskij, G.D., 1977.:** The Ultrasonic Cleaning, Mashinostroenie, Leningrad.
17. **Hickling, Robert, 1966.:** "Some Physical Effects of Cavity Collapse in Fluids", Transaction of the ASME, Journal of Basic Engineering, Vol. 88, No. 1, pp. 229-235.
18. **Stepanov, Y.N., 2000.:** "The Fracture Mechanism of Brittle and Plastic Samples at Ultrasonic Impact", Journal of Physics and Chemistry of Materials' Processing, No. 5, pp. 96–100.
19. **Anchev, V.H., Skakov, Y.A., 1974.:** "The Influence of Ultrasound on Microhardness and Dislocation Structure of Copper", Journal Izvestiya Vuzov, Ferrous Metallurgy, No. 11, pp. 132–139.
20. **Tyapunina, N.A., Naimi E.K., 1999.:** "The Influence of Ultrasound on Crystals with Defects", Moscow State University, Moscow.
21. **Kozhanov, V.N., Smirnov, B.N., Filosofova, A.B., Putilina, O.V., 1988.:** "Variation of the Surface Morphology of a Copper Electrodeposit During Its Growth. I. Formation of Dendritic Structure", Powder Metallurgy and Metal Ceramics, Vol. 27, Issue 7, pp. 512-517.
22. **Polotskii, I.G., Bazeliuk, G.Ya., 1970.:** "The Influence of Ultrasound on Misorientation of Fragments into the Volume of Copper Single Crystals", Journal of Metallophysics, No. 29, p. 99.

ПОЛУЧЕНИЕ МЕДНОГО ПОРОШКА ИЗ ОТХОДОВ ЭЛЕКТРОЛИТИЧЕСКОГО ПРОИЗВОДСТВА

Людмила Рябичева, Юрий Никитин, Ирина Белянская

Аннотация. Определена максимальная величина гидростатического давления, которому соответствует максимальная величина эрозионной активности звукового поля. Разработана технология измельчения отходов в виде отсеянного порошка, которые образуются при производстве медного порошка электролизом. Представлены свойства медного электролитического порошка марки ПМС-В, обработанного в ультразвуковом поле. Выполнен сравнительный анализ порошка марки ПМС-В до и после диспергирования.

Ключевые слова: электролитический медный порошок, ультразвуковое диспергирование, ультразвуковая установка.

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Informative and communicative technologies as a factor of increase industrial efficiency production: regional aspect

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Summary. In the article the factor of increase industrial production efficiency is explored in a region – the informative and communicative technologies. Meaningfulness and components of the informative and communicative technologies are explored, their definition are given. Influences of the informative and communicative technologies are set on efficiency of industrial production in a region.
Keywords: the technologies, the industrial production, a region , the informative and communicative technologies.

INTRODUCTION

The tendencies of developing economic processes are lead, that information pierces practically all spheres of economy. In this connection the question about informative co-operation consideration of economic subjects will not be full without researching information technologies. Their application directly affects on curvature of the informative field and on distribution and information transfer in spacious, and in time. In modern informative society unauthorized penetration to the informative resources is one of the most widespread crimes. Information is getting to all directions of state activity, society, citizen. Consequently, the government and separate region are spare considerable attention to providing of the proper informative systems protection. In society all anymore technologies that lie in the basis of many administrative processes, social, informative and communication are get more valuable. Similar technologies are acting considerable part in the unique systems of energy supply, in the systems of motion by a transport air and railway. At the planning of informative and communication technologies it is necessary to take into account a risk factor and make efforts for its minimization or provide safety ICT.

OBJECTS AND PROBLEMS

In domestic and foreign scientific economic literature there are many works, devoted to researching of information problems, informative resources, informative and communication technologies, their role in economic processes Abdeev R.F. [1], Gritsenko V.I. [3], Minuhin S.V. [6], Panshin B.N. [8], Poppel G. B. [9], Prihotniy D.G. [10], Vasilyuk V.Ya. Klimchuk S.O. [12], Voices O.V., Ohrimenko S.A., Horoshilov A.V., Martin U.Dg. [13], Yasin E.G. [14], Zavgorodniy V.I. [15]. Ivahnenkov S.V. [17]. However for the reason that in their illumination are retrace a lot of indefiniteness and lacks of coordination that extent stipulates actuality of their detailed research, these questions are enough new and they are provided with the great dynamics of development.

Research the question efficiency increasing of public production is the purpose of the article through technologies information, informative and communication as one of the main factors of influence on economy region development.

RESULTS AND DISCUSSION

In present condition the great part in economic development of society and functioning of enterprises is acted by informative and

communication technologies (ICT). The appearance of new information technologies, based on a wide introduction of the computing engineering facilities, the connection, the systems of telecommunications, information become the attribute of the state permanent providing activity and necessary, the legal entities, the public associations. Informative and communicative technologies have already become the part of everyday life in state establishments. As a result, the normal life of society is depend on the rightness of functioning informative and communicative technologies. Moreover, they become the most important object for the attack from the hostile side for society (or the separate state). An informative sphere becomes not only one of the most important spheres of international cooperation, but also is the object of rivalry.

The most developed countries translated management into creative information technologies of a new higher level in the last decade. They include a new informative cycle such as work of information, its transmission, processing of using for object transformation, achievement of new higher aims [14]. The subsystem of information management is intended to promote a level and authority of the automated systems of region management [8].

The informative influence on the state, society, citizen now is more effective political knife, economic and even military. Countries with more developed informative infrastructure is setting technological standards and giving the resources to the buyers, it determine the forming terms and activity of informative structures in other countries, substantially affect on developing of their informative spheres [12].

Among the basic tendencies of the modern information technologies development it is possible to select such as creation of the unique incorporated informative environment; possibilities of the outsourcings access of information; introduction of intellectual creative facilities of information treatment; convergence and integration of the dedicated informative systems [17].

Consideration of informative and communicative technologies determination should be noted that information technologies and telecommunications in the common understanding - it is simple information transfer, inalienable one from other.

Row of scientists are understanding in scientific labours under information technology all «aggregate of forms, methods, facilities of informative automation activity of in different spheres and above all things at a region management» [2,11]. In this time they are limited only by the questions of automation management, planning and projection.

In Y. Macgovan researches is determines information technologies as «calculable possibilities increased on electronic data-bases and are bound together by the front-rank telecommunication systems» [11]. Determinations of informative and communicative technologies in other editions are pointed «as the using of the computing engineering and communication networks for creation, collection, transmission, saving and treatment of information for all public life spheres » [9]. It is necessary to mark that the denoted authors have advantages because they extended notion ICT and delivered it to all spheres of public life. Examining scientific labours of question researchers, it is possible to assert ,that they [14] entered notion ICT and select base technologies such as technology of microelectronic components, technology of providing; technology of software; technology of communications. But, analyzing the examiner list of technologies, it is necessary to add what determination is seen to us enough narrow and limited, and interpretation is limited in the dual understanding: in historically ICT is examined as the phenomenon characteristic only for the present level of human civilization development; the ICT is founded only on technique achievements and not taken into account its subsequent possible development in time, ICT is conjuncture phenomenon.

On these reasons they do not expose all essence of this economic category, it is necessary for mostly complete idea of modern economic development questions. The ICT determination as the technologies is oriented for the receipt, treatment and distribution (transmission) of information, [4] in our understanding it is more adequate. Analyzing the certain part of scientific sources, it is possible to do a conclusion: in whole informative and communicative technologies could be defined as an aggregate of methods and principles, that lie in the basis of collection, treatment, transmission, saving and presentation of information in all spheres of human activity.

In the above-mentioned determination the ideal information is materialized in different second forms - this information. It is needed to mark that in imitation of the transmission not only the transmission in spacious is meant, but also in time, in force of that information is indissoluble related to memory, and a data (memory) carrier moves in

time. Informative and communicative technologies are acting double part.

1. They are accountable for the transmission between people of the operative information which is necessary for realization by them current activity.
2. The task of information transfer in time is fixed on ICT, it is accountable for the transmission of form information which is called knowledge.

In accordance to this double function it is turning up the double function of co-operation ICT on human society and on an economy in whole. Doubling is become apparent in. At first, it is co-operation on the material factors of public production, but not straight, but through a man, through the personal factor of production forces.

Secondly, it is an influence on the speed and volumes of information, which is passing between people in the process of co-operations, including economics.

The ICT, in turn, is uniting two oppositions: accumulation (saving) of information; distribution (transmission**)** of information. These oppositions are simultaneously found in indissoluble unity, as saving of information – its transmission in time and other information, before it would be anywhere passed, it must be well-kept on transmitters, but at the transmission in spacious it is also passed in time. The ICT side, which is related to the information transfer in spacious, is predominate in the fundamental mass of the relations between people, accordingly, it would be having substantial advantages at economic co-operation of subject management. The ICT is showing the economic relations: in the information transfers between the subjects of these relations, in smoothing or creation the economic informative field.

It is possible to add that the information which is circulates between the subjects of these relations, is also operative information. The economic intensification of co-operation development will be providing that ICT side, which is accountable for the information transfer in spacious, improvement of its methods, modes. The influencing of this side ICT will be expose advantages before all in the distributing spheres, exchange and consumption, touching directly production.

The other ICT side is influence on the accumulation (by saving) of information and on production forces of society. The development of ICT side affects on knowledge accumulation speed. Such aspect of the ICT is touching exactly the basis of material production – direct production; it is affects on production forces development of society. For this reason, there is the necessity of such factor revision that will be characterizing the public development as a degree of development ICT.

In the development of production forces and economic relations, where is a question of such consideration factor which is used in characterizing the public development as a degree of development ICT, there is the necessity of role and value ICT revision. The factor, which is not, simply characterizes the level of production forces in society, but also pierces all structure of public development; it is the degree of ICT development. The ICT come forward to one of the basic factors of society development so far as they are responsible for people co-operation [5,7].

Accumulation of knowledge and development of production society forces are found in certain dependence in public life, which is based on the methods of collection, treatment, saving and information transfer, from one individual to other.

Informative and communicative technologies lies in the basis of development production forces and simultaneously the production forces are motive power of ICT development, but the last are more primary for the material side of production forces. On that score it is possible to say that ICT – is the deep factor of developing forces production.

It is necessary to mark: that ICT is affect on the economic relations, their intensity, because they remove co-operation between people. Simultaneously it is a general category, because it pierces not only the aggregate of material-economic relations but also other public relations too. It is possible to assert that ICT come forward the fundamental basis of society life, affecting on production forces, and on development of economic relations and also on other spheres of public life, getting the active influencing reverse.

It is obviously, that ICT exactly characterize the human society on all stages of its development, but only, on a modern stage is becoming the basis of all society and acquire in comparison with the past periods of principle a new high-quality level. Also it is possible to speak about informative and communicative development of economy approaches, without casting informative and civilization approach side [18].

Examining their influence on accumulation of structural information, as a result, on the production of society forces, on the intensification of production relations, in which the ICT is determined. It is possible to look after informative

and communicative approach. Expedient the selection of two influence vectors is seen on a public ICT development in accordance to the above-mentioned duality of last – it is a structural vector, that describes influencing of that ICT side and it accountable the accumulation of structural information (knowledge) in society and operative vector, that describes influencing of the ICT side, which affects on circulation of operative information in society.

The characteristic feature of structural influencing ICT vector is a possibility to select such tendency: the ICT transitions which are accountable for accumulation (saving) of a new high-quality level. In subsequent it is accompanied by transition of production forces on a new high-quality level. It is necessary to add, that influence on the ICT structural vector is observe above all things on the material side of production forces, the influencing is not directly - the mediated through a human. In the field of economic co-operation subjects and above all things in the sphere of circulating the influencing of operative ICT vector is retracing.

On an intensification of co-operation the high-quality bound in technology of the ICT operative vector is substantially influenced. It is possible to make such example: the appearance of written language opened the possibility of territorial widespread states organization and appearance of the telephone and the radio affected on a forming of monopolies. Development of multinational corporations, large holding and also internationalization of economic life promoted the appearance and development of electronic communications. Exploring the scientific labours through this question ,it is necessary to mark, that telecommunications definitely predetermine efficiency of many other economy sectors , for example, banking, transportations a passenger and freight. Consequently, today there is a transformation of information in a commodity and international informative market creation [9].

Last years two high-quality changes of ICT vectors are coming, they are structural and operative. Accumulation of structural information is walked up to the border of high-quality changes from one side, of society cognition and from the side of nature cognition. In society it is the reason of substantial changes, consequently it is possible to establish transition on a new level of civilization – informative and computer.

Becoming of informative society is the characteristic sign of transition society for the new social-economic structure, changes, that takes place in the social life, advancement to the successive management. All it causes difficulty during the economic analysis processes that happen.

The supervision after informative and communicative development technologies and conducting of the ICT development analysis is lying in the basis of long-term society development prognostication. In accordance to the conception of cyclic dynamics and the proper technological modes is becoming the innovation basic factor of economy growing.

Forecasting the development of perspective mode, it is possible to apply the proper actions from optimum development of economy.

In society there could be large technological changes at the development of ICT proper, consequently, the forecasting development of those or other ICT; it is possible to foresee the possible getting up in economy. Has not a necessity to examine, what technology, getting up will be thanks to. It is enough to predict the possible ICT development and after their development the structural changes in economy will be passing.

CONCLUSIONS

Analyzing the ICT influence on the development of society and economic relations, it is possible to select two vectors: the structural and operative influencing. Before abrupt intensification of accumulation structural information processes in society and changes of production forces which are conduce to the changing of the technically-economic modes, they brought over the high-quality changes of the first. Before intensification of economic agent's co-operation, the high-quality changes of the second are brought over.

The equipment by information and communication technologies is strike root and perfected on every agricultural subject, as such equipment allows to save charges administrative, considerably promotes efficiency of project-designer works, provides the effective planning, promoting potential of production. At the same time the introduction of the informative systems through informative and communicative technologies, as a rule, is bring to synergic effect in a successful activity of organizations ,thanks to the increasing management efficiency which caused by conference of using the information technologies.

REFERENCES

1. **Abdeev R.F., 2001.:** Philosophy of informative civilization. Progress, - 254 p.
2. **Boguta A., 2011.:** Zastosowanie monitoringu ip w systemie nadzoru budynkuLublin University of Technology. TEKA Commission of Motorization and Power Industry in Agriculture, Tom XIC, p. 9-17.
3. **Gritsenko V.I., 2008.:** Information technology: questions of development and application. Kiev, 272 p.
4. **Marcin B., Andrzej S. 2011.:** Wykorzystanie srodowiska labview do budowy systemu nadzoru kontrolujacego parametry klimatyczne i techniczne w pomieszczeniach w gospodarstwie rolnym TEKA Commission of Motorization and Power Industry in Agriculture, Tom XIC, p.18-28.
5. **Martin U.Dg. 2010.:** Informative society. Problems and illusions. INION, 423 p.
6. **Minuhin S.V. 2010.:** Forming of the informative providing of the system of management business by the processes of enterprise. Aktualni problemi ekonomiki. № 10. p.70-178.
7. **Nawrocki W. 2008.:** Komputerowe systemy pomiarowe, wkil, Warszaw, 11, p.245-267.
8. **Panshin B.N., 2008.:** New information technology in the organizational systems of management // Sensor-based systems and machines, №1. p.7-13.
9. **Poppel, Goldstayn B. 2000.:** Informatsionnaya technology is millionth incomes. Economy, 238 p.
10. **Prihotniy D.G., 2002.:** Socio-economic nature of informative product and informative resource. Finances and statistics, 174 p.
11. **Macgovan Y. 1990.:** Telesommunications and global competitiveness / Vital speeches of the day. – N.Y., Vol. 57. № 1-2.
12. **Vasilyuk V.Ya. Klimchuk S.O., 2008.:** Informatsiyna bezpeka dergavi. Course of lektsiy. Skif, 136 p.
13. **Voices O.V. , Ohrimenko S.A. , Horoshilov A.V., Tihomirova V.P., 1996.:** :Introduction to informative business: train aid. Finances and statistics, 240 p.
14. **Yasin E.G. 2000.:** Economic information. Statistics, 80 p.
15. **Zavgorodniy V.I. 2001.:** Complex defence of information in the computer systems. Logos, 201 p.
16. **Bicac A.O., 2008.:** Bases of economic informatics. Minsk, 184 p.
17. **Ivahnenkov S.V., 2011.:** Informatsiyni tehnologiї in organizatsiї: navchalniy posibnik. Kiev, 349 p.
18. **Marcin B., Andrzej S. 2011.:** Wykorzystanie srodowiska labview do budowy systemu nadzoru kontrolujacego parametry klimatyczne i techniczne w pomieszczeniach w gospodarstwie rolnym TEKA Commission of Motorization and Power Industry in Agriculture, Tom XIC, p.18-28.

ИНФОРМАЦИОННО-КОММУНИКАЦИОННЫЕ ТЕХНОЛОГИИ КАК ФАКТОР ПОВЫШЕНИЯ ЭФФЕКТИВНОСТИ ПРОМЫШЛЕННОГО ПРОИЗВОДСТВА: РЕГИОНАЛЬНЫЙ АСПЕКТ

Ксения Серебряк

Аннотация. В статье исследован фактор повышения эффективности промышленного производства в регионе – информационно-коммуникационные технологии. Исследована значимость и компоненты информационно-коммуникационных технологий, предоставлены их дефиниции. Установлено влияния информационно-коммуникационных технологий на эффективность промышленного производства в регионе.

Ключевые слова: информационно-коммуникационные технологии, промышленное производство, регион.

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The results of the experimental research of the heat transfer coefficient during steam condensation in the tubes of the diesel radiator sections

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Summary. The schemes of the stand equipment, testing methods, experiment planning as well as the main calculations of dependence and the obtained results of the tests of serial sections of the radiator of the diesel locomotive in the mode of steam condensers have been presented in this article.

Key words. Experiment, stand equipment, radiator section, heat transfer coefficient, heat transfer ratio.

INTRODUCTION

Many years of international experience in the designing of ICE proved the advantage of using the phase transitions of coolant in the cooling system (CS) of a power plant [Seliverstov, 1973]. The usage of evaporation and condensation of cooling liquid in all the circuits can reduce the power consumption of the coolant flow and convert a part of the steam heat energy into the work in steam turbines, increasing the overall efficiency of the marine ICE by 5 ... 10% [Radchenko, Stahel, Sirota, Konovalov, 2009; Sirota, Bes, Radchenko, Konovalov, 2009].

Earlier the level of technical facilities did not allow to create similar CS of the small size, and phase transitions of the coolant were used only in the CS of the marine ICE. However, modern technologies have solved this problem, and the world's leading manufacturers got interested in this field. For example, BMW has created a car that has an extra coolant circuit with phase transitions [Sintezgaz.org.ua, 2011].

