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Editorial Office Address
Commission of Motorization and Energetics in Agriculture
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e-mail: eugeniusz.krasowski@up.lublin.pl

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The mathematical model of material particle motion

V. Batluk, R. Sukach

Departament of industrial safety and safety management,
Lviv State University Of Life Safety
v.a.butluk@gmail.com

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Abstract. This article is concerned with the problem of high-performance dust-catching equipment creation for various industries, where: fine-dyspersated dust fractions are emitted, in order to make their emissions conform to sanitary norms. This article elucidates new tendencies in the area of the creation of equipment for air from dust cleansing, which are based on the use of centrifugal inertia forces.

Key words: dust collecting , air cleaning, pollution, centrifugal, cyclone.

INTRODUCTION

Ecological aspects are well-known to those, who have a notion of air environment state in the rooms, where:, for instance, welding fumes are given off. The emitted hazardous substances comprises gases and aerosols, some particles of which are so tiny, that can get into the blood, penetrating through the lung tissue. In the most frequent cases welding fume contains the particles of iron, zinc, cadmium, manganese oxides, as well as the particles of fluorine, asbestos, chromium, copper etc [1]. As a result of such particles action, the conjunctivae are traumatised, allergic diseases, silicosis, pulmonary oedema, headaches, stethalgias arise, kidneys destructs and cancerous diseases emerge.

The application of local exhaust ventilation ensures the required MPC level in the worker's breathing zone during various production processes, and that is controlled by the legislation of all countries in the labour protection and ecology sphere.

The Latest Researches Analysis. Electrostatic precipitators are the most widespread and are used in different spheres due to high catching degree of the most hazardous particles from 1 to 0,01 microns and less in size. At this point, such agents of serious diseases as microbes, viruses, bacterium, pathogen fungi and pests simply perish in the filter's electrostatic field. Thus electrostatic filters compare favourably with the mechanic ones, the elements of which accumulate in themselves hazardous particles and with bad care of the filter they can become the pollution sources themselves [2].

Electrostatic filters are effectively used for the cleansing of air from the particles of various fume types, oil mist and fine-dyspersated dust, from 200 to 0.01 microns in size. For this reason the air from dust cleansing efficacy reaches 94%.

Air filters with the mechanic method of air filtration are used for polluted air cleansing from big particles of different dust types, oil mist, welding fume, which is emitted in the process of galvanised steel, aluminium, stainless steel welding and galvanics, and also from the fume, which is emitted in the process of soldering and spot welding. Mechanic filters have high degree of air cleansing from the particles from 200 to 0,1 microns in size.

Dust catching units (dry cyclones) with the mechanic method of air filtration are used for polluted air cleansing from medium- and coarse-dyspersated particles of various dust types. According to the efficacy suggested units refer to the 3 class air filters, which catch the dust particles more than 10 microns in size.

Instrumental and laboratory measurements determined that at initial dust content of the atmosphere of 5,3 g/m^3 the efficacy of the first degree cyclones cleansing is 81-85%, of bag filters – 99%, and general unit's ECE – 99,8%. The application of dusty air dry cleansing in the high-performance apparatuses of the present day design allows us to secure the reduction of atmospheric emissions to 20-40 mg/ m^3.

Analysing the above-mentioned, we can precisely determine that currently for the security of sanitary-

hygiene requirements of environmental protection there is no apparatus support for the creation of hazardous release norms. The best of the units, existing for this purpose, are not able to cope with this task. Therefore we made it our aim to create the units, which are able to highly effectively catch fine-dyspersated dust.

The development of technology and constantly growing requirements for energy and material saving results in the need for the creation of brand-new air-cleansing devices with higher energy conversion efficiency and simultaneously with lower material expenditures on the cleansing itself. The analysis of dust-air mixture motion within the separator has a considerable influence on the substantiation of new type dust catchers basic parameters. Despite the external simplicity of such apparatuses design, aerodynamic processes, taking place within, are extremely complicated and up to this day there are no full mathematical models of dusty air behavior in separator. Thus, the tasks of newly created apparatuses aerodynamics research have both theoretical and practical values.