The Department of the railway transport of the East Ukrainian National Dahl University has developed an energy-saving CS of the diesel locomotive engine with coolant phase transitions [Mohyla, Sklifus, 2010]. The proposed cooling system allows to maintain the constant optimum temperatures of the cooling objects (oil diesel 70 ... 86 ° C, charge air 60 ... 75 ° C, water in the diesel jacket 80 ... 105 ° C [Filonov, Gibalov, Nikitin, 1996; Volodin, 1978]) at ambient temperature ± 40 ° C and at any mode of the diesel engine. The application of the phase transition can significantly reduce the average power consumption of the coolant flow, to increase the maximum of heat dissipating ability of the radiator sections [Mohyla, Sklifus, 2011], to accumulate heat for short circle of idle diesel locomotive with the diesel switched off during the cold season of the year with the possibility of further starting a diesel without pre-heating (minimum: 1 hour at - 30°C and 3 hours at 0°C) [Mohyla, Sklifus, 2012]. This significantly reduces the average fuel consumption of the diesel locomotive.

THE MAIN OBJECTIVE OF THE ARTICLE

To design the SO of the locomotive diesel it is necessary to have a series of calculations of the heat balances [Bugaevsky S. B., 2006]. One of the key elements of the CS is a radiator section.

To make a heat calculation of a radiator section operating in the condenser mode, one must have the equations describing this process. At the moment there are no such equations, and that's why it is necessary to conduct experimental studies of the natural samples of locomotive radiator section, the results of which are presented in this work.

RESEARCH ANALYSIS

When calculating the CS using phase transitions of the coolant, one can use a number of existing formulas that are rather accurate in describing the processes of heat transfer at boiling [Zhukauskas A. A., 1982]. These formulas are widely used for heat exchangers calculation in various fields of industry. They are accurate and verified by numerous investigations and years of experience.

To calculate the heat transfer ratio in the diesel locomotive radiator sections, it is very convenient to use the formula [Kamaev, Apanovich, Kamaev, 1981], which binds the processes inside and outside the tubes irrespective of their physical characteristics:

$$K_t = \left[\left(\frac{1}{\alpha_1} + \frac{\partial_w}{\lambda_w} + \Sigma r_1 \right) \cdot \frac{F_2}{F_1} + \frac{1}{\alpha_2} + \Sigma r_2 \right]^{-1}; \quad (1)$$

where: α – the heat transfer ratio, W / (m^2K) - the wall thickness of the tube, m;

λ_w – thermal conductivity of the wall material, W / (mK);

F - heat exchange surface area, m^2;

Σr - coefficient of thermal resistance of pollution, (m^2K) / W;

indices 1,2 point out the process inside and outside of the tube respectively (1- a hot coolant, 2 - cooling air).

There are many scientific papers devoted to the investigation of coefficient α_2. For the chosen type of the serial radiator section (BC-0,5) α_2 can be calculated with a high accuracy according to the formulas associated with that type of sections [Kulikov, 1988].

It should be noted that the shape of the cross section pipe of the radiator is not circular. The external dimensions of the pipe are 19.5 x 2.2 mm and the wall thickness is 0.55 mm [Kulikov, 1988]. When having these parameters, the pipe can be called "flat." Such form of the pipe is optimal, and provides the best ratio of the intensity of heat transfer to the air and aerodynamic resistance.

Heat transfer coefficient α_1 for single-phase water flow to the walls of pipes has been much investigated and can be calculated according to the known criteria dependences [Kulikov, 1988]. However, at present there are no any calculated dependences for determining α_1 coefficient for steam condensation in the "flat" tube. To plan the experiment and analyze the obtained data we used the values of α_1 obtained from the known calculated dependences, determining heat transfer coefficient during steam condensation inside a circular pipe of the equivalent diameter [Isachenko, 1977; Wong, 1979].

PROBLEM SOLUTION

To improve the accuracy of the research results and determine Σr, some thermal engineering tests of the chosen water-air section of the BC-0,5 on the universal thermotechnical bench [Kulikov, 1988] by using a method of PJSC "Luganskteplovoz" have been carried out.

The external and internal surfaces of the radiator section were carefully prepared after cleaning by means of the water and air flow, mechanical and chemical treatments.

The conducted tests of the chosen radiator section in the standard mode resulted in the experimental heat transfer ratio having coincided with the theoretical discrepancy in ± 0,4% for all the modes. It allows us to make the conclusion about the high purity of the external and internal surfaces of the presented section of the radiator, and make Σr equal to the zero.

Further the tests were carried out in the radiator section at the steam condensation mode. The experiments were performed on a modified bench for thermal radiator's testing (fig. 1).

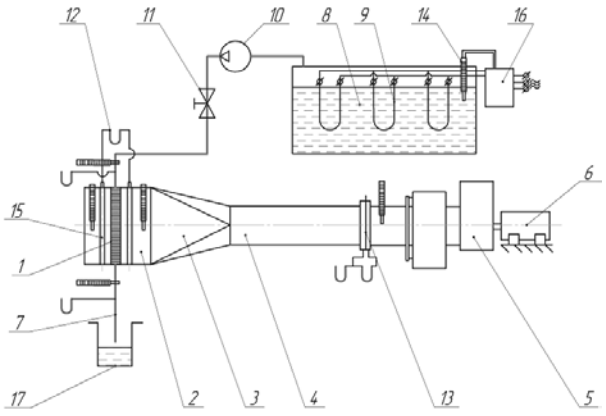

Fig. 1. The scheme of the stand for thermal testing of the radiator sections during condensation of the coolant: 1 – radiator; 2 – branch pipe; 3 – adapter; 4 - air duct; 5 - centrifugal fan; 6 – engine; 7 - condensate duct; 8 – heating tank; 9 – TEH; 10 – compressor; 11 – valve; 12 – micromanometer; 13 - segment diaphragm; 14 – thermometer; 15 - total pressure pipe; 16 - remote control; 17 – condensate measuring unit.

The stand works as follows: a liquid coolant in the heating tank 8 boils under the influence of the tubular electric heaters (TEH) 9 and the obtained steam is fed through the heat-insulated pipe through valve 11 to radiator 1, where it is condensed and transfers the heat to the cooling air. Engine 5 drives a centrifugal pump 6, which sucks the cooling air from the room into pipe 4 through branch pipe 2 with the given consumption, which is controlled by the segment diaphragm 13. The condensate is removed through line 7 into measuring unit 17. The steam is fed by gravity flow at normal pressure, which allows using an open circuit connected to the atmosphere, and prevents the formation of the high redundant pressure, which causes a change in the boiling temperature and condensation. Compressor 10 is an auxiliary device. Micromanometer 12 takes the readings of the total pressure tubes 15 and allows to calculate the aerodynamic resistance. The heat transfer ratio is determined according to the transferred heat, which is calculated by the readings of thermometer 14 and is checked by the obtained mass of condensate in measuring unit 17.

In the experiment the values of three factors ranged as follows: the working length of the pipes z (i.e. the working surface of the heat transfer), the linear steam inlet velocity ω_n and mass air velocity when entering the radiator u_2 (directly influences on the temperature of the wall [Vinogradov S. N., Tarantsev K. V., Vinogradov O. S., 2001]). The other factors (radiator pipes shape, physical and chemical properties of the coolant, the pressure in the tank and the radiator, air inlet temperature in the radiator, etc.) were constant.

The results of the experimental studies have shown that the heat transfer coefficient during condensation α_{1_ex} inside the "flat" pipe of the diesel radiator section is slightly higher than the theoretical value of the coefficient α_{1_t} for condensation inside a circular pipe of the equivalent diameter [Isachenko V. P, 1975]. In this case, the values of the local heat transfer coefficients at the beginning of the pipe α_{1_0} are almost the same for the pipes of various sections. The decrease α_{1_ex} and α_{1_t} regarding α_{1_0} with the enlargement of the pipe is shown in figure 2:

This difference can be easily explained by the physics of the process. When the steam is condensed in the pipe of a circular section, the created condensate makes a liquid film, the thickness of which increases with the length of the pipe. This film of condensate creates additional thermal resistance (∂_c / λ_c) [Miheev, Miheeva, 1977; Hartmann, 1961], which deteriorates the process of heat transfer, hence α_1 is significantly reduced with the enlargement of the pipe.

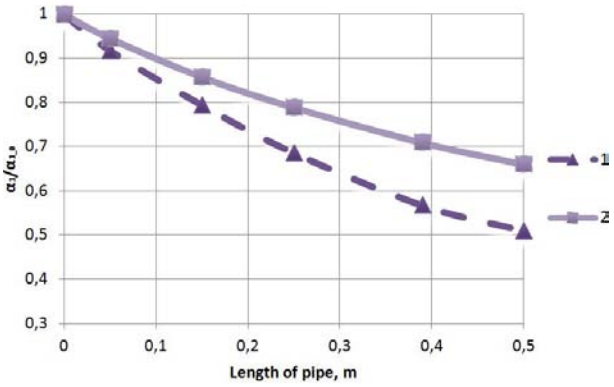

Fig. 2. Reduction of heat transfer coefficient with the enlargement of the pipe: 1 - for a circular pipe; 2 – for a pipe of the "flat" section.

When the steam is condensed inside the pipe of the "flat" section (especially of a small equivalent diameter) the created condensate film moves to the both edges of the cross section under the action of surface tension, freeing up the main flat area of the internal surface of the "flat" pipe [Gerasimov Y.I., Gejderih V.A., 1980].

The results of experimental studies have shown the differences between α_{1_ex} and α_{1_t}, which increases when the Reynolds number (i.e. steam consumption) is increased (fig. 3).

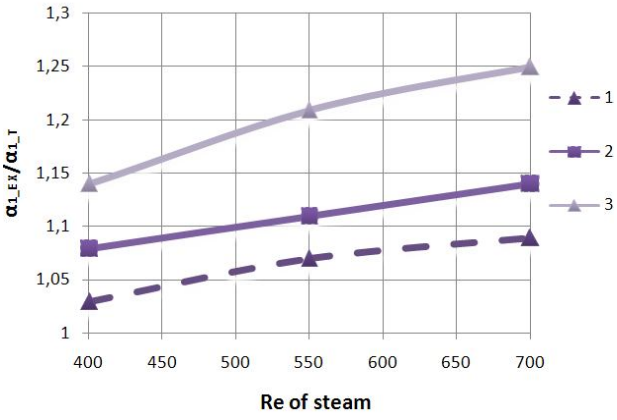

Fig. 3. The increase of average length α_{1_ex} regarding average length α_{1_t} with the increase of the Reynolds number: 1 - for the pipe length L = 0,235 m; 2 - L=0,385 m; 3 - L=0,535 m.

Since the Reynolds number is directly proportional to the speed of the steam, this increase α_{1_ex} can be explained by the displacement of the condensate to the edge of the "flat" section of the pipe under the pressure of the steam flow supplied to the pipe.

CONCLUSIONS

Experimental study of the processes of heat transfer during steam condensation inside the pipes of the diesel radiator sections proved that there is a circulation of the coolant in the cooling system of locomotive diesel without using the pumping equipment (i.e. gravity flow) when the air temperature entering the radiator t_{2_en} is up to 18°C. At $t_{2\_en} > 18$°C it is necessary to apply some energy to the compressor supplying the coolant to the radiator sections.

The advantage of the heat transfer coefficient during steam condensation in the pipes of the "flat" sections over the heat transfer coefficient during steam condensation in the circular pipes has been experimentally confirmed. The difference increases with the length of the pipe and it reached a maximum value of + 30% in the given experiment.

REFERENCES

1. **Bugaevsky S. B., 2006.:** Locomotive 2TЭ116M cooling device of diesel. Calculation. 2624.00.00.000 PP1. Lugansk, “Luganskteplovoz”. p. 16.
2. **Filonov S.P., Gibalov A.I., Nikitin E.A., 1996.:** Locomotive 2TE116. Moscow, «Transport», p. 97-99.
3. **Gerasimov Y. I., Gejderih V. A., 1980.:** Thermodynamics of solutions. Moscow, Publishing house of the Moscow university, p. 91.
4. **Hartmann H., 1961.:** Heat transfer during condensation of the vapor moving in vertical pipes. Chemie - Ingeneur - Technic, №33, Volume 5. p. 343-348.
5. **Isachenko V. P., 1975.:** Heat transfer. Moskow, "Energya", p. 106
6. **Isachenko V.P., 1977.:** Heat transfer in condensation. Moskow, "Energya", p. 106-114.
7. **Kamaev A.A., Apanovich N.G., Kamaev V.A., 1981.:** Design, calculation and design of locomotives. Moskow, «Mashinostroenie», p. 172-184.
8. **Kulikov Y. A., 1988.:** Cooling propulsion of locomotives. Moskow, «Mashinostroenie», p. 117-145.
9. **Miheev M.A., Miheeva I. M., 1977.:** Heat transfer bases. Moskow, "Energya", p. 129.
10. **Mohyla V. I., Sklifus J.K., 2010.:** The prospects of increasing the effectiveness of the cooling device of a diesel locomotive. TEKA Commission of Motorization and Power industry in agriculture, Lublin, Volume Xc, p. 198-203.
11. **Mohyla V. I., Sklifus J.K., 2011.:** The cooling devise of locomotive with vaporizing coolant. TEKA Commission of Motorization and Power industry in agriculture. Lublin, Volume XIa, p. 169-176.
12. **Mohyla V. I., Sklifus J.K., 2012.:** Thermal storage systems in locomotives and prospects. "Lokomotivinform", Kharkov, № 9. p. 4-6.
13. **Radchenko N.I., Stahel A., Sirota A.A., Konovalov D.V., 2009.:** The direction of heat recovery in marine diesel installations and their implementation with the use of cold. Aerospace engineering and technology, № 4 (61), p. 62-65.
14. **Seliverstov V.M., 1973:** Heat recovery in marine diesel installations. Leningrad: «Sudostroenie», p. 17-36.
15. **Sintezgaz.org.ua, 2011.:** Steam engine in the BMW 5-series. Internet resource, access mode: http://sintezgaz.org.ua/energonovosti/173/parovoi-dvigatel-na-bmw-5-i-serii.
16. **Sirota A.A., Bes T., Radchenko N.I., Konovalov D.V., 2009.:** Marine diesel installation trigeneration contours. Aerospace Engineering and Technology, № 8 (65), p. 47-51.
17. **Volodin A.I., 1978.:** Locomotive’s engines of internal combustion. Moscow, «Transport», p. 53-78.
18. **Vinogradov S. N., Tarantsev K. V., Vinogradov O. S., 2001.:** Choice and calculation of heat exchangers. Penza, Publishing of state university of Penza, p. 107.
19. **Wong H., 1979.:** The basic formulas and data on heat transfer for engineers. Transl. from English. Moskow, "Atomizdat", p. 185.
20. **Zhukauskas A. A., 1982.:** Convective carrying over to heat exchangers. Moscow, “Nauka”. p. 9.

РЕЗУЛЬТАТЫ ЭКСПЕРИМЕНТАЛЬНЫХ ИССЛЕДОВАНИЙ КОЭФФИЦИЕНТА ТЕПЛООТДАЧИ ПРИ КОНДЕНСАЦИИ ПАРА В ТРУБКАХ ТЕПЛОВОЗНЫХ РАДИАТОРНЫХ СЕКЦИЙ

Ярослав Склифус, Валентин Могила

Аннотация. В статье представлены схемы стендового оборудования, методика испытаний, планирование эксперимента, основные расчетные зависимости, и полученные результаты испытаний серийной радиаторной секции тепловоза в в режиме конденсаторов пара.

Ключевые слова. Эксперимент, стендовое оборудование, радиаторная секция, коэффициент теплопередачи, коэффициент теплоотдачи.

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Simulation of the power unit of the automatic electrohydraulic drive with volume regulation

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Summary. The mathematical model of the dynamic characteristics of the power unit of the automatic electrohydraulic drive volume regulation is developed. A block diagram of the control signal transmission is represented. Transfer function of the drive is received.
Key words: pump, motor, pressure, flow, volume control, a block diagram, transfer function.

INTRODUCTION

Modern technologies of materials processing, plastic molding machine designs placing ever-increasing demands on the technical and functional characteristics of machine tools and special process equipment. The quality of the products for machining, forming, plastic molding depends on the feasibility of optimal laws of motion of blades, precision control of their movements, stability, speed with variable load. Therefore important the scientific and technical task is to improve the accuracy and extend the functionality of machines and equipment for processing materials.

Achievement of any of the kinematics of the working body, the possibility of program implementation optimal laws of motion provided by the use of automatic hydraulic transmission and, in particular, auto electrohydraulic drive (EHD) with volume control in equipment capacity exceeding 8 kW. However, there are currently no generic mathematical model of the work processes that take place in the drive, there is no generally accepted methods for calculating EHD adapted to drive machine tools and special equipment for material processing, enables the assessment and selection of drive components and devices, to predict its static and dynamic characteristics.

The power part of the electrohydraulic servo drive (EHD) includes a positive displacement pump with adjustable pitch, and accessories, the executive hydraulic motor displacement type [1, 2]. The most widely used in servo-hydraulic actuator has axial-piston pumps, which flow is regulated by a change in the angle of the cylinder, or changing the angle of inclination of the puck. As actuation hydraulic cylinders typically used with linear transmission output link, hydraulic cylinders with a rotary motion of the output link and axial piston and radial piston motors. Auxiliary devices include valves, filter, pump and tank system of feeding with work fluid of hydraulic power unit.

The aim of this work is to develop mathematical models of dynamic characteristics of the power unit of the automatic electrohydraulic drive with volume control and obtaining the transfer function of the drive by the control signal.

OBJECTS AND PROBLEMS

At fig. 1 a schematic diagram of a typical power unit of the drive with volume control containing two axial piston hydraulic machines: the main hydraulic pump 2 and 5 is presented. The pump shaft is driven by an asynchronous motor 1. Pump capacity is controlled by varying the angle of the cylinder block (or angle washer) with the 3, which can also be power, consisting of cylinder

and valve. The pipe is connected to motor with two pipelines 4. Motor shaft via a gear 6 is connected to the governing board 7. For the leakages of fluid is an auxiliary pump (usually gear or plate) 13 driven in rotation by the shaft of the main pump. If the angle of the cylinder (tilt washer) of the ground the pump is controlled by steering, the auxiliary pump is also used to supply hydraulic fluid under pressure. The pressure in the pressure line of the auxiliary pump is supported overflow valve 10. This highway two make-up valve 9 is connected to a pipeline linking the main pump and motor. When the pressure in one of the pipes below the value of the corresponding make-up valve opens and passes the pressurized fluid from the pressure line of the auxiliary pump for as long as the line does not restore the required level of pressure. After that, make-up valve by the pressure in the pipe is closed. Make-up valves must maintain such a minimum pressure in the pipeline not to occur a cavitation in basic pump. To do this, set the required pressure in the pressure line of the auxiliary pump by adjusting the tension of the spring (set pressure) relief valve 10.

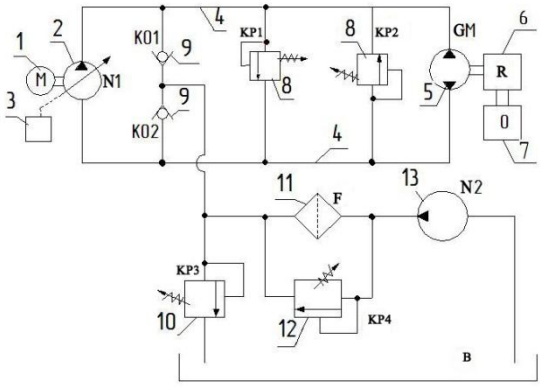

Fig. 1. The scheme of the power unit with interior

EHD regulation

From the occurrence of excessively high pressure hydraulic lines are protected by two safety valves 8. During excessive rise in pressure in one of the pipelines can open a safety valve to leak into another pipeline with low pressure. In the discharge of the auxiliary pump also has a pressure relief valve 12, which protects the pump from pressure build-up clogging the filter 11.

Let`s note symbols of the hydraulic machines and hydraulic units in fig. 1. Here H1…H2 - pumps, GM - motor; KO1…KO2 - check valves; KR1...KR4 - safety valves, F - filter.

Before constructing a mathematical description of the power of the EHD surround regulation, form the design scheme, taking into account the following basic assumptions of:

1. Asynchronous motor 1 rotates shaft with angular velocity Ω_n, the value of which is independent power developed by the pump.

2. When operating hydraulic pressure in the pipelines 4 do not reach the values for opening the safety valves 8.

3. Pressure p_{nn} in the line before the make-up valve is kept constant.

4. Efforts, overcome by hydraulic motor 5 in the management of object 7, may be represented by the sum of points given to the shaft of the motor inertia loads, load positioning and hydraulic friction.

5. Pipelines will take as short to allow them to neglect the inertia of the fluid and pressure loss due to friction.

The design scheme is shown in fig. 2. In this circuit, the arrows show on the direction of fluid flow at the moment when the pressure is greater than the pressure p_1 and p_2.

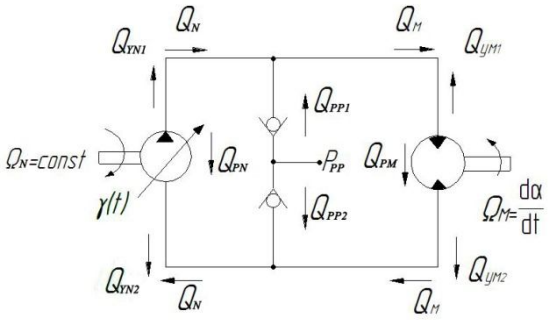

Fig. 2. The design scheme of the hydraulic power

With all the above assumptions made obtaining a linear mathematical model of the power of the EHD with interior control prevents one essentially nonlinear characteristic that determines the dependence of flow and recharge Q_{nn1} and Q_{nn2} through the make-up valve from the pressures p_1 and p_2 in the pipelines. If the pressure in the pipe is below the supply pressure p_{nn} to the make-up valves, small changes can apply pressure ratio

$$Q_{nn1} = k_{kl}(p_{nn} - p_1); \quad (1)$$

$$Q_{nn2} = k_{kl}(p_{nn} - p_2); \quad (2)$$

where: $k_{кл}$ - the conductivity of makeup valve [3, 4].

If the pressure in the pipeline exceeds the charge pressure p_{nn}, the

$$Q_{nn1}=Q_{nn2}=0, \quad (3)$$

as make-up valves are closed by the pressure in the pipelines.

At steady state hydraulic drive, for which the unloaded motor shaft does not rotate, the pressure in the pipes due to leakage of fluid from the pump and motor and final values of the conductivity of valves installed below the p_{nn}. With fluctuations in each pipeline after a certain make-up valve on one half cycle at low pressure enters the amount of fluid is compensated not only leaks, but the compressibility of the liquid. In the next half-cycle of the compression of large volume of fluid in the pipe happens, which leads to an increase in its pressure. Flow of fluid through the make-up in the hydraulic valves is accompanied by increase in the average for the period of pressure fluctuations in the system or in increased levels of pressure in them. The amount of fluid received in the pipelines for the period of oscillation depends on the amplitude of fluctuations in pressure p_1 and p_2, so the average for the period of the valve conductance amplitude pressure in the pipes.

In the study of the dynamics of the hydraulic drive with small deviations of the variables from the steady-state values the level of pressure in the lines can be adopted under p_{nn} pressure, so is permissible to use the linear relationship (1, 2). In the study of the dynamics of the hydraulic drive with large changes of variables have to take into account the non-linear characteristics of make-up valves.

For the time, when a small deviation of the cylinder (or the clone disk) from the equilibrium pump delivers fluid through the pipeline to the pressure p_1 and sucks fluid from the pipeline to the pressure p_2, the flow equation can be written using the D. Popov`s approach [4], as follows:

for pipeline pressure p_1 pump flow

$$Q_n = Q_m + Q_{nn} + Q_{nm} + Q_{yn1} + Q_{ym1} + Q_{cg1} - Q_{nn1}; \quad (4)$$

for a pipeline with pump flow pressure p_2

$$Q_n = Q_m + Q_{nn} + Q_{nm} - Q_{yn2} - Q_{ym2} - Q_{cg2} + Q_{nn2}. \quad (5)$$

In equations (4) and (5) the costs Q_{cg1} and Q_{cg2} are the components of the distribution moves that are associated with the compensation of compressibility. The remaining components designated in accordance with the design scheme (fig. 2). To simplify expressions, determining the coefficients in the following equations, we consider the pump and motor hydraulic machines of the same type, such as axial piston, differing only in the fact that the pump is regulated by the angle cylinder (or disk) is not regulated. In this case, you can take

$$Q_{nn} = Q_{nm} = Q_{per};$$
$$Q_{yn1} = Q_{ym1} = Q_{ym1};$$
$$Q_{yn2} = Q_{ym2} = Q_{ym2}.$$

Given these relations, we define the components of the pump flow in the form of

$$Q_m = \frac{q_m}{2\pi}\Omega_m = \frac{q_m}{2\pi}\frac{d\alpha}{dt}; \quad (6)$$

$$Q_{per} = k_{per}(p_1 - p_2); \quad (7)$$

$$Q_{ym1} = k_{ym}p_1; \quad (8)$$

$$Q_{ym2} = k_{ym}p_2; \quad (9)$$

where: q_m - working volume of the hydraulic motor; Ω_m - motor shaft angular velocity; α - the angle of rotation of the shaft motor; k_{per} - conductivity slits through which the pump and drive have a transmission of the fluid from the high pressure in the cavity with a low pressure; k_{ym} - the conductivity of the slits, which the leakage of fluid from the pump and motor.

Costs Q_{nn1} and Q_{nn2} determined by the ratio (1) and (2), and the costs Q_{cg1} and Q_{cg2} assuming the pipes is hard to find the following relationships [5]

$$Q_{cg1} = \frac{W_0}{E_g}\frac{dp_1}{dt}; \quad (10)$$

$$Q_{cg2} = \frac{W_0}{E_g}\frac{dp_2}{dt}; \quad (11)$$

where: W_0 - the internal volume of the pipeline with the connected volume of the cavity pump and motor;

E_g - bulk modulus of the working fluid.

Substitute the components of the costs according to (1, 2, 6-11) in equation (4, 5). Then add these equations and transform

$$Q_m = \frac{q_m}{2\pi}\frac{d\alpha}{dt} + 2k_{per}(p_1 - p_2) + k_{yt}(p_1 - p_2) + \frac{k_{kl}}{2}(p_1 - p_2) + \frac{W_0}{2E_g}\frac{d(p_1 - p_2)}{dt}. \quad (12)$$

Ideal pump flow Q_n in the form depending on the angle of inclination γ of cylinder blocks or angle swash plate pump

$$Q_n = \frac{q_n}{2\pi}\Omega_n, \quad (13)$$

where: $q_н$ - the pump displacement.

For axial piston pump

$$q_n = F_n z_n D_n tg\gamma, \quad (14)$$

where: F_n the working area of one piston (plunger) pump; z_n - the number of pistons; D_n - the diameter of the circle on which the axis of the piston pump.

As can be seen, the function is nonlinear. For small deviations of cylinder blocks (spacers) of the pump from the neutral position of the specified function can be linearized, and the equation (14) is written in the form

$$Q_n = k_{Q\gamma}\gamma, \quad (15)$$

where:

$$k_{Q\gamma} = \frac{\partial Q_n}{\partial \gamma}.$$

For axial piston pump

$$k_{Q\gamma} = \frac{F_n z_n D_n \Omega_n}{2\pi}.$$

Applying (15), we reduce (12) to the form

$$\frac{q_m}{2\pi k_{Q\gamma}}\frac{d\alpha}{dt} + \frac{W_0}{2E_g k_{Q\gamma}}\frac{dp_m}{dt} + \frac{k_\Sigma}{k_{Q\gamma}}p_m = \gamma, \quad (16)$$

where:

$$k_\Sigma = k_{yt} + 2k_{per} + \frac{k_{kl}}{2};$$

$$p_m = p_1 - p_2. \quad (17)$$

In equation (16), except for the input and output values γ and α, found of changing the time differential pressure p_m, which is dependent on hydro-motor overcomes the load. When the inertial load value p_m determined torque M_m, which is included in the equation of the rotational movement of the shaft motor

$$M_M - M_{mr1} - M_{mr2} - M_{poz} = J\frac{d^2\alpha}{dt^2}, \quad (18)$$

where: J - moment of inertia of the rotating parts of the motor to the shaft (given moment of inertia of the load and the rotor motor). In the future, this value will be called reduced moment of inertia motor.

Torque for the bulk hydraulic [6-8] is defined by the relation

$$M_m = \frac{q_м}{2\pi}p_m. \quad (19)$$

Friction torque M_{mp1} is created by friction in the motor. In general, the friction in the hydraulic motor can be mixed. To simplify the mathematical model of hydro-drive we will consider only the hydraulic friction [9, 10], setting

$$M_{mr1} = k_{mr1}\frac{d\alpha}{dt}, \quad (20)$$

where: k_{mp1} is calculated from the slope of the approximating performance $M_{mr1} = M_{mr1}(\Omega_m)$.

Friction torque M_{mr2} arising due to the friction of the load, consider the analogous dependence

$$M_{mr2} = k_{mr2}\frac{d\alpha}{dt}. \quad (21)$$

Moment due to the positional load

$$M_{poz} = k_{poz}\alpha, \quad (22)$$

where: k_{poz} - the rigidity of positional load.

Using (19-22), from (18) that

$$\frac{2\pi J}{q_m}\frac{d^2\alpha}{dt^2} + \frac{2\pi k_{mr}}{q_m}\frac{d\alpha}{dt} + \frac{2\pi k_{poz}}{q_m}\alpha = p_m, \quad (23)$$

where: $k_{mr} = k_{mr1} + k_{mr2}$.

Considering simultaneously the equations (16) and (23) we find

$$\frac{\pi J W_0}{E_g q_m k_{Q\gamma}}\frac{d^3\alpha}{dt^3} + \left(\frac{\pi k_{mr} W_0}{E_g q_m k_{Q\gamma}} + \frac{2\pi k_\Sigma J}{q_m k_{Q\gamma}}\right)\frac{d^2\alpha}{dt^2} + \quad (24)$$
$$+ \frac{q_m}{2\pi k_{Q\gamma}}\left(1 + \frac{2\pi^2 k_{poz} W_0}{E_g q_m^2} + \frac{4\pi^2 k_\Sigma k_{mr}}{q_m^2}\right)\frac{d\alpha}{dt} + \frac{2\pi k_\Sigma k_{poz}}{q_m k_{Q\gamma}}\alpha = \gamma.$$

In real hydrodrives usually

$$1 + \frac{2\pi^2 k_{poz} W_0}{E_g q_m^2} + \frac{4\pi^2 k_\Sigma k_{mr}}{q_m^2} \approx 1. \quad (25)$$

Therefore, instead of (24) we have

$$\frac{\pi J W_0}{E_g q_m k_{Q\gamma}}\frac{d^3\alpha}{dt^3} + \left(\frac{\pi k_{mr} W_0}{E_g q_m k_{Q\gamma}} + \frac{2\pi k_\Sigma J}{q_м k_{Q\gamma}}\right)\frac{d^2\alpha}{dt^2} + \quad (26)$$
$$+ \frac{q_m}{2\pi k_{Q\gamma}}\frac{d\alpha}{dt} = \gamma - \frac{2\pi k_\Sigma k_{poz}}{q_m k_{Q\gamma}}\alpha.$$

We consider the following parameters:

time constant hydraulic

$$T_{gp} = \frac{q_m}{2\pi k_{Q\gamma}}. \quad (27)$$

time constant motor

$$T_m = \sqrt{\frac{2\pi^2 JW_0}{q_m^2 E_g}}. \quad (28)$$

the relative damping motor

$$\zeta = \frac{\pi\left(2JE_g k_\Sigma + k_{mr} W_0\right)}{\sqrt{2JW_0 E_g q_m^2}}. \quad (29)$$

factor own feedback

$$k_{coc} = \frac{2\pi k_\Sigma k_{poz}}{q_m k_{Q\gamma}}. \quad (30)$$

As can be seen from this expression, the coefficient of its own feedback part of the hydraulic power unit due to the combined action of hydraulic positional load and no-leak of hydraulic machines.

Given the input parameters (26) the Laplace transform [11, 12] to the form

$$T_{gp} s\left(T_m^2 s^2 + 2\zeta_m T_m s + 1\right)\alpha(s) = \gamma(s) - k_{coc}\alpha(s). \quad (31)$$

Block diagram of the power part of EHD according to equation (31) are shown in fig. 3.

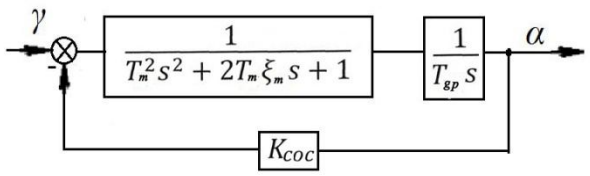

Fig. 3. Block diagram of the power part of EGP

In the absence of positional load (22) or seals for hydraulic, or insignificant moment of the forces positional load and high hydraulic leak (which is usually the case in practice) coefficient of the own feedback is negligible. It should be noted that this ratio in the event of significant influence can be included in the external feedback EHD.

Then, a block diagram of the power of the drive will be as shown in fig. 4. This scheme is, in fact, reflects the transfer of the control signal - the angle to clone the cylinder (or puck) γ - and its influence on the output signal - the angle of rotation of the shaft motor α.

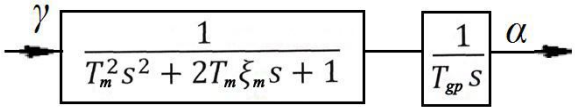

Fig. 4. The block diagram of the control signal EHD in the power section with interior control

In the future, consider the block diagram of the power part of EHD with the volume control as shown in fig. 4. According to this block diagram is obtained for the transfer function of the angle of rotation of the drive motor shaft angle α on the cylinder (or puck) γ

$$W_{\alpha\gamma}(s) = \frac{\alpha(s)}{\gamma(s)} = \frac{1}{T_{gp} s\left(T_m^2 s^2 + 2\zeta_m T_m s + 1\right)}. \quad (32)$$

CONCLUSIONS

Thus, the mathematical model of the dynamic characteristics of the power unit automatic electrohydraulic drive volume regulation is developed. The block diagram of the control signal is presented. Transfer functions for the drive output shaft angle motor with control signal (the slope of the cylinder or disk) is received.

REFERENCES

1. **Leshchenko V.A., 1975.:** Hydraulic servo system and drive machines with computer control. – M.: Engineering. – 672 p.
2. **Popov D.N., 1987.:** Dynamics and regulation hydro- and pneumatic systems / D.N. Popov. - M: Mechanical engineering. - 464 p.
3. **Terskyh V.Z., 1976.:** Comparative analysis of dynamic properties of throttle hydrodrives// Publishing house of high schools. Mechanical engineering, №7. - 59-62 P.
4. **Abramov E.I., Kolesnichenko K.A., Maslov V.T., 1977.:** Hydrodrive elements: the Directory. - K: "Technics". - 320 p.
5. **Chuprakov JU.I., 1975.:** Electrohydraulic amplifiers. - M: MADI. - 124 p.
6. **Sveshnikov V.K, Usov A.A., 1988.:** Moustaches hydrodrives: the Directory. - 2 publ. - M: Mechanical engineering. – 512 p.
7. **Dorf R., 2002.:** Modern systems of management / Dorf R., Bishop R. – M.: Laboratory of Base Knowledge. – 831 p.
8. **Sokolova Ya.V., 2010.:** Nonlinear mathematical model of the electrohydraulic watching drive with throttle regulation / Sokolova Ya.V., Tavanuk T.Ya., Sokolov V.I. // Messenger of the East-Ukrainian National University named by V. Dal. –- № 10 (152). – P. 168-175.
9. **Popov D.N., 1982.:** Non-stationary's hydromechanical processes / D.N. Popov. - M: Mechanical engineering. - 240 p.
10. Aerohydrodynamics: textbook for universities / M.D. Andrijchuk [etc.]. - Lugansk: Publishing house of Volodymyr Dal East-Ukrainian National University, 2009. - 516 p.
11. **Hohlov V.A., 1964.:** Electrohydraulic watching drive. - M: the Science.

12. **Chuprakov JU.I., 1977.:** Electrohydraulic watching drives. - M: MADI. – 88 p.
13. **Navrotsky K.L., 1991.:** Theory and designing hydro- and pneumodrives. - M: Mechanical engineering. - 384 p.
14. **Yakovlev V.B., 1984.:** Adaptive Cruise Control: A Textbook. - L.: Len University. – 428 p.
15. **Alexeev A.A., 1999.:** Control theory / A.A. Alekseev, D.H. Imayev, N.V. Kuzmin, V.B. Yakovlev. - St. Petersburg.: ETU "LETI". – 526 p.
16. **Gamynin N.S., 1972.:** Hydraulic drive control systems. - Moscow: Mashinostroenie. – 756 p.
17. **Leshchenko V.A., 1968.:** Hydraulic servo drives. - Moscow: Mashinostroenie. – 822 p.
18. **Goodwin G.K., 2004.:** Design of Control Systems / G.K. Goodwin., F. Grefe, M.E. Salgado. – M.: Knowledge Lab. – 218 p
19. **Sokolova Ya., Tavanuk T., Greshnoy D., Sokolov V., 2011.:** Linear modelling of the electrohydraulic watching drive \\ TEKA, Commision of Motorization and Power Industry in agriculture, Lublin University of technology, Volodymyr Dal East-Ukrainian National University of Lugansk. - Tom XI B. – Lublin. – P. 167-177.
20. **Sokolova Ya., Ramazanov S., Tavanuk T., 2010.:** Nonlinear modeling of the electrohydraulic watching drive \\ TEKA, Commision of Motorization and Power Industry in agriculture, Lublin University of technology, Volodymyr Dal East-Ukrainian National University of Lugansk. - Tom XC. – Lublin. – P. 234-242.