The significance of problem lies in the lack of complete scientific theory of dust-cleansing process, which would meet the requirements to air from dust cleansing degree.

RESULTS AND DISCUSSION

The motion of material part M will be referred to the cylindrical coordinate system. Point M coordinates are determined by the radius r, azimuth and applicate z. The azimuth is positive when it is reckoned from the polar axis Ox to the radius r in a counterclockwise direction.

The radius r indicates the distance from the axis Oz to the point M, and obtains only positive values.

The applicate z indicates the point M position in regard to the axis Oz.

The coordinates origin, point O, is located on the symmetry axis of the frame at the top of it. [3-5]

The point M velocity r,j,z n cylindrical coordinate system is determined as the sum of three components $\vec{V}_z, \vec{V}_j, \vec{V}_z$ i.e.:

$$\vec{V} = \vec{V}_z + \vec{V}_j + \vec{V}_z, \qquad (1)$$

$\mathrm{e}V_\mathrm{r} = \frac{\mathrm{d}r(t)}{\mathrm{d}t}$ – the point M $(\mathrm{r},j,\mathrm{z})$, radial velocity, which is directed along the radius r, i.e. along the line the point M $(\mathrm{r},j,\mathrm{z})$, transverse velocity, which is directed perpendicular to the line O_1M and the vector $\vec{V}_j$ is perpendicular to the axis *Oz*; [6-8]:

$$V_\mathrm{Z} = \frac{\mathrm{d}z(t)}{\mathrm{d}t}, \qquad (2)$$

– the point M $(\mathrm{r},j,\mathrm{z})$, velocity about the axis *Oz* and it is directed parallel to the axis *Oz*.

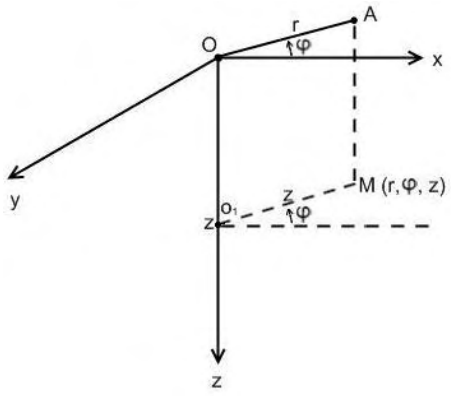

Fig. 1. The axis symmetry of the case

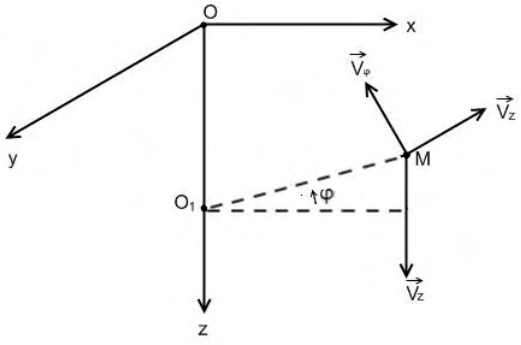

Fig. 2. Point M in cylindrical coordinate system

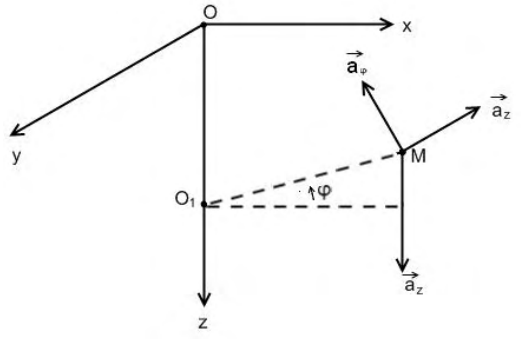

Fig. 3. The point M (r,j,z), acceleration about the axis *Oz*

The point M $(\mathrm{r},j,\mathrm{z})$ acceleration in cylindrical coordinate system is equal to the sum of three vector components: $\vec{a} = \vec{a}_r + \vec{a}_j + \vec{a}_z$,

where: $$a_r = \frac{d^2r(t)}{dt^2} - r\left(\frac{dj}{dt}\right)^2, \qquad (3)$$

radial acceleration component, which is directed along the line O_1M:

$$a_j = r\frac{d^2j(t)}{dt^2} + 2\frac{dj(t)}{dt}\cdot\frac{dr(t)}{dt}, \qquad (4)$$