МОДЕЛИРОВАНИЕ СИЛОВОЙ ЧАСТИ АВТОМАТИЧЕСКОГО ЭЛЕКТРОГИДРАВЛИЧЕСКОГО ПРИВОДА С ОБЪЕМНЫМ РЕГУЛИРОВАНИЕМ

Владимир Соколов, Наталья Азаренко, Яна Соколова

Аннотация. Разработана математическая модель динамических характеристик силовой части автоматического электрогидравлического привода с объемным регулированием. Представлена структурная схема передачи управляющего сигнала. Получена передаточная функция привода.

Ключевые слова: насос, гидромотор, давление, расход, объемное регулирование, структурная схема, передаточная функция.

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Researches of the system of neutralization process control in the production of ammonium nitrate on the basis of rheological transitions principles

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S u m m a r y. The results of theoretical and experimental researches of the system of neutralization process control in the production of ammonium nitrate on the basis of rheological transitions principles have been presented in the paper. A new method of nitric acid neutralization control through temperature field stabilization has been developed.
K e y w o r d s. Neutralization, rheological transitions, control system, mathematical model, reaction, temperature.

INTRODUCTION

Chemical-engineering processes are followed by rheological transformations, which are based on transfer of quantity of mass, energy and motion [Taganov 1979; Bird, Stewart, Lightfoot 1974; Eckert, Drake 1962; Weinberg 2009]. As it is shown in [Stentsel 1992; Stentsel 1993], presence of one or another rheological transition causes change of technological process parameters and, consequently, appearance of errors in neutralization control process. It is particularly related to chemical processes with simultaneous transfer of mass, heat and motion of material flows, for which preservation of optimal operating mode depends on accuracy of control [Stentsel 2007; Golubenko, Marchenko 2008; Syomin, Pavljuchenko, Maltsev, Rogovoy, Dmitrienko 2009]. So, in [Porkuyan, Stentsel, Prokaza 2010; Porkuyan, Prokaza 2011; Stentsel, Porkuyan, Prokaza 2011] it is shown that rheological transformations, taking place in a neutralization apparatus, are characterized with sinks of mass and energy quantity and they induce non-linear phenomena, which affect operation of monitoring and control system of acid neutralization in ammonium nitrate production. Therefore determination of new principles, which can form the basis of neutralization process control in ammonium nitrate production, is an important scientific task [Porkuyan, Prokaza 2009].

OBJECTS AND PROBLEMS

Control of nitric acid neutralization by means of ammonia gas is mainly performed through concentration of nitric acid solution (non-concentrated nitric acid) in ammonium nitrate solution [Ivanov, Olevskiy, Polyakov 2009; Adylov, Turapina, Perekrestov, Yusupbekov 2004]. Temperature mode in a vessel of the neutralization apparatus is stabilized through change in consumption of the nitric acid solution.

The most widespread method is neutralization process control through regulation of nitric acid at the apparatus outlet, depending on difference in potential between the platinum electrode and the standard one [Miniovich 1974]. The main disadvantage of the above method of control is that the ammonium nitrate solution acidity is measured outside the reaction zone, resulting in increase of inertia of automatic regulation system and accordingly in oscillation processes, during which ammonia consumption changes sharply, and sudden changes of acidity in ammonium nitrate and juice vapor. In works of

[Anokhin, Bielik, Dovgalov, Patalakha, Tsyglevskyi, Chystoklietov 2001] there is a description of method of the acid neutralization apparatus control, when controlling action for nitric acid supply is conditioned by a signal of the platinum electrode as to the standard one. At that the platinum electrode is positioned in the reaction zone of the apparatus below the point of ammonium nitrate solution overflow and the silver-chloride electrode, connected to the reaction zone by means of an electrolytic bridge, functions as the standard one. Such automatic regulation system has significant drawbacks, because, firstly, it is not clearly understood what the "lower" point of ammonium nitrate solution overflow is; secondly, due to the electrolytic bridge two meters long the displacement of signals arises between the main platinum electrode and the auxiliary silver-chloride one. These drawbacks also have a certain influence on operation of the automatic regulation system, which is carried out by varying nitric acid consumption.

For optimization of control of technological process of nitric acid neutralization stage, as a rule, temperature mode is used, which is sufficiently inert and, if strong disturbing impacts are available, it gives rise to oscillation unstable and quasi-stable processes, causing deviation from the optimal operating mode of the technological apparatus (automatic regulation systems operate in critical modes, when regulating units suddenly increase or decrease input and output material flows). As experimental investigations have shown, impact of difference of temperature in the reaction zone and temperature of the ammonium nitrate solution at the outlet of the neutralization apparatus vessel on technological process efficiency is stronger than change of the platinum electrode potential relative to the standard silver-chloride one due to the fact that thermocouples are installed directly in the reaction zone (zone of reaction maximum temperature) and in the ammonium nitrate solution at the outlet from the neutralization apparatus vessel.

As it is known [Stentsel, Tselishchev, Loriya, 2007], electric potential of a measuring galvanic transmitter consisting of the platinum and the silver-chlorine electrodes, is described by the following equation:

$$E_B = \frac{RT}{F} \ln \frac{a_{1(H^+)}}{a_{2(H^+)}}, \qquad (1)$$

where: R - is universal time constant; T - is temperature of the solution; F - is Faraday constant; $a_{1(H^+)}$ - is activity of hydrogen ions in the solution under analysis; $a_{2(H^+)}$ - is activity of hydrogen ions in the normal solution.

From formula (1) it can be seen that while applying the galvanic transmitter dependence of electric potential E_B on change in the solution acidity (change in ratio $a_{1(H^+)} / a_{2(H^+)}$) is a non-linear logarithmic function, which results in loss of control sensitivity in case of significant changes of nitric acid quantity in the apparatus. It turned out that the principle of acid neutralization control by potential value of the platinum electrode relative to the silver-chloride one can be used only, if there are small deviations of acidity of the ammonium nitrate solution from its particular value, specified by the solution in the electrolytic cell, where the silver-chloride electrode is positioned. On the other hand, dependence of electric potential E_B on change in the solution temperature is a linear function. Besides, electrolytic cells are rather complex, expensive and unreliable means.

It is suggested [Prokaza 2012; Stentsel, Prokaza, Porkuyan, Litvinov 2012] to control the acid neutralization process in ammonium nitrate production by temperature difference $\Delta T = T_1 - T_2$ through regulation of juice vapor supply to the reaction zone that is directed to recycling from the neutralization apparatus upper part. Temperatures T_1 and T_2 are controlled with back-connected thermocouples (chromel-copel); at that the thermocouple, measuring temperature T_1, is positioned directly in the reaction zone (maximum temperature point) and the thermocouple, measuring temperature T_2, is positioned at the outlet of the ammonium nitrate solution from the vessel.

The method of control is explained by means of scheme (fig. 1), on which the following is shown:

1 – neutralization apparatus;
2 – reaction vessel;
3 – device for ammonia supply;
4 – device for juice vapor supply;
5 – device for nitric acid supply;
6 – thermocouple for measuring reaction temperature;
7 – thermocouple for measuring temperature of ammonium nitrate solution;
8 – normalizing transducer;
9 – microcontroller;
10 – actuating mechanism;
11 – regulating unit;

12 – steam pump.

Ammonia is conveyed to reaction vessel 2 of apparatus 1 through the device 3 and nitric acid – through the device 5. In the vessel 2 reacting components enter into a reaction and as a result ammonium nitrate in water is created.

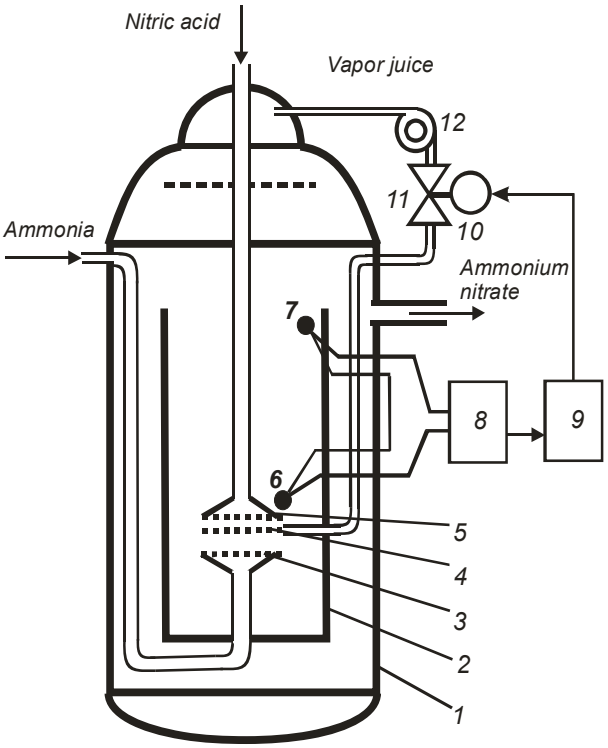

Fig. 1. Diagrammatic view of method of automatic control of acid neutralization in ammonium nitrate production

As reaction between nitric acid and ammonia is exothermic with a big evolution of heat, in the reaction zone temperature may reach up to 435 K and it depends on stoichiometric ratio of weak nitric acid and ammonia. At this reaction temperature water from the weak nitric acid goes to gaseous state and is being removed from the vessel in a form of juice vapor having temperature of 400-410 K. The ammonium nitrate solution free from water vapor particles is withdrawn from the vessel for further processing. Thermocouple 6 is arranged on the same level with device 5 and thermocouple 7 – at the outlet of the ammonium nitrate solution from the vessel 2. Juice vapor is conveyed to the reaction zone through ring bubble flask 4, similar to the device 3 for supply of ammonia gas. Vapor juice is removed from the vapor pipe by pump 12 and through regulating unit 11 is conveyed to the reaction zone of the apparatus. The temperature difference of thermocouples 6 and 7 reaches the normalizing transducer, where thermal EMF transforms into normalized current signal of 4-20 mA. The last is conveyed to microcontroller 9, which after current signals processing forms the control mode and distributes an analogous signal to actuating mechanism 10, rigidly bound with regulating unit 12, changing juice vapor consumption.

The automatic system operates as follows. During the rise of temperature T_1 in the reaction zone, conditioned by increase of nitric acid consumption F_k, decrease of ammonia gas consumption F_a or increase of nitric acid concentration Q_k, thermal EMF E_1 and E_2 of thermocouples 6 and 7 and their difference $\Delta E = E_1 - E_2$, which is being carried to normalizing transducer 8, grow. Normalized signal of the last one in microcontroller 9 forms consumption increase of juice vapor F_{VJ}, which temperature is somewhat lower than temperature T_2. At that nitric acid consumption is being stabilized and ammonia gas consumption is conveyed to the apparatus VTN in particular stoichiometric ratio.

Using theory of rheological transitions and the suggested method of reaction temperature control in [Stentsel, Prokaza, Porkuyan 2012] a mathematical model for temperature field in the reaction vessel is obtained. Investigations established that mass consumption of juice vapor F_{VJ} is the main parameter, by which technological process can be run. Besides, in the point of nitric acid neutralization maximum temperature (x_p) and at the reaction zone output (at $x \approx L$) field temperature change is that additional parameter, which can be used for running the technological process.

Theoretical and experimental investigations of the mathematical model of the reaction temperature while changing juice vapor consumption are conducted. Temperature dependence in the reaction zone T on current height of the reaction vessel x and juice vapor consumption F_{VJ} is shown in fig. 2.

When bringing juice vapor in ring bubble flasks some shift of the maximum temperature by the reaction vessel height is indicated. Initial velocity of the reaction increases, which promotes rising of circulating factor of the ammonium nitrate solution, of water evaporation rate from nitric acid and of vapor quantity in the reaction zone and due to high heating capacity of juice vapor the absorption of the chemical reaction heat takes place; therewith the temperature mode changes insignificantly. Owing to this the neutralizer operation efficiency increases by 20%.

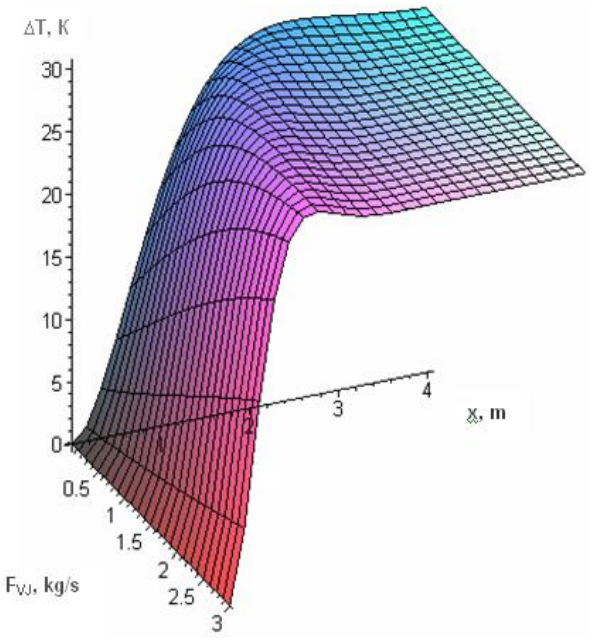

Fig. 2. Temperature dependence in the reaction zone T on current height of the reaction vessel x and juice vapor consumption F_{VJ}

CONCLUSIONS

New method of nitric acid neutralization process control due to stabilization of temperature field, determined by difference of temperature in the reaction zone of the neutralization apparatus vessel and temperature of the ammonium nitrate solution at the vessel outlet, by which consumption of juice vapor, conveyed to the neutralization apparatus reaction zone in recycle mode, changes, is suggested.

Efficiency of the neutralization apparatus operation rises owing to stable consumption of nitric acid and stable ratio of nitric acid and ammonia gas consumptions, almost always being on the same level with stoichiometric one, and also owing to repeated use of juice vapor, resulting in economic consumption of ammonia and nitric acid.

Usage of high-precision and highly reliable thermocouples (for instance, chromel-copel) increases reliability of the automatic control system and accuracy of control by measurement.

Repeated use of juice vapor during nitric acid neutralization allows reducing rheological transition zone of nitric acid and ammonia in the ammonium nitrate solution, which results in thermal mode stabilization in the apparatus VTN reaction vessel, rise of the neutralization apparatus efficiency, improvement of the technological process safe running due to lowering of nitric acid concentration in juice vapor, which acidity approximates to the neutral one, lowering of influence of nitric acid concentration change on neutralization process, expansion of the rheological transition zone of reaction heat temperature field, which decreases quantity of weak ammonium nitrate solution conveyed for lowering of temperature in neutralization apparatuses, and also increase of distribution efficiency of the temperature field and the ammonium nitrate solution density by height of the neutralization apparatus vessel.

REFERENCES

1. **Adylov F.T., Turapina N.N., Perekrestov V.V., Yusupbekov N.R., 2004.:** Control system of technological process of weak nitric acid and ammonium nitrate production in aggregates AK-72M and AS-72M on Fergan SW “Azot”. Industrial controllers ACS, No.4, pp.1-6.
2. **Anokhin A.O., Bielik S.V., Dovgalov L.Y., Patalakha V.V., Tsyglevskyi P.M., Chystoklietov M.V., 2001.:** Patent of Ukraine No. 43404 Method of automatic control of acid neutralization process in ammonium nitrate production in apparatus of applying neutralization heat, Bull. N 11.
3. **Bird R., Stewart V., Lightfoot E., 1974.:** Transport phenomena. Moscow, Chemistry, 688 p.
4. **Eckert E.R., Drake R.M.,, 1962.:** Heat and mass transfer. - Moscow.: Gosenergoizdat, 1962., 562 p.
5. **Golubenko A., Marchenko D., 2008.:** Features of diagrams of phases and anomaly of structures of dynamic systems during degradation of their properties. TEKA Commission of motorization and Power Industry in Agriculture, №8, V.III, pp. 77-81.
6. **Ivanov M.E., Olevskiy V.M., Polyakov N.N., 1990.:** Ammonium nitrate production in aggregates having large unit capacity. Moscow, Chemistry, 228 p.
7. **Miniovich M.A., 1974.:** Ammonium nitrate production. Moscow, Chemistry. 276 p.
8. **Porkuyan O.V., Prokaza E.I., 2009.:** Problems and tasks of optimal control of neutralization process in ammonium nitrate production in conditions of uncertainty. Bulletin of the East-Ukrainian National University named after Volodymyr Dahl, Sievierodonetsk, ENU named after V. Dahl, No. 12 (132), p. 2, pp. 38–45.
9. **Porkuryan O.V., Prokaza E.I., 2011.:** Investigation of mathematical model of control by measurement during rheological transformations of chemical processes. Collection of theses of reports of 1-st International scientific conference in memory of Prof. Volodymyr Podzharenko “Measurement, control and diagnostics in technical systems” (VKDTS-2011), Vinnytsia, VNTU, October 18-20, p. 153.
10. **Porkuyan O.V., Stentsel I.I., Prokaza E.I., 2010.:** Rheological models of technological control of parameters with internal connections in ammonium

nitrate production. Bulletin of Kharkiv National University "Kharkiv Polytechnical Institute". Collected scient. proceedings. "Electric power industry and converter equipment". Kharkiv: NTU "KhPI", No. 12, pp. 21 – 28.

11. **Prokaza E.I., 2012.:** Control of acid neutralization process in ammonium nitrate production. Materials of 8th International scientific and practical conference "Scientific investigations – theory and experiment 2012", Poltava: Publication «InterGraphika», May 28 - 30, vol.6., pp. 44-45.
12. **Stentsel I.I., 1993.:** Mathematical modelling of technological objects under control. Kyiv. ISDO, 328 p.
13. **Stentsel I.I., 2007.:** Mathematical modelling of chemical processes based upon theory of rheological transitions. Bulletin of the East-Ukrainian National University named after Volodymyr Dahl: Scientific journal. Lugansk, No.5 (111), P.2., pp. 91 – 96.
14. **Stentsel I.I., 1992.:** Photocolorimetric gas analyzers: Monograph. Kyiv, NMK VO, 120 p.
15. **Stentsel I.I., Porkuyan O.V., Prokaza E.I., 2011.:** Investigations of control by measurement of technological parameters during rheological transformations of chemical processes. Bulletin of Kharkiv National University "Kharkiv Polytechnical Institute". Collected scient. proceedings. "Electric power industry and converter equipment". Kharkiv: NTU "KhPI", No. 19, pp. 31-36.
16. **Stentsel I.I., Prokaza E.I., Porkuyan O.V., 2012.:** Mathematical models of acid neutralization apparatus control over reaction temperature in ammonium nitrate production. Bulletin of the East-Ukrainian National University named after Volodymyr Dahl, No.15 (186)., pp.114-122.
17. **Stentsel I.I., Prokaza E.I., Porkuyan O.V., Litvinov C.A., 2012.:** Patent of Ukraine No.73954. Method of acid neutralization process control in ammonium nitrate production, bull. No. 19.
18. **Stentsel I.I., Tselishchev O.B., Loria M.G., 2007.:** Measurement in chemical industry. Textbook, Lugansk: Publication of the East-Ukrainian National University named after Volodymyr Dahl, 480 p.
19. **Syomin D., Pavljuchenko V., Maltsev Y., Rogovoy A., Dmitrienko D., 2009.:** Vortex executive devices in control systems of fluid mediums. TEKA Commission of motorization and Power Industry in Agriculture, №9, V.III, pp. 57-62.
20. **Taganov I.N., 1979.:** Modelling of mass- and energy transfer processes. Lviv.: Chemistry, 1979., 203 p.
21. **Weinberg A.M., 2009.:** Mathematical modelling of transport processes. Solution of non-linear boundary-value problems. Moscow-Jerusalem, 210 p.

ИССЛЕДОВАНИЯ СИСТЕМЫ УПРАВЛЕНИЯ ПРОЦЕССОМ НЕЙТРАЛИЗАЦИИ В ПРОИЗВОДСТВЕ АММИАЧНОЙ СЕЛИТРЫ НА ОСНОВЕ ПРИНЦИПОВ РЕОЛОГИЧЕСКИХ ПЕРЕХОДОВ

Иосиф Стенцель, Ольга Поркуян, Елена Проказа

Аннотация. В работе приведены результаты теоретических и экспериментальных исследований системы управления процесса нейтрализации в производстве аммиачной селитры на основе принципов реологических переходов. Разработан новый способ управления процессом нейтрализации азотной кислоты за счет стабилизации температурного поля.

Ключевые слова. Нейтрализация, реологические переходы, система управления, математическая модель, реакция, температура.

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Mathematical simulation of gas bubble moving in central region of the short vortex chamber

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S u m m a r y. The research results of analytical investigations of insulated gas bubble moving in central region of the short vortex chamber in a dropping liquid are presented. The describing mathematical model of the trajectory of a bubble under influencing of forces, operating on it is compounded, in which one the change of radius of a bubble is taken into account. The ratio of magnitudes rendering the main effect on kinematic parameters of a bubble moving is obtained. The outcomes of researches can be applied at research of behavior of a bubble in a dropping liquid, rotated with a constant angular velocity.

K e y w o r d s: motion path, gas bubble, dropping liquid, angular velocity, vortex chamber.

INTRODUCTION

In engineering processes coal, oil producing, chemical industries, agriculture, pipeline transport, heat-and-power engineering etc the transportation of different fluid mediums is realized dynamic pumps, the overall performance which one by an essential image influences and a production efficiency. Thus, unfavorable operation conditions, such as the impact loads, chattering, chemical aggressiveness and heat of fluids, presence of abrasive fragments in transferred and enclosing mediums, reduce or restrict service performances of dynamic pumps [Rogovyi 2007].

Unite of superchargers virtues of centrifugal and ink-jet types has bringing in creation of a new type of pumps - with vortex working chamber called as us irrotational centrifugal pumps [Rogovyi 2007, Syomin 2005, 2007], which one have performances practically independent from the majority of the unfavorable factors reduced above. The transfer of power to a moving particle takes place in a field of an operation of centrifugal forces, that is a feature of a working process of a irrotational centrifugal pump. Thus, the particles having a density large, than density of an actuating medium, are displaced to peripherals of the vortex chamber to a plenum, and with a smaller density - to rotation axis [Rogovyi 2007, Syomin 2010. In many cases the presence of bubbles in a fluid can result in to essential change of transportation parameters, and to a collection them in axis zone [Syomin 2010, Chahine 1996, Van Nierop 2007]. Thereof, at transportation of dropping liquid the origin on an axis of the chamber of a gas rotational cord lowering expenditure of transferable liquid is possible. The cavitational conditions in such pump do not result in loss of its functionability, and only reduce its performance parameters.

Thus, the study of behavior of a gas bubble in central zone of the short vortex chamber of a irrotational centrifugal pump is an actual problem, the solution will allow which one to increase power performances irrotational centrifugal pumps at transportation dropping liquid.

RESEARCH OBJECT

To simulation of gas bubble moving there are two approaches: maiden is grounded on the share solution of three-dimensional flow equations of liquid-gas bubble mixture, that requires enough long time of calculation and considerable computational capabilities [Akhtar 2006, Hua 2007], owing to what the calculation more precise, but not always usables for an estimation of the factors effecting on behavior of a gas bubble. The

second approach is grounded on a superposition method of moving of an insulated bubble on known flow of a fluid [Syomin 2010, Chahine 1996, Hsiao 2004, Latorre 1980, Maxey 1983, Raoufi 2006], with usage of a balance of power operating on a bubble.

Many researches [Syomin 2009, Akhtar 2006, Chahine 1996, Hsiao 2004, Hua 2007, Latorre 1980, Maxey 1983, Raoufi 2006] are dedicated to behavior and calculation of pathways of bubbles, but the majority of them consider behavior of a cavitational bubble [Chahine 1996, Hsiao 2004, Latorre 1980, Plesset 1948] or gas liquid streams which are transportation in tubes [Hua 2007, Maxey 1983, Raoufi 2006]. The operations concerning to behavior of a bubble in a vortex [Arndt 1995, Van Nierop 2007], will use pressure profiles intrinsic to a volume or diverse engineering device, that hampers their correct usage at calculations of bubble behavior in the short vortex chamber of irrotational centrifugal pump. Schematize it is possible conditionally to dissect flow in the vortex chamber, it on two zones: quasisolid rotation of a fluid and potential voretx in at an axial zone [Rogovyi 2007, Syomin 2002]. Both indicated zones have a different radial pressure gradient. The given operation is dedicated to motion study of a bubble in axis zone of the short vortex chamber, where is watched quasisolid rotation of a fluid, as it has a place in rotary vessel. In operation [Syomin 2010] the research of bubble motion in the short vortex chamber, without the registration of quasisolid rotation zone of a fluid was conducted, but because the bubbles at formation of a rotational cord are concentrated in axis zone of the chamber, the gas bubble behavior in this area requires further researches. Besides on performances of irrotational centrifugal pump, exerts influence presence of a gas cord, and thus, it is necessary to clarify, whether it is possible at definite ratio of kinematic parameters of bubble motion, escape by him of axis zone of the pump, and by that fading or not origin in general of gas cord.

As the bubble during the moving passes areas with various pressure, there is a change of bubble radius, it is necessary to allow for which one at calculation, and it is described by an Rayleigh-Plesset equation [Syomin 2010, Plesset 1948]. One of the purposes of the given operation is the justification of Rayleigh-Plesset equation applicability at calculations of gas bubble motion in the short vortex chamber of irrotational centrifugal pumps at transportation dropping liquid.

The purpose of a paper is deriving ratio of kinematic parameters which are exerting influence on gas bubble motion in a transportation dropping liquid in axis zone of irrotational centrifugal pumps. The definition of motion characteristics, at which one is possible evacuating a gas bubble from axis zone.

RESULTS OF RESEARCH

For definition of gas bubble motions in a stream of a transportation dropping liquid most frequently will use the theory of a single spherical cavitational bubble oscillations, i.e. arranged far from other bubbles and other microparticles, walls of a vessel and free surface of a fluid. To take into account change of bubble radius owing to change and effect on it of a gas pressure in a bubble, pressure in a fluid, viscosity and surface-tension, will use a general purpose dynamical equation of a cavitational bubble, or the Rayleigh-Plesset equation [Syomin 2010, Hsiao 2004, Plesset 1948], which one is updated by the optional component injection, bound with a variance of velocities of a bubble moving and fluid flow:

$$R\frac{d^2R}{dt^2}+\frac{3}{2}\left(\frac{dR}{dt}\right)^2+ \\ +\frac{1}{\rho_L}\left[p_\infty-p_v+\frac{2\sigma}{R}+\frac{4\nu}{R}\frac{dR}{dt}-p_0\left(\frac{R_o}{R}\right)^{3k}\right]- \\ -\frac{\left(\overline{V}-\overline{V}_b\right)^2}{4}=0, \quad (1)$$

where: R - current radius of a bubble; p_∞ – the static pressure of a fluid, is received according to [Hsiao 2004], as middle pressure scaled on a surface of a bubble; p_0 – gas pressure in a bubble at $R=R_0$; p_v - saturated vapor pressure in a fluid; ρ_L – density of a fluid; ν – kinematic viscosity of a fluid; σ – surface-tension constant of a fluid; k – polytropic exponent; $\overline{V}$ - velocity of a fluid; $\overline{V}_b$ – velocity of a bubble. The pressure variation of gas inside a bubble owing to change of its radius is received under the adiabatic law of compression [Hsiao 2004, Latorre 1980].

The gas bubble motion equation in view of forces operating on a spherical bubble of radius R is recorded as follows [Maxey 1983, Raoufi 2006]:

$$m_b\frac{d\overline{V}_b}{dt}=\overline{F}_g+\overline{F}_p+\overline{F}_D+\overline{F}_{add}, \quad (2)$$

where: m_b – mass of gas in bubble; $\overline{F}_g$ – gravity; $\overline{F}_p$ – force of fluid pressure on a body surface, immersed in it; $\overline{F}_D$ – drag force [Syomin 2010, Hsiao 2004, Raoufi 2006], $\overline{F}_{add}$ – added mass of a fluid [Pozdeev 2003, Syomin 2010] (fig. 1). Sometimes at calculations of gas bubble motion will use lift force operating on a bubble rotation [Van Nierop 2007] and force, originating owing to change of a bubbles volume [Hsiao 2004, Latorre 19809, Raoufi 2006], which one in the given research were leave outed of account to their smallness, that is connected to features of flow field in fluid rotated with a constant angular velocity.

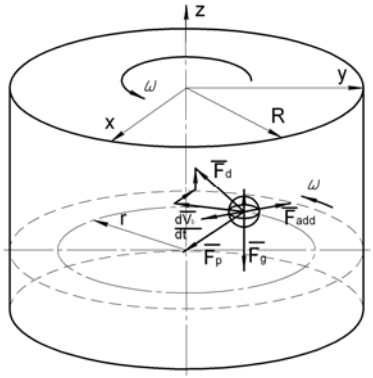


Fig. 1. Forces, operating on a bubble in central area of the vortex chamber

Thus, after a forces substitution and simplifications for steady flow is obtained a following bubble motion equation:

$$\frac{d\overline{V}_b}{dt} = 2\frac{\rho_b}{\rho_L}\overline{g} + \frac{2}{\rho_L}\overline{\nabla} p + \frac{3}{4R} C_D \left(\overline{V} - \overline{V}_b\right)\left|\overline{V} - \overline{V}_b\right|. \quad (3)$$

Integrating equations (1) and (3) and recording in projections on an coordinates axes, for gas bubble moving in the fluid rotated field with a constant angular velocity is obtained a system of ordinary non-linear differential equations (4).

The calculations are conducted with the help of a license software Matlab on a Runge-Kutta method of the fourth and fifth orders. For each instant t the coordinates $x(t)$, $y(t)$, $z(t)$, $r(t)$, $r = \sqrt{x^2 + y^2}$, velocity $\frac{dx_b}{dt}$, $\frac{dy_b}{dt}$, $\frac{dz_b}{dt}$, $\frac{dR}{dt}$ were determined. The outcomes of calculation of radius bubble change R, in different points of the chamber are displayed in a fig. 2.

$$\begin{cases} R\frac{d^2R}{dt^2} + \frac{3}{2}\left(\frac{dR}{dt}\right)^2 + \frac{1}{\rho_L}\left[p_\infty - p_v + \frac{2\sigma}{R} + \frac{4\nu}{R}\frac{dR}{dt} - p_0\left(\frac{R_o}{R}\right)^{3k}\right] - \\ -\frac{\left(\overline{V} - \overline{V}_b\right)^2}{4} = 0; \\ \frac{dV_{bx}}{dt} = 2\omega^2 x + \frac{3}{4R} C_D \left(V_x - V_{bx}\right)\left|V_x - V_{bx}\right|; \\ \frac{dV_{by}}{dt} = 2\omega^2 y + \frac{3}{4R} C_D \left(V_y - V_{by}\right)\left|V_y - V_{by}\right|; \\ \frac{dV_{bz}}{dt} = -2\frac{\rho_b}{\rho_L} g + 2g + \frac{3}{4R} C_D \left(V_z - V_{bz}\right)\left|V_z - V_{bz}\right|; \\ C_D = \frac{24}{\mathrm{Re}_b}\left(1 + 0{,}197 \cdot \mathrm{Re}_b^{0{,}63} + 2{,}6 \cdot 10^{-4}\,\mathrm{Re}_b^{1{,}38}\right); \\ \mathrm{Re}_b = \frac{2R\left|V - V_b\right|}{\nu}, \end{cases} \quad (4)$$

where: ω – constant angular velocity of fluid rotation; ρ_b - gas density in a bubble.

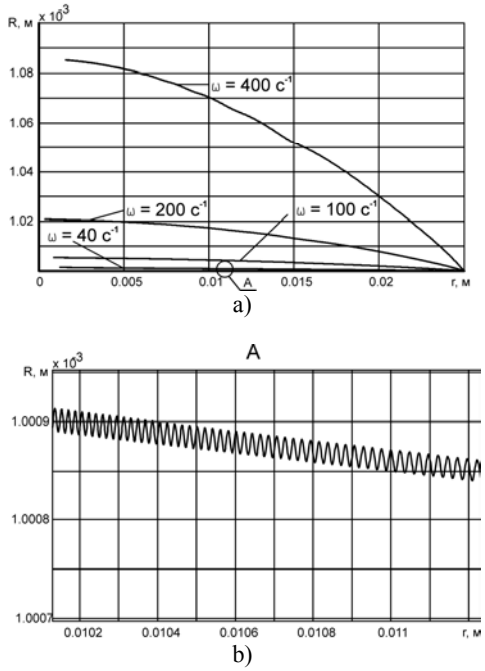
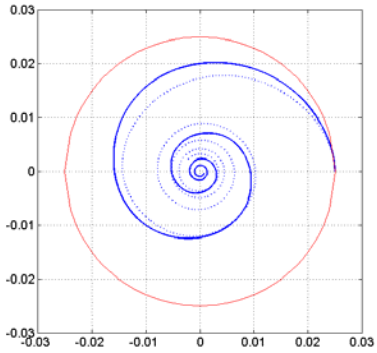


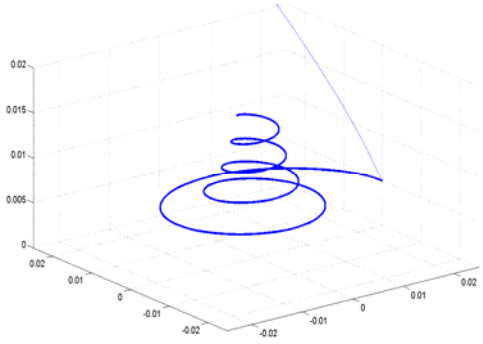
Fig. 2. Dependence of bubble radius to radius of the vortex chamber

As it is visible from a fig. 2, greater angular fluid rotation velocity, there corresponds the greater change of a radius bubble value. For $\omega \le 200$ s^{-1} change of bubble radius on exceeds of one percent. Besides as usage of an Rayleigh-Plesset equation is visible from a fig. 2.b, to take into account influencing change of bubble radius on its motion characteristics, results that time of calculation owing to a considerable variability of radius change is augmented sharply. Thus, at $\omega \le 100$ s^{-1}, there is no necessity to apply to calculation of bubble radius of an Rayleigh-Plesset

equation, and simplistically in further calculations it is possible to count, that the motion bubble in the a fluid rotated field with a constant angular velocity, has constant radius, besides the time expended on calculation is diminished.



a)



b)

Fig. 3. Results of a trajectory calculation of a gas bubble in a fluid rotated with a constant angular velocity (a - in meridian plane, b - in space)

In a fig. 3 typical trajectories of gas bubble motion in the vortex chamber are displayed. They have the good agreement with theoretical and experimental researches, cited in operation [Van Nierop 2007]. At change of main specifications influential in motion characteristics of moving (ω, R_b, ν), aspect of trajectories invariable, that is visible from a fig. 3.a, where the solid and dash lines two trajectories with a various set ω, R_b, ν. The main difference between trajectories - time, during which one a gas bubble reaches zone of an axial output channel of the vortex chamber. Thus, at an identical aspect of trajectories, two versions of bubble moving in the vortex chamber are possible: if the bubble reaches an axis, it there and remains, if the bubble reaches the upper end wall of the vortex chamber (light line in a fig. 3.b) earlier, than axis of the vortex chamber, it can be evacuated by flow of a fluid in a boundary layer on end walls escaping the vortex chamber.

By main specifications influential in time, for which one the bubble can reach radius of an output axial channel, are ω, R_b, ν, that is visible from a set of equations (4). As at bubble motion in a fluid flow through a definite instant, velocity of a bubble and the fluids are completed, it is possible to consider, that the flow steamlining of a bubble takes place to small numbers of the Reynolds Re_b, then it is possible to suppose, that $C_D = \frac{24}{\mathrm{Re}_b}$ or $C_D = \frac{12\nu}{R\omega r}$. Then, by transformations of a system (4) it is possible to receive, that the basic complex which is exerting influence on a trajectory looks like this - $\frac{2}{9}\frac{\omega R}{\nu}$. It is confirmed by outcomes of timing of reaching by a gas bubble of radius of an output axial channel of the short vortex chamber $\left(\overline{R}_0 = \frac{R_0}{R_k}0,2\right)$, displayed on a fig. 4.

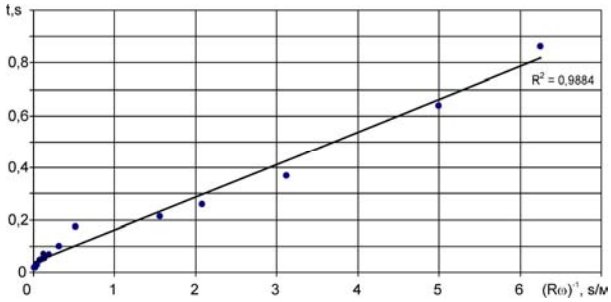


Fig. 4. Dependence of bubble moving time in the chamber from a complex of parameters $R\omega$

As the requires time for a gas bubble is visible from a fig. 4, to reach an axial channel in an end wall of the vortex chamber, is directly proportional to a complex of magnitudes $(R\omega)^{-1}$, that is confirmed by quadrate of a mixed correlation, equal 0,988. The relation of time to kinematic viscosity of a fluid is not showed, as the researches were conducted at constant viscosity, equal water viscosity. Generally speaking, time of moving, as well as the motion characteristics of bubble moving depend on a complex of values - $\frac{\nu}{\omega R}$. Thus, than more angular velocity of a fluid rotation, the more initial gas bubble radius, that the smaller time is necessary for it to reach an axis of the vortex chamber, and on the contrary, the

smaller angular velocity of rotation and radius, the greater is necessary time.