– transverse acceleration component, which is directed perpendicular to the line O_1M and the vector $\vec{a}_j$ is perpendicular to the axis *Oz*; [9-11]:

$$a_z = \frac{d^2z(t)}{dt^2}. \qquad (5)$$

In the process of material particle motion inside the apparatus frame it is exerted by: $\vec{P}$ – the material particle weight and $\vec{R}$ – the force, caused by air-dust mixture. According to the Second Law Of Dynamics we shall write:

$$m\vec{a} = \vec{P} + \vec{R}. \quad (6)$$

Projecting this equation on the axis of cylindrical coordinate system, we shall obtain:

$$\begin{aligned} ma_r &= -R_r, \\ ma_j &= +R_j \cdot sign(w_0 - \dot{j}), \\ ma_z &= P - R_z, \end{aligned} \quad (7)$$

where: m – material particle mass.

In the process of material particle motion it is affected by air-dust mixture, its affecting is characterised by the force $\vec{R}(R_r; R_j; R_z)$ [11-14].

The component R_r is determined by using a formula:

$$R_r = C_r \cdot V_r^2 \cdot F_r \cdot \rho, \quad (8)$$

where: C_r – the coefficient, which accounts for material particle aerodynamic properties due to the component of the motion along the radius r; V_r – radial component of the material particle motion velocity; F_r – maximum material particle sectional area of a plane, perpendicular to its radial velocity direction; r – air-dust mixture density:

$$R_\varphi = C_\varphi \left(\frac{\upsilon_0}{r_0} - \dot{\varphi} \right)^2 \cdot r^2 \cdot F_\varphi \cdot \rho, \quad (9)$$

where: C_φ – the coefficient, which accounts for material particle aerodynamic properties due to the component of the motion towards $\vec{V}_\varphi$ [15]; V_0 – the velocity of material particle when entering the inlet fitting; r_0 – the distance from material particle at that instant of time, when it is situated at the entry to the inlet fitting, to the apparatus symmetry axis; F_φ – maximum material particle sectional area of a plane, perpendicular to its transverse velocity component direction:

$$R_Z = C_Z \left(\frac{dz}{dt} \right)^2 \cdot F_Z \cdot \rho, \quad (10)$$

where: C_z – the coefficient, which accounts for material particle aerodynamic properties due to the component of the motion about the axis *Oz*; F_z – maximum material particle sectional area of a plane, perpendicular to the axis *Oz*.

The function sign $(\omega_0 - \dot{\varphi})$ is depicted by the following dependence:

$$\sin g(\omega_0 - \dot{\varphi}) = \begin{cases} +, якщо \omega_0 - \dot{\varphi} > 0 \\ -, якщо \omega_0 - \dot{\varphi} > 0 \end{cases}. \quad (11)$$

Taking into consideration (3) – (11), the material particle motion is depicted by the differential equation system [16]:

$$m\left(\frac{d^2 r(t)}{dt^2} - r\left(\frac{d\varphi}{dt} \right)^2 \right) = -C_r \left(\frac{dr}{dt} \right)^2 \cdot F_r \cdot \rho, \quad (12)$$

$$\begin{aligned} &m\left(r\frac{d^2\varphi(t)}{dt^2} + 2\frac{d\varphi(t)}{dt} \cdot \frac{dr(t)}{dt} \right) = \\ &= C_\varphi \left(\frac{\upsilon_0}{r_0} - \dot{\varphi} \right)^2 \cdot r^2 \cdot F_\varphi \cdot \rho \cdot sign(\omega_0 - \dot{\varphi}), \end{aligned} \quad (13)$$

$$m\frac{d^2 z(t)}{dt^2} = mg - C_z \left(\frac{dz}{dt} \right)^2 \cdot F_z \cdot \rho. \quad (14)$$