CONCLUSIONS

1. The more angular velocity of a fluid rotation, the greater change of bubble radius at moving it to an axis of the vortex chamber. For $\omega \le 100$ s^{-1} change of bubble radius on exceeds of one percent.

2. At $\omega \le 100$ s^{-1}, there is no necessity to apply to calculation of a bubble radius an Rayleigh-Plesset equation, and it is possible to count, that the bubble at moving in the field of a fluid rotated with a constant angular velocity, has constant radius.

3. Two versions of a bubble moving in the vortex chamber are possible, that it will reach - axis of the chamber or end wall earlier. If the bubble reaches an axis, it there and remains, if the bubble reaches an end wall, it can be evacuated by flow of a fluid in a boundary layer on end walls escaping the vortex chamber.

4. The time for a gas bubble to reach an axial channel in an end wall of the vortex chamber, is directly proportional to a complex of magnitudes $(R\omega)^{-1}$. Therefore, than more angular velocity of a fluid rotation, and, the more initial radius of a gas bubble, that the smaller time is necessary for it to reach an axis of the vortex chamber, and on the contrary, the smaller angular velocity of rotation and radius, the greater is necessary time.

REFERENCES

1. **Akhtar M. A., 2006.:** Two-Fluid Eulerian Simulation of Bubble Column Reactors with Distributors / Akhtar, M. A., M. O. Tade and V. K. Pareek // Journal of Chemical and Engineering of Japan, Vol. 39, No. 8, 831-841 (2006).
2. **Ardnt R., 1995.:** "Vortex Cavitation," Green , S. Ed. FLUID VORTICES, Fluid Mechanics and Its Applications, Vol. 30, Kluwer Academic Publisher, Boston, pp. 731-782
3. **Chahine G.L, 1996.:** "Bubble Dynamics and Cavitation Inception in Non-Uniform Flow Fields," 20th Symposium on Naval Hydrodynamics, Santa Barbara, California, August 1996, pp. 290-311.
4. **Hsiao C., Chahine G., 2004.:** "Prediction of Vortex Cavitation Inception Using Coupled Spherical and Non – Spherical Models and UnRANS Computations", Symposium on Naval Hydrodynamics Fukooka, JAPAN, 8-13 July 2004.
5. **Hua J. and Lou J., 2007.:** Numerical simulation of bubble rising in viscous liquid, J. Comput. Phys. 222 (2007), 769-795.
6. **Latorre R. 1980.:** "Study of Tip Vortex Cavitation Noise from Foils and Propellers," International Shipbuilding Progress pp. 676-685.
7. **Maxey M. R., Riley J. J., 1983.:** "Equation of Motion for a Small Rigid Sphere in a Nonuniform Flow", Phys. Fluids, Vol. 26, No. 4, pp. 883 –889.
8. **Plesset M . S., 1948.:** "Dynamics of Cavitation Bubbles", Journal of Applied Mechanics, 16, 228-231.
9. **Pozdeev V.A., Tsurkin V.N., 2003.:** About low frequency oscillation of bubbles in a chattering liquid. / //Acoustical visnyk. – Kiev.:2003. – V 6., №1. – C. 43-47.
10. **Raoufi A, Shams M, Ebrahimi R, Ahmadi G, 2006.:** "The Eulerian–Lagrangian analysis of the bubble motion in a gate slot", 14th International Mech. Engng. Conf., Esfehan, Iran.
11. **Rogoviy A.S., 2007.:** Perfecting of the power characteristics of ink-jet superchargers.- The manuscript. Thesis on support of a scientific degree of the candidate of technical science on a speciality 05.05.17 - Hydraulic machines and hydropneumatics sets.- Sumy State University, Sumy – 193 p.
12. **Syomin D.A., 2002.:** Asymptotic values of vortex devices parameters by control transportation of liquid mediums. // Visnyk of ENU named after V.Dal. – №6(52), 2002, V.2. – C.189 – 196.
13. **Syomin D., Pavljuchenko V., Maltsev Y., Rogovoy A., Dmitrienko D., 2010.:** Vortex mechanical devices in control systems of fluid mediums. // Polish academy of sciences branch in Lublin. TEKA. Commission of motorization and power industry in agriculture. Volume X. TEKA Kom. Mot. Energ. Roln. – OL PAN, № 10. – P. 440-445.
14. **Syomin D., Rogovoy A., 2010.:** Power characteristics of superchargers with vortex work chamber // Polish academy of sciences branch in Lublin. TEKA. Commission of motorization and power industry in agriculture. Volume XB. TEKA Kom. Mot. Energ. Roln. – OL PAN, № 19. – 2010 - P. 232-240.
15. **Syomin D., Rogovyi A., 2012.:** Features of a working process and characteristics of irrotational centrifugal pumps. // Procedia Engineering, Volume 39, 2012, Pages 231–237. http://dx.doi.org/10.1016/j.proeng.2012.07.029
16. **Syomin D.A., Rogovyi A.S., 2005.:** Experimental investigations of the fluidic vortex pump. // Visnyk of SumDU. – 2005. – 12(84). – C. 64-70.
17. **Syomin D.A., Rogovyi A.S., 2010.:** Mathematical modelling of a gas bubble motion in the short vortex chamber.// Visnyk of ENU named after V.Dal. – Luhansk: №5 (147). P.1 – 2010. – C. 189 – 195.
18. **Van Nierop E, Luther S, Bluemink B, Magnaudet J, Prosperetti1 A., Lohse1 D., 2007.:** Drag and lift forces on bubbles in a rotating flow // J. Fluid Mech. (2007), vol. 571, pp. 439–454.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ ДВИЖЕНИЯ ГАЗОВОГО ПУЗЫРЬКА В ЦЕНТРАЛЬНОЙ ОБЛАСТИ КОРОТКОЙ ВИХРЕВОЙ КАМЕРЫ

Сёмин Дмитрий, Роговой Андрей

Аннотация. Приведены результаты теоретических исследований движения изолированного газового пузырька в центральной области короткой вихревой камере в капельной несущей среде. Составлена математическая модель, описывающая траекторию движения пузырька под влиянием сил, действующих на него, в которой учтено изменение радиуса пузырька. Получено соотношение величин, оказывающих основное воздействие на кинематические параметры движения пузырька. Результаты исследований могут быть применены при исследовании поведения пузырька во вращающейся с постоянной угловой скоростью капельной жидкости.

Ключевые слова: траектория движения, газовый пузырек, капельная жидкость, угловая скорость, вихревая камера.

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Mathematical design and operations of electronic vehicles management and introduction of results of researches in an educational process

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Summary. In work is grounded and is offered mathematical model and transmissions functions of the adjusting system for the process of production of electronic vehicles for the different setting and external environments. Also work is devoted to introduction of the got results in an educational process, namely in the process of teaching of students

Key words: management, process of production, electronic vehicle, mathematical model, process of production, channels of influencing, introduction, educational process.

INTRODUCTION

In the modern terms of work of higher educational establishments it is necessary to instill skills of analysis and generalization of the got information to the students. This task can successfully decide within the framework of educational-research work of students. That this work joins in a curriculum is the feature of educational-research work of students, and to the individual jobs processing all students of educational group are brought over. During organization of educational-research work of students it is necessary widely to use possibilities of modern computer technique application of which allows to show out educational-research work of students on a high-quality new level [1].

OBJECTS AND PROBLEMS

The improvement of method of teaching to the students, providing establishment and cooperate to the realized application of mathematical design, is the purpose of researches, to research of transmissions functions of the systems of adjusting, channels of influencing, operator calculation directly for the process of production of electronic vehicles of the different setting and external environments [2].

For the decision of the set problem functional dependence of process of production of block of electronic vehicle of the domestic setting was got as the stochastic model of type [3]:

$$y=3.721*10^{-4}+0.435(0.013+0.895((1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}* x^{<7>}+5.628*10^{-3*}x^{<4>}*x^{<7>}-2.317**10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2))-0.047((7.897*10^{-6}+7.642*10^{-4}* x^{<3>}-1.171*10^{-3}* x^{<9>}+1.169*10^{-3*} x^{<3>}**x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2))+7.427*10^{-3}(1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}* x^{<7>}++5.628*10^{-3*} x^{<4>}* x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)(7.897*10^{-6}+7.642*10^{-4}* x^{<3>}-1.171*10^{-3}**x^{<9>}+1.169*10^{-3*} x^{<3>}* x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)+0.317(1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-- 2.04*10^{-3}* x^{<7>}+5.628*10^{-3*} x^{<4>}* x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)^2-0.018(7.897*10^{-6}+7.642**10^{-4}* x^{<3>}-1.171*10^{-3}* x^{<9>}+1.169*10^{-3*} x^{<3>}* x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)^2)+0.508 (1.459**10^{-5}+5.611*10^{-3}*x^{<4>}+4.329*10^{-3}*x^{<19>}+1.518*10^{-3*}x^{<4>}*x^{<19>}-1.843*10^{-3}*(x^{<4>})^2-4.444*10^{-4}*(x^{<19>})^2)++2.142 *10^{-4}(0.013+0.895((1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}*x^{<7>}+5.628*10^{-3*} x^{<4>} *x^{<7>}- 2.317*10^{-3}**(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2))- 0.047((7.897*10^{-6}+7.642*10^{-4}*x^{<3>}-1.171*10^{-3}*x^{<9>}+1.169*10^{-3}*x^{<3>} *x^{<9>}--3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2))+7.427*10^{-3}(1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}* x^{<7>}+5.628**10^{-3*} x^{<4>} * x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)*(7.897*10^{-6}+7.642*10^{-4}* x^{<3>}-1.171*10^{-3}* x^{<9>}++1.169*10^{-3*} *x^{<3>} * x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)+ 0.317(1.876*10^{-4}+6.167*10^{-3}* x^{<4>}- 2.04**10^{-3}* x^{<7>}+5.628*10^{-3*} x^{<4>} * x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)^2-0.018(7.897*10^{-6}+7.642*10^{-4}*$$

$$*x^{<3>}-1.171*10^{-3}* x^{<9>}+1.169*10^{-3*} x^{<3>} *x^{<9>}- 3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)^2)(1.459*10^{-5}+5.611* *10^{-3}* x^{<4>}+4.329*10^{-3}*x^{<19>}+1.518*10^{-3}* *x^{<4>}*x^{<19>} -1.843*10^{-3}* *(x^{<4>})^2-4.444*10^{-4}*(x^{<19>})^2) +0.153* *(0.013+0.895((1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}* x^{<7>}+5.628*x10^{-3*} x^{<4>} * x^{<7>}- 2.317*10^{-3}*(x^{<4>})^2+ +4.873*10^{-4}*(x^{<7>})^2))- 0.047((7.897*10^{-6}+7.642*10^{-4}* x^{<3>}-1.171*10^{-3}* *x^{<9>}+1.169*10^{-3*}x^{<3>}*x^{<9>}-3.953* *10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2))+ 7.427*10^{-3}(1.876*10^{-4}+6.167*10^{-3}*x^{<4>}-2.04*10^{-3}* x^{<7>}+5.628*10^{-3*}x^{<4>}* *x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)(7.897*10^{-6}+7.642*10^{-4}*x^{<3>}-1.171*10^{-3}*x^{<9>}+1.169*10^{-3}*x^{<3>}* *x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)+ 0.317(1.876*10^{-4}+6.167*10^{-3}* x^{<4>}-2.04*10^{-3}* *x^{<7>}+5.628* *10^{-3*}x^{<4>}*x^{<7>}-2.317*10^{-3}*(x^{<4>})^2+4.873*10^{-4}*(x^{<7>})^2)^2- 0.018*(7.897*10^{-6}+7.642*10^{-4}*x^{<3>}-1.171*10^{-3}* *x^{<9>}+1.169*10^{-3*}x^{<3>}*x^{<9>}-3.953*10^{-4}*(x^{<3>})^2+9.188*10^{-5}*(x^{<9>})^2)^2)^2+0.161(1.459*10^{-5}+5.611*10^{-3}* x^{<4>}+ +4.329*10^{-3}*x^{<19>}+1.518*10^{-3*}x^{<4>} *x^{<19>}-1.843*10^{-3}*(x^{<4>})^2- 4.444*10^{-4}*(x^{<19>})^2)^2. \quad (1)$$

All coefficients at variables in (1) is determined in accordance with the selection of applicants by the method of group account of argument [4, 6, 11].

Examining the got type of model, it is necessary to estimate its sensitiveness on the explored channels, signals on the other channels we suppose equal to the zero. At the same time we determine Laplas's transformation for the subsequent receipt of transmission function on the explored channel of influencing [9, 10].

After transformation [14, 16], adduction of similar and simplifications (1) for a channel x3 the following model of influencing was got:

$$y_{x3\to y}= 6.1339*10^{-3} – 1.5768*10^{-5}*x3+ 8.1522* *10^{-6}*x3^2 + 4.5704*10^{-9}*x3^3 – -1.1822*10^{-9}*x3^4 + 9.2704*10^{-14}*x3^5 – -1.5963*10^{-14}*x3^6 – 9.3602*10^{-18}*x3^7 + + 1.2104*10^{-18}*x3^8. \quad (2)$$

Laplas's transformation for (2) looks like:

$$L\{y_{x3\to y}\}=6.1339*10^{-3}*1/s – 1.5768*10^{-5}*1/s^2+ +1.6304*10^{-5}*1/s^3 + 2.7423*10^{-8}*1/s^4 – -2.8374*10^{-8}*1/s^5 + 1.1125*10^{-11}*1/s^6 – -1.1494*10^{-11}*1/s^7 – 4.7175*10^{-14}*1/s^8 + +4.8805*10^{-14}*1/s^9. \quad (3)$$

For a channel x4 the following model of influencing was got:

$$y_{x4\to y}=6.1339*10^{-3} + 5.2739*10^{-3}*x4 – 1.8318* *10^{-3}*x4^2 – 1.0795*10^{-5}*x4^3 + +1.930*10^{-6}*x4^4+ 8.5962*10^{-9}*x4^5 – 1.0619* *10^{-9}*x4^6 – 4.7176*10^{-12}*x4^7 + +4.4311*10^{-13}*x4^8. \quad (4)$$

Laplas's transformation for (4) looks like:

$$L\{y_{x4\to y}\}=6.1339*10^{-3}*1/s + 5.2739*10^{-3}*1/s^2 – -3.6635*10^{-3}*1/s^3 - 6.4768*10^{-5}*1/s^4 + +4.6320*10^{-5}*1/s^5+ 1.0315*10^{-6}*1/s^6- - 7.6455*10^{-7}*1/s^7– 2.3777*10^{-8}*1/s^8 + +1.7866*10^{-8}*1/s^9. \quad (5)$$

For a channel x7 the following model of influencing was got:

$$y_{x7\to y}=6.1339*10^{-3}-8.0169*10^{-4}*x7 + 1.9259* *10^{-4}*x7^2 – 5.2117*10^{-7}*x7^3+ + 6.2687*10^{-8}*x7^4 – 1.2644*10^{-10}*x7^5 + +1.0139*10^{-11}*x7^6 – 1.4517*10^{-14}*x7^7 + +8.6695*10^{-16}*x7^8. \quad (6)$$

Laplas's transformation for (6) looks like:

$$L\{y_{x7\to y}\}=6.1339*10^{-3}*1/s – 8.0169*10^{-4}*1/s^2+ +3.8518*10^{-4}*1/s^3 –3.1271*10^{-6}*1/s^4+ +1.5045*10^{-6}*1/s^5 – 1.5173*10^{-8}*1/s^6 + +7.2997*10^{-9}*1/s^7 – 7.31678*10^{-11}*1/s^8 + +3.4956*10^{-11}*1/s^9. \quad (7)$$

For a channel x9 the following model of influencing was got:

$$y_{x9\to y}= 6.1339*10^{-3} + 2.4162*10^{-5}*x9 – 1.9062* *10^{-6}*x9^2 + 1.6273*10^{-9}*x9^3 – -6.3762*10^{-11}*x9^4– 7.7064*10^{-15}* *x9^5 +2.0423*10^{-16}*x9^6 – 1.8011*10^{-19}*x9^7+ +3.5328*10^{-21}*x9^8. \quad (8)$$

Laplas's transformation for (8) looks like:

$$L\{y_{x9\to y}\}=6.1339*10^{-3}*1/s + 2.4162*10^{-5}*1/s^2- -3.8124*10^{-6}*1/s^3 + 9.7641*10^{-9}*1/s^4 – -1.5303*10^{-9}*1/s^5 - 9.2477*10^{-13}*1/s^6 + +1.4705*10^{-13}*1/s^7 – 9.0771*10^{-16}*1/s^8+ +1.4244*10^{-16}*1/s^9. \quad (9)$$

For a channel x19 the following model of influencing was got:

$$y_{x19\to y}= 6.1339*10^{-3} + 2.1992*10^{-3}*x19 – 2.2274* *10^{-4}*x19^2 – 6.1947*10^{-7}*x19^3+ +3.1796*10^{-8}*x19^4. \quad (10)$$

Laplas's transformation for (10) looks like:

$$L\{y_{x19\to y}\}= 6.1339*10^{-3}*1/s + 2.1992*10^{-3}*1/s^2 – - 4.4548*10^{-4}*1/s^3 – 3.7168*10^{-6*}1/s^4 + + 7.6311*10^{-7}*1/s^5. \quad (11)$$

Supposing that on the entrance of the system discrete moments of time discrete signals enter, as entrance influence on the explored channels we will take $\delta(t)$- function for which $L\{\delta(t)\}=1$. For construction of the control [2, 5, 18] system, we unite the explored channels parallel, on their basis we build the watching system. A public transmission function will look like on the taken into account in a model channels of management, incorporated parallel [12, 13]:

$$W(s)=\frac{\left(\begin{array}{l}3.067\cdot10^{25}\cdot s^8+6.680\cdot10^{24}\cdot s^7-\\-3.711\cdot10^{24}\cdot s^6-7.158\cdot10^{22}\cdot s^5+\\+4.856\cdot10^{22}\cdot s^4+1.016\cdot10^{21}\cdot s^3-\\-7.573\cdot10^{20}\cdot s^2-2.385\cdot10^{19}\cdot s+\\+1.790\cdot10^{19}\end{array}\right)}{\left(\begin{array}{l}1.000\cdot10^{27}\cdot s^9+3.067\cdot10^{25}\cdot s^8+\\+6.680\cdot10^{24}\cdot s^7-3.711\cdot10^{24}\cdot s^6-\\-7.157\cdot10^{22}\cdot s^5+4.856\cdot10^{22}\cdot s^4+\\+1.016\cdot10^{21}\cdot s^3-7.573\cdot10^{20}\cdot s^2-\\-2.385\cdot10^{19}\cdot s+1.790\cdot10^{19}\end{array}\right)}. \quad (12)$$

Examining the discrete system [7,8 17], for the receipt of impulsive transmission function from the got continuous function, examining five parallel united blocks incorporated parallel, realized (3), (5), (7), (9), (11). Limited to consideration of region of frequencies substantially less frequencies of quantum, organizing watching system, we get a discrete transmission function realizing (12), which looks like:

$$W(z)=\left(\sum_{p_k}\frac{z}{z-e^{p_k/T}}\operatorname{Re}s\left(W\left(p_k\right)\right)\right), \quad (13)$$

where: p_k – poles continuous transmission function (12), Res($W(p_k)$) - deduction (coefficient at p_k in decomposition in the Loran's row of continuous transmission function (12)) .

After transformation (12) and substitution in (13), the last expression will assume an air:

$$W(z)=\left(\begin{array}{l}\frac{2.0\cdot10^{18}\cdot z}{z-e^{-0.123/T}}+\\+\frac{(8.621\cdot10^{18}+3.445\cdot10^{18}\cdot i)\cdot z}{z-e^{-9.136\cdot10^{-2}-8.973\cdot10^{-2}\cdot i/T}}+\\+\frac{(8.621\cdot10^{18}-3.445\cdot10^{18}\cdot i)\cdot z}{z-e^{-9.136\cdot10^{-2}+8.973\cdot10^{-2}\cdot i/T}}+\\+\frac{(1.062\cdot10^{19}-9.981\cdot10^{18}\cdot i)\cdot z}{z-e^{-6.461\cdot10^{-2}-0.171\cdot i/T}}+\\+\frac{(1.062\cdot10^{19}+9.981\cdot10^{18}\cdot i)\cdot z}{z-e^{-6.461\cdot10^{-2}+0.171\cdot i/T}}-\\-\frac{0.5\cdot z}{z-e^{7.431\cdot10^{-2}-9.756\cdot10^{-2}\cdot i/T}}-\\-\frac{0.5\cdot z}{z-e^{7.431\cdot10^{-2}+9.756\cdot10^{-2}\cdot i/T}}+\\+\frac{(1.0-9.999\cdot10^{18}\cdot i)\cdot z}{z-e^{0.127-3.471\cdot10^{-2}\cdot i/T}}+\\+\frac{(1.0+9.999\cdot10^{18}\cdot i)\cdot z}{z-e^{0.127+3.471\cdot10^{-2}\cdot i/T}}\end{array}\right). \quad (14)$$

Structure of calculable block, realizing (14), simultaneously being part of the intellectual system of support of decision-making for production of electronic vehicles [3, 15], will look like, represented on a fig. 1.

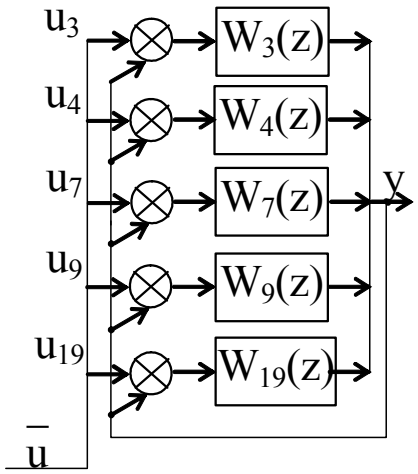

Fig. 1. Calculable block of case frame for production of domestic electronic vehicle

For a fig. 1 acting discrete signals on the entrance of the digital summarizing are processed in accordance with (14) and due to the watching system high exactness and fast-acting of all chart is provided, however at construction of the system it is necessary to consider ceiling of the variables selected as managing influences, for the electronic vehicles of the different setting of the general intellectual control system [19, 20].

Implementation of similar variant of individual tasks of educational-research work of students is instrumental in intellectual development of students, systematization of the accumulated and again got knowledges, capture by the methods of estimation of designers decisions. Teaching to the receipt of transmissions functions of the system and its elements, public transmission function of the system, theorem of deductions, is carried out on the examples of the known environment of constructing and production of electronic vehicles, that acts not unimportant part in intellectual development of taught.

CONCLUSIONS

As a result of the conducted researches, the improved method of teaching of disciplines for students, providing establishment and cooperant to the realized application of mathematical design, was offered, researches of transmissions functions

of the systems of adjusting, channels of influencing, operator calculation directly for the process of production of electronic vehicles of the different setting and external environments.

REFERENCES

1. **Ivakhnenko A.G. 1985.:** Samoorganyzatsyya of the forecasting systems / A.G. Ivakhnenko, I.F. Myuller. − Kyiv: Technique, 1985. − 223 P.
2. **Saaty T. 1993.:** Decision-making. Method of analysis of hierarchies / T. Saaty. – M.: Radio and svyaz, 1993. – 320 P.
3. Flexible computerized systems: planning, design and management / L.S. Jampolskyy, P.P. Melnychuk, B.B. Samotokin, M.M. Polishuk, M.M. Tkach, K.B. Ostapchenko, O.I. Lisovichenko.- Shytomyr: SNTU, 2005. - 680 P. + CD
4. Patent of Ukraine on an useful model №25789. Method of design of process of production of electronic vehicle / V.A. Ulshin, V.N. Smoliy; East Ukrainian National University named after V.Dal; Published. 27.08.2007; Bulletin. № 13.
5. **Ulshin V.A., Smoliy V.N., 2007.:** Application of method of analysis of hierarchies for research of purpose, external and features of process of production of electronic vehicles environments // Problems of informations technologies. – 2007. - №2 (002). – PP. 106 – 111.
6. **Ulshin V.A., Genkin B.I., Smoliy V.N., 2010.:** Automation of designer preparation of production of electronic vehicles // Visnik of the East Ukrainian National University named after V.Dal. – - № 6 (148) Part.2. - PP. 61 - 66.
7. **Smoliy V.N., 2009.:** Use of method of group account of argument for the design of operations management of domestic electronic vehicles / V.N. Smoliy // Visnik of the East Ukrainian National University named after V.Dal. – Lugansk: East Ukrainian National University named after V.Dal, 2009. - № 1(131) - PP. 163-169.
8. **Smoliy V.N., 2008.:** Research of economic costs of the modified process of production of electronic vehicles by the method of analysis of hierarchies / V.N. Smoliy // Visnik of the East Ukrainian National University named after V.Dal. – Lugansk: East Ukrainian National University named after V.Dal, – №7 (125). - PP. 75-80.
9. **Smoliy V.N., 2009.:** Case frame by production of stationary electronic vehicle/ V.N. Smoliy // Progressive technologies and systems of construction of machines: International collection of scientific labours. – Donetsk: DNTU, - Issue 37. – PP.255-259.
10. **Smoliy V.N. 2009.:** Case frame by production of transporting electronic vehicle / V.N. Smoliy // Scientific Papers of Donetsk National Technical University. Series «Informatics, Cybernetics and Computer Science» (ICCS - 2009). – Donetsk: DNTU, - Issue. 10(153) – PP. 217-223.
11. **Smoliy V.N., 2009.:** Knowledges bases for the electronic vehicles of different purpose / V.N. Smoliy // Visnik of the Kherson National Technical University. – Kherson: KNTU, – № 1 (34). - PP. 121 - 126.
12. **Smoliy V.N., 2009.:** Operations management of the difficult organized technological objects / V.N. Smoliy // Visnik of the East Ukrainian National University named after V.Dal. – Lugansk: East Ukrainian National University named after V.Dal, - № 2 (132). – PP. 46 - 55.
13. **Smoliy V.N., 2009.:** System of support of decision-making production of electronic vehicles / V.N. Smoliy // Praci Lugansk Branch of International Informatization Academy. – Lugansk: East Ukrainian National University named after V.Dal, – №2 P.2. (20). - PP.44-49.
14. **Smoliy V.N., 2010.:** Research of efficiency of management of process of production of electronic vehicles // Progressive technologies and systems of construction of machines: International collection of scientific labours. – Donetsk: DNTU, - Issue 39. – P. 174 - 178.
15. **Smoliy V.N., 2009.:** Research of administrative benefits of the modified process of production of electronic vehicles by the method of analysis of hierarchies // Visnik of the East Ukrainian National University named after V.Dal. – - № 12 (142) Part 2. - P. 92 - 98.
16. **Smoliy V.N., 2010.:** Case frame by production of electronic vehicle of military purpose // Scientific Papers of Donetsk National Technical University. Series «Informatics, Cybernetics and Computer Science» (ICCS - 2010). – Donetsk: DNTU. - - Issue 11(164) – PP. 188 - 193 .
17. **Smoliy V.N. 2006.:** Automation of processes of production of blocks of electronic vehicles: Monographija. – Lugansk: East Ukrainian National University named after V.Dal, – 124 P.
18. **Smoliy V.N. 2010.:** Hierarchy of criteria in the operations management of electronic vehicles / V.N. Smoliy // Praci Lugansk Branch of International Informatization Academy. – Lugansk: East Ukrainian National University named after V.Dal, – №1(21). - PP. 64 - 69.
19. **Ulshin V., 2011.:** Automated management by designer preparation of production of electronic vehicles/ Vitaly Ulshin, Victoria Smoliy // TEKA Kom. Mot. I Energ. Roln. – 2011. - 11A. - P. 276 – 281.
20. **Ulshin V., 2011.:** Case-based reasoning method for diagnostic decision support system of bridge cranes/ Vitaly Ulshin, Sergey Klimchuk // TEKA Kom. Mot. I Energ. Roln. – 2011. - 11A. - P. 266 – 275.

МАТЕМАТИЧЕСКОЕ МОДЕЛИРОВАНИЕ И УПРАВЛЕНИЕ ПРОИЗВОДСТВОМ ЭЛЕКТРОННЫХ АППАРАТОВ И ВНЕДРЕНИЕ РЕЗУЛЬТАТОВ ИССЛЕДОВАНИЙ В УЧЕБНЫЙ ПРОЦЕСС

Виталий Ульшин, Виктория Смолий, Ярослав Фомин

Аннотация. В работе обосновывается и предлагается математическая модель и передаточные функции системы регулирования для процесса производства электронных аппаратов различного назначения и условий эксплуатации. Также работа посвящена внедрению полученных результатов в учебный процесс, а именно в процесс обучения студентов.

Ключевые слова: управление, процесс производства, электронный аппарат, математическая модель, процесс производства, каналы влияния, внедрение, учебный процесс.

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Development of control system of hydraulic press based on zelio logic controller

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S u m m a r y Modernization of control system of hydraulic press of model 2240D with the usage of programmable logical controller, namely intellectual relay Zelio Logic is considered. The consequence of technological operations fulfillment such as pressing, non-formal control algorithm, choice motivation of PLC model SR3B261B, control program fragment in the FBD language is given.
K e y w o r d s : Press, input, output, algorithm, the controller program, logical controller, software, language

INTRODUCTION

The development and mass industrial usage of microprocessor control units (MCU) and microprocessor control systems (MCS) is one of the most important directions of scientific-technological progress in the sphere of automation of stationary and mobile objects in industrial production, transport and communication.

Functionally finished MCU on the base of which the majority of information and control systems are built today are the most interesting ones among a lot of other means of MP technique for the specialists dealing with the automation of industrial objects. MCU can be directly built up into the technological units, assembly complexes, stationary and mobile objects. Thus, control quality of a technological process is essentially, greatly increased, the consumption of energy, raw materials is saved, and the industrial production and product quality is greatly increased.

By nowadays the majority of up-to-date systems of industrial automation are built on the basis of highly-reliable and easily-arranged programmable logic controllers (Programmable logic controllers) PLC and industrial computers (Industrial Computers) IC. Both of them are adapted to work under hard production conditions and they differ from others that PLC are aimed only at direct control of industrial equipment (that is to solve the tasks only in the mode of "tough real time"), but IC along with the control tasks solve the tasks of processing and visualizing of a great amount of information at high levels of complex integrated systems of automation of industrial production [12], [Korop 2011].

The diversity of PLC and IC models, functional possibilities and technological characteristics allows us to consider them as multi-purpose means with the help of which practically all tasks of industrial automation can be solved [11].

The development of control system of hydraulic press 2240D [19] on the basis of programmable controller- intellectual relay Zelio Logic is investigated in this work. Developing control systems the intellectual relay Zelio Logic model SR 3B261B and programmable software Zelio Soft have been used. The program is written in FBD language.

The aim of work is to develop and adjust control system of hydraulic press 2240D.

OBJECTS AND PROBLEMS

The press is designed for pressing of large-sized manufactured goods made of plastics. The size of a product depends on the main mould. Pressing force is 1000 tons. Maximum height of pressed products is 650 mm. Press is a vertical

column structure with an upper hydraulic drive. It has a movable cross-piece, a central pusher adjusted for a products blasting in a mould, regulating its motion that is the pusher's motion can be done at definite height (100 mm, 150mm 200mm, 250mm). The photo of the upper part of the hydraulic press is given on figure 1.

Fig. 1. Hydraulic press

The weight of the products is till 30kg. Hydraulic drive consists of a filling and reserved tanks, two pumping plants, two hydro-panels. The press bed is a frame consisting of a basis with the place for a sliding table and an upper cross-piece tightened by 4 columns taking press force. For comparison we see that thermo-plastic automate KYASE 1000 creates locking force of 1000 tons and a maximum weight of product shot is only 6 kg.

Mould preheating is done with the help of two regulators Micra 602 which control the mould heating. The temperature is controlled by thermocouples of TXK type. Load current is visually controlled by the ammeter readings. Short-circuit protection is performed by high speed switches with nominal current of 50A.

Developing the control system all necessary modes of press working and blocking are realized. The analysis of designed circuit interaction showed that it is necessary to have a controller with 16 discrete inputs (a Cross –piece down, a Cross-piece up, a Pusher down, a Pusher up, EKM maxim., a Cross-piece at the bottom, a Cross-piece at the top, a Pusher at the bottom, a Pusher at the top, Switching on the hydro-power station, Switching off the hydro-power station, EKM minim., Pressure relay, Pusher position).

To give the commands the controller must have 9 discrete outputs (a Cross –piece down, a Cross – piece up, a Pusher up, a Pusher down, Electro-magnets YM 5, 6, Pressure release, Electro-magnet YM 4, High pressure of M1, Control of M3.

In accordance with necessary number of input and output signals the model of Intellectual relay Zelio Logic SR3B261B [20] is chosen. Input signals are connected to the ports of microcontroller I1 – IG, and output signals are connected to out ports Q1 –Q9. The location of electrical equipment in the control cabinet is shown on fig.2.

Fig.2. The location of electrical equipment in the control cabinet.

ALGORITHM OF PRESS CONTROL

Initial position: a cross piece is at the top (transducer SQ1); a pusher is at the bottom (transducer SQ2). A worker lays down weighted hot polymeric mass PP or PE (after extruder) into a mould of a press. Then he presses button SA1 (a cross piece is going down). YM1 is switched on, the controller Q1 is out. The cross piece is moving down till the transducer SQ3 operation (a cross piece is at the bottom). As a result, outputs Q5, Q6 of a micro controller are activated switching on the electro magnets YM5, YM6 and creating high pressure. Press influences the melted down mass into a mould with the force given by an electro-contacted manometer.

Initial position: a cross piece is at the top (transducer SQ1); a pusher is at the bottom (transducer SQ2). A worker lays down weighted hot polymeric mass PP or PE (after extruder) into a mould of a press. Then he presses button SA1 (a cross piece is going down). YM1 is switched on, the controller Q1 is out. The cross piece is moving down till the transducer SQ3 operation (a cross piece is at the bottom). As a result, outputs Q5, Q6 of a micro controller are activated switching on the

electro magnets YM5, YM6 and creating high pressure. Press influences the melted down mass into a mould with the force given by an electro-contacted manometer.

A cross piece is hosted till the transducer operation of a cross piece upper position SQ1 – input I7. Q2 –YM2 is switched off, a cross piece stops.

The operator presses SA4 buttons (input I4), switches output Q3 –YM3, a pusher is moving upward during the given time, by this the hosting height is determined which is given by using four buttons. The operator extracts the product from a mould and then lowers a pusher down. The cycle may be repeated. The protection of press working area is realized using photo-electric transducers.

CONTROL PROGRAM

The program fragment is written in FBD language, and it is given on fig.3.

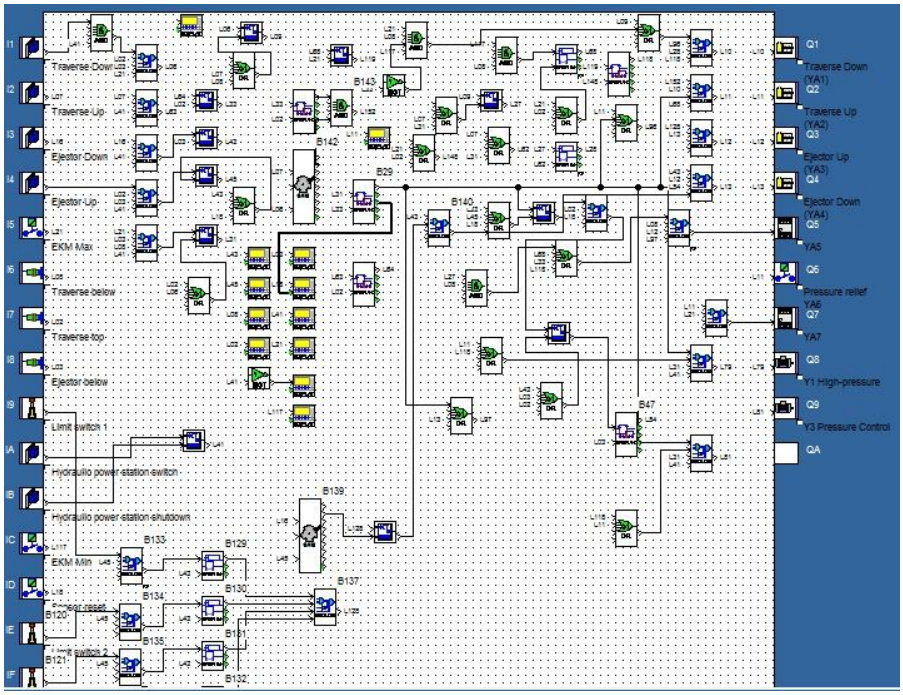

Fig. 3. The control program fragment in FBD language

Developing the control system program software Zelio Soft [21] has been used. Programming has been done in the language of functional blocks (FBD) providing the flexibility of programming and high productivity. Zelio Soft performs the checking of coordination, makes syntaxes checking and checks the correctness of data introducing; all this helps correct all errors immediately. The program is tested in real time, and in this case the module can be either connected to the PC or not. Control window shows the input or output conditions of a module in the sphere of applied program.

LCD display on a chosen controller model and usage of DISPLAY function allowed us to show constantly the condition of operated mechanisms what makes the adjusting of control system considerably easier.

CONCLUSIONS

On the basis of considered principles to fulfill technological operations of plastic products pressing, studying the principle hydraulic circuit design of 2240D press, the circuit which has existed earlier on the relay-contact elements, designing the cyclorama of its work, defining necessary quantity of input and output signals we can come to the conclusion that it is possible to use a programmable controller, namely intellectual relay Zelio Logic.

The fixing of input and output signals to the corresponding ports of intellectual relays is done; the control program in FBD language is developed. The principle circuit of control system is designed and the adjusting of its work is performed.

The usage of intellectual relay Zelio Logic allowed us to reduce the sizes of the control system cabinet and the usage of software Zelio Soft and

programmable software in FBD language allowed us to develop and adjust the control system quickly.

REFERENCES

1. **Verhovodov A.V. 2009.:** Using the programme package WinPLC V4 at development managerial system. Praci Lugansk Branch of IIA №2 (20). Part 2, p.10-13.
2. **Verhovodov A.V. 2010.:** Study of the use pulsed sensor at development managerial system pipecarved tool. Praci Lugansk Branch of IIA №2 (22), p.18-22.
3. **Verhovodov A.V., Oleinik R.G. 2009.:** Study of the using the block PI regulator of the programme package WinPLC at regulation temperature processes. Visnik SNU №3, p.32-35.
4. **Verhovodov A.V., Sereda A.A. 2009.:** Use the language and programming facilities SFC standard IEC 61131 at syntheses managerial system on base PLC Zelio Logic. Visnik SNU №3, p. 32-35.
5. **Verhovodov A.V., Malahov O.V., Kalikhevich N.V. 2007.:** Syntheses managerial system horizontally-closed transport system with use the programming language FBD. System technologies. – № 2(31). – Dnepropetrovsk, p.104 -112.
6. **Verhovodov A.V., Malahov O.V., Oleinik R.G. 2008.:** Studies of the possibility of the using PLC VIPA-100 for industrial robot governing MP-9. Praci Lugansk Branch of IIA №1, p.22-25.
7. **Verhovodov A.V., Oleinik R.G. 2008.:** Study of the possibilities of the module of the analog entering-conclusion and text panel at regulation of the temperature. Praci Lugansk Branch of IIA №2, p.14-17.
8. **Verhovodov A.V., Strelbytskyy A.A., Dyubakova V.M. 2010.:** Sintesing of control system of the packaging machine with use eventing operated logic. Visnik SNU №2, p.28-34.
9. **Verkhovodov O, Kovalenko M. 2011.:** Studies of WinPLC7 V4 programming environment in developing robotic workcell control system. TEKA Kom. Mot. i Energ. Roin. – OL PAN, 11B, p. 206-212.
10. **Korop G., Parkhomenko V, Stepanchenko S., Morgachev D, Sosnov N. 2011.:** Greating a softvare system for construction of the daily schedule for rail way industrial enterprise. TEKA Kom. Mot. i Energ. Roin. – OL PAN, 11B, p. 48-53.
11. AKM-Engineering production / www.akmeng.ru
12. Components of industrial electricity saving and automation systems/ http://svaltera.prom.ua
13. Design of automatic process control system / http://energopolis.co.ua
14. Industrial controllers / http://electroalyans.com.ua
15. Manual WinPLC7 V4. / www.vipa.de.
16. PLC Vipa / http://electromatica.ru
17. Programmable logic controller Vipa / http://interexpo.com.ua
18. VIPA art of automation/ www.vipa.de / www.speed7.com.
19. Passport of Hydraulic press model 2240D.
20. Smart relays Zelio Logic. http://www. sneider electric.ru.
21. Zelio Logic. Smart relays. Users Manual. A brand of Sneider Electric, January 2004, 151p.

РАЗРАБОТКА СИСТЕМЫ УПРАВЛЕНИЯ ГИДРАВЛИЧЕСКИМ ПРЕССОМ НА ОСНОВЕ КОНТРОЛЛЕРА ZELIO LOGIC

Александр Верховодов, Александр Карпюк

Аннотация. Рассмотрена модернизация системы управления гидравлического пресса модели 2240D с использованием программируемого логического контроллера – интеллектуального реле Zelio Logic. Приведены последовательность выполнения технологической операции прессования, неформальный алгоритм управления, мотивация выбора модели ПЛК Zelio Logic модели SR3B261B, фрагмент программы управления на языке FBD.

Ключевые слова: пресс, вход, выход, алгоритм, программа управления, логический контроллер, программное обеспечение, язык.

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Control system of pneumatic air-spring suspension on transport

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Summary. The purpose of this article consists in development of the system of management by the PNEUMATIC air-spring suspension, which is allow to improve the comfort of passengers and to reduce dynamic impact on a way. The object of research is pneumatic air-spring suspension of high-speed railway transport. The work is performed by a method of theoretical research of control systems of pneumatic air-spring suspension. The task, the structure and the algorithm of a work of a control system of the pneumatic air-spring suspension are discussed in article. The problem of management is formulated as follows : it is necessary to provide the stable provision of a body concerning the way plane in the set interval and regulation by damping depending on the speed of movement of the vehicle and a condition of a way. The developed control system is recommended for use on passenger high-speed railway transport.

Key words: pneumospring, sensor, servomotor, three-stage throttle, electric air gates, GPS navigator.

INTRODUCTION

Nowadays the speed of movement of passenger trains increase to 200 km/h what is, considering a condition of a railway line, puts in the forefront problems of improvement of comfort for passengers and reduction of dynamic influence by a way.

One of solutions of these problems is using of systems of spring suspension on the basis of pneumatic springs. However, their operation shows that one of the basic elements - the regulator of provision of a body (the valve which regulates height "HV") doesn't correspond to a modern technological level on stability of characteristics because of demanding costs of carrying out adjusting works.

In particular, the work of HV which don't have delay mechanisms, is accompanied by considerable loss of the compressed air at body fluctuations on pneumosprings. Work of HV, in which hydraulic delay mechanisms are applied, depends on environment conditions in connection with change of viscosity of liquid that demands their change-over. They are also ecologically imperfect because of possible leakages of working liquid. More perfect are HV with electric delay mechanisms as their work doesn't depend on environment conditions, they are simpler in control. However wear and a burning of contacts of the sensor of provision of a body doesn't ensure of due stability functioning of all system as a whole.

More perfect is the regulator of provision of a body at which rubbing couples are excluded, and burning electric contacts are replaced by the contactless inductive sensor [Makarenko Y.V, Balev V.N., Masliev V. G., 2010]. However, instability of the conditions depending on conditions of environment, dispersion of parameters of analog elements and complexity of control is peculiar to the analog actuation mechanism. The purpose of this article consists in development the system of regulation of set of a body of the vehicle on height concerning the way plane at the pneumatic spring suspension, excluding the listed above shortcomings. This control system of a pneumospring differs from standard AYR-200 established on an electric train by the opportunity to make management of damping of fluctuations, to regulate level of a floor in dependence not only on a static deflection, but also on the speed of movement and a condition of a way.

OBJECTS AND PROBLEMS

The task, the structure and the algorithm of work of a control system of the pneumatic air-spring suspension of vehicles are considered in thearticle (fig.).

The task of management is formulated as follows : it is necessary to provide the stable provision of a body concerning the way plane in the set interval, at possible change from average situation ± 40 mm and regulation by damping depending on the speed of movement of the vehicle and a condition of a way.

Object of management is the pneumospring. As actuation mechanisms two electric air valves are used. One of them is forcing, and other is dumping a compressed air from a pneumospring. And also there is a three-stage throttle for regulating air supply from the additional body in a pneumospring.

It is necessary to define the provision of a body of the vehicle over level of the plane of a way of a nominal rate for regulation of height of level of a floor. The measuring subsystem is used for this purpose. It represents the module in structure of which three subsystems enter: measuring, decisive (managing director) and executive.

Measuring subsystem.

1 . The sensor of height of level of a floor consists of two rectangular plates which make longitudinal movements comparative vertical axis of the vehicle. Plates are established in such a way that they don't adjoin with each other. The reed sensors, the Vb5.42.Khkh.Khkh type, 10.5 are installed on one of them, the distance between them is 3 mm. This plate is rigidly fixed by one end on a body frame. The second plate is rigidly fixed by one of the ends on a cart frame, on other its end the constant magnet is located. By movement of the vehicle there is a vertical relative movement of a magnet along a plate to reed sensors. Depending on a deviation of a magnet comparable with initial situation (up-down) the signal Δ which arrives on the COMPUTER is formed which arrives on the COMPUTER.

2 . The sensor of acceleration of MMA1213D which is reading out geometrical roughnesses of a way.

3 . The GPS system defining the position of object in two planes (in vertical and horizontal).

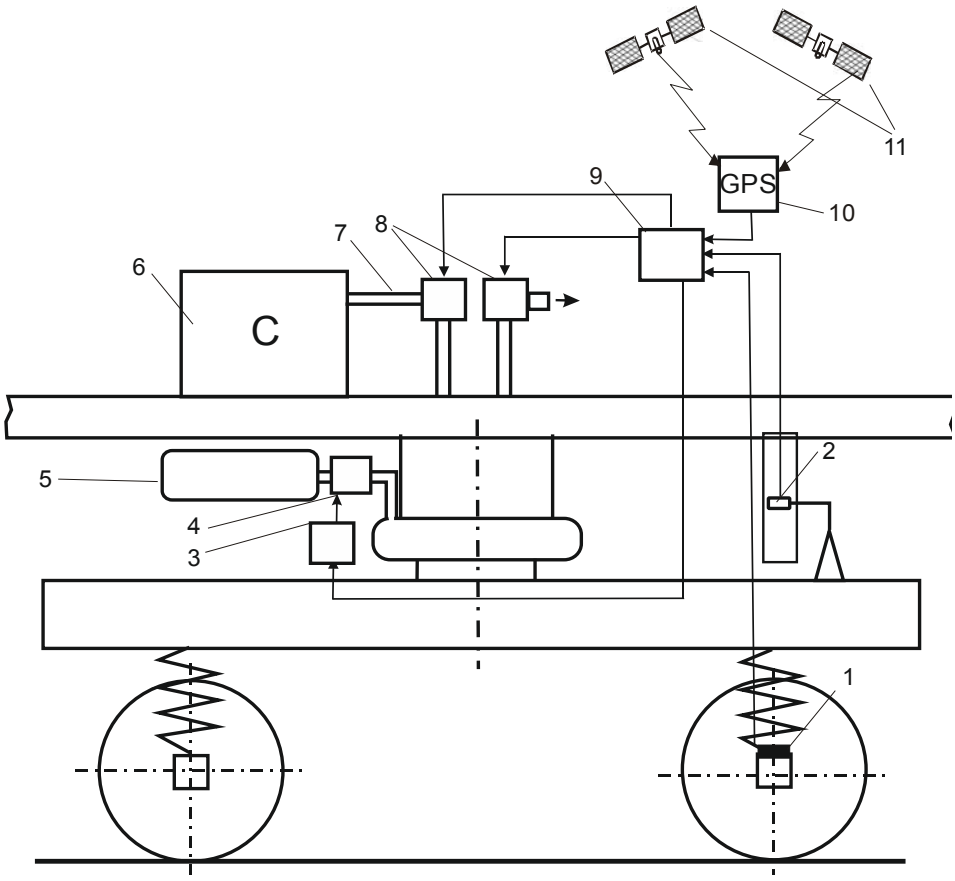

Fig. Control system of pneumatic spring suspension on transport
1 sensor of acceleration; 2 sensor of height of level of a floor; 3 servomotor; 4-three-stage throttle; 5-additional tank; 6 – compressor; 7-connecting pipeline; 8 – electric air gates; 9 – COMPUTER; 10 – GPS navigator; 11 – satellites of GPS system.

Operating subsystem.

1 . The COMPUTER which has the external (system) interface for ensuring communication between subsystems.

Executive subsystem.

1 . Two electric air VV-32 valves.

The electric air valve VV-32 of TU 16-559.341-04 is intended for management of filling depletion process in pneumosprings.

2 . Servomotor of AVV of a series 9C which through a shaft is rigidly connected to an axis of a three-stage throttle. Depending on a signal arriving with the COMPUTER, the servomotor turn of the axis regulates the provision of a butterfly.

3 . Three-stage throttle.

The algorithm of work of the managing director of system is described as follows: the sensor of height of level of a floor during movement gives out continuous sequence of electric signals. Signals represent exact display (which is corresponding to the way) of fluctuations of a body and arrive on the COMPUTER. The received signals are compared established to in advance values of possible fluctuations (according to the card of a way of routes of movement). Calculation of a phase of shift of fluctuations is made. Depending on the size of an antiphase the operated signal which arrives on one of electric air valves and on a servomotor is developed. At level excess more than 3 mm it is necessary to turn on dumping electric air gate which will let out a quantity of the compressed air, and at level reduction, more than on 3 mm, it is necessary to turn on the electric air gate of the forcing highway through which the compressed air moves in a pneumospring. Seted turn of a shaft of a servomotor establishes the section of a throttle which is necessary for damping.

The algorithm of work of system has to be steady against influencing factors, they are fluctuations and the vibrations arising at movement of the vehicle on a real railway line. Realization of operating influences has to be provided with some temporary delay (5-10 s) that these fluctuations didn't cause operation of system conducting to the increased consumption of air for a food of pneumosprings. Besides, it is necessary to provide possibility of remote change of settings of system (for example, for ensuring passing of curve sites of a way).

CONCLUSIONS

On the basis of the carried-out work, it is possible to draw the following conclusions:

- using of GPS– systems allows to recustomize hard characteristics of a pneumospring earlier that allows to improve comfort for passengers and to reduce dynamic impacts on a way;

- the developed system allows to operate more flexibly clearing of fluctuations of rolling high-speed stock;

- the offered system excludes an excessive consumption of the compressed air via electric air gates at body fluctuations on pneumatic springs, isn't sensitive to change of external climatic conditions, is protected from false operations at action of random factors;

- this system doesn't demand control in use, contains the minimum quantity of wearing-out couples of friction and electric contacts that allows to recommend it for use on modern high-speed transport.

REFERENCES

1. **Birukov I.V., Savoskin A.N., Byrchak G.P., 1992.:** "Mechanical part of hauling rolling stock", M.:Transport.- 440 p.
2. **Vivdenko Y.G., Krasnobryzheva J.S. 2004.:** «World wide experience of applying for suspension for high-speed railway vehicles.» Dal's East Ukrainian National University – Lugansk.
3. **Vivdenko Y., Masliev V. G., Krasnobryzheva J., Spiryagin M, Spiryagin V, 2007.:** "System of cartography of routes of motion for a railway transport" Declarative patent on an useful model № 21577 15.03.2007 B. №.3
4. **Makarenko Y.V, Balev V.N., Masliev V. G., 2010.:** "Application of mehatronic at creation of regulators of a pneumatic spring hanging on a transport." Kharkiv: NTU "KPI". - №38. Pp.72 - 75
5. **Masliev V. G., 2002.:** "Scientific fundamentals of a choice of design-engineering parameters of devices for locomotive sprockets bindings wear reduction," D.Sc. dissertation, Ukrainian State Academy of Railway Transport, Kharkov, Ukraine.
6. **Iwnicki S., 2006.:** "Handbook of Railway Vehicle Dynamics," CRC Press, UK, ch. 3, 11.
7. **Pearson J.T., Goodall R.M., Mei T.X., S. Shuiwen, C. Kossmann, O. Polach G. and Himmelstein, 2004.:** "Design and experimental implementation of an active stability system for a high speed bogie," Vehicle System Dynamics Supplement, vol. 41, pp. 43-52.
8. **Garcia C., Mart T.. 2002.:** International Railway Journal, № 10, p. 15 – 20.
9. **Briginshaw D.. 2000.:** International Railway Journal, N 5, p. 15- 18.

10. **Kurz H. 2000.:** Railway Technical Review, N 2, p. 13-22.
11. **Abbott J. 2000.:** European Railway Review, N 4, p. 24- 26.
12. **Hanke R. 2000.:** Eisenbahntechnische Rundschau, , № 5, S. 307 – 312.
13. **Spiryagin M, Spiryagin V, Ulshin V. 2010.:** "Active steering control system of a rail vehicle based on fuzzy logic and the analysis of the sound radiation". TEKA Kom.Mot I Energ. Roln -OL PAN, 10B, 186-198.
14. **Spiryagin V., 2004.:** "Improvement of dynamic interaction between the locomotive and railway track," Ph.D. dissertation, East Ukrainian National University named after Volodymyr Dal, Lugansk, Ukraine.
15. **Gorbunov M., Spiryagin V., Spiryagin M., Lapin D., 2003.:** "Triaxial truck of a railway vehicle", Patent UA62900, 15 December,
16. **Dwight R., Jiang J., 2006.:** "Analysis of wheel-rail noise," Patent WO 2006/021050, 2 March.
17. **Spiryagin M., Lee K. S., Yoo H. H., 2010.:"**Control system for maximum use of adhesive forces of a railway vehicle in a tractive mode," Mechanical Systems and Signal Processing, submitted for publication..
18. **Hsu S. S., Huang Z., Iwnicki S., Thompson D. J., Jones J. C., Xie G. and Allen P. D., 2007.:** "Experimental and theoretical investigation of railway wheel squeal," Proc. IMechE Part F:J. Rail and Rapid Transit, vol. 221, pp. 59-73,
19. **Gorbunov M., Kostyukevich A., Kravchenko K., 2010.:** "Efficiency function for evaluation of the locomotive traction and adhesion qualities", TEKA Kom.Mot I Energ. Roln -OL PAN, 10C, 80-86.

СИСТЕМА УПРАВЛЕНИЯ ПНЕВМАТИЧЕСКИМ РЕССОРНЫМ ПОДВЕШИВАНИЕМ НА ТРАНСПОРТЕ

Юрий Вивденко, Юлия Краснобрыжева

Аннотация. Цель данной статьи заключается в разработке системы управления пневматическим рессорным подвешиванием, позволяющей улучшить комфорт пассажиров и уменьшить динамическое воздействие на путь. Предметом исследования является пневматическое рессорное подвешивание скоростного железнодорожного транспорта. Работа выполнена методом теоретического исследования систем управления пневматического рессорного подвешивания. В статье рассмотрены задача, структура и алгоритм работы системы управления пневматическим рессорным подвешиванием. Задача управления формулируется следующим образом – необходимо обеспечить стабильное положение кузова относительно плоскости пути в заданном интервале и регулирование демпфированием в зависимости от скорости движения транспортного средства и состояния пути. Разработанная система управления рекомендуется для использования на пассажирском скоростном железнодорожном транспорте.
Ключевые слова: пневморессора, датчик, серводвигатель, трехступенчатый дроссель, электропневматические вентили, GPS-навигатор.

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