Let us specify the initial conditions for material particle: $\varphi(0) = 0$ – at the initial instant of time the material particle was situated on the polar axis *Ox*; $\dot{\varphi}(0) = \frac{v_0}{z_o}$ – the material particle rotational velocity about the axis *Oz* at the initial instant of time; r(0) – the material particle initial distance to the axis *Oz*; $\dot{r}(0) = 0$ – at the initial instant of time the material particle radial velocity is equal to zero; z(0)=0 – the material particle was situated at the upper casing; $\dot{Z}$ (0)=0 – at the initial instant of time the material particle vertical velocity is equal to zero;

The differential equation system (12), (13) is solved by means of software.

The differential equation (14) is solved by using the separation of variables method. Let us write this equation as [17-18]:

$$m\frac{d\dot{z}}{dt} = mg - C_z F_z \rho \cdot \dot{z}^2; \quad \frac{d\dot{z}}{dt} = g - \frac{C_z F_z \rho}{m} \cdot \dot{z}^2.$$

Let us introduce the notation: $K^2 = \frac{C_z F_z \rho}{m}$ then

$$\frac{d\dot{z}}{dt} = g - k^2 \dot{z}^2, \quad \frac{d\dot{z}}{g - k^2 \dot{z}^2} = dt : \frac{1}{2\sqrt{g}} \left(\frac{d\dot{z}}{\sqrt{g} - k\dot{z}} + \frac{d\dot{z}}{\sqrt{g} + k\dot{z}} \right) = dt,$$

$$\frac{1}{2k\sqrt{g}} \ln \frac{\sqrt{g} + k\dot{z}}{\sqrt{g} - k\dot{z}} = t + \frac{\ln c_1}{2k\sqrt{g}}, \quad \frac{\sqrt{g} + k\dot{z}}{\sqrt{g} - k\dot{z}} = C_1 e^{2k\sqrt{g}t}.$$

The constant magnitude C_1 is determined by application of the initial condition $\dot{z}$ (0)=0, then:

$$\frac{\sqrt{g} + k \cdot 0}{\sqrt{g} - k \cdot 0} = C_1^{2k\sqrt{g} \cdot 0}, \quad \frac{\sqrt{g}}{\sqrt{g}} = C_1; \quad C_1 = 1.$$

Therefore, the velocity of material particle motion about the axis *Oz* is equal to:

$$\sqrt{g} + k\dot{z} = \left(\sqrt{g} - k\dot{z} \right) e^{2k\sqrt{g}t} : k\dot{z}\left(1 + e^{2k\sqrt{g}t} \right) = \sqrt{g}\left(e^{2k\sqrt{g}t} - 1 \right),$$

$$z(t)=\frac{\sqrt{g}\left(e^{2k\sqrt{g}t}-1\right)}{k\left(e^{2k\sqrt{g}t}+1\right)}:\dot{z}(t)=\sqrt{\frac{mg}{C_zF_zP}}\cdot\frac{e^{2\sqrt{\frac{CzFzpg}{m}}t}-1}{e^{2\sqrt{\frac{CzFzpg}{m}}t}+1}. \quad (15)$$

Let us consider, that material particles are in the form of the ball, then:

$$m=\frac{4}{3}\pi r_m^{\,3}\cdot\rho_m : F_r=F_\varphi=F_z=\pi r_m^{\,2},$$

where: r_m – the ball radius; ρ_M – the material particle specific mass. The differential equation system (12), (13) acquires the form [19]:

$$\frac{d^2r(t)}{dt^2}-r(t)\left(\frac{d\varphi(t)}{dt}\right)^2=-\frac{3C_r\rho}{4r\rho_m}\left(\frac{dr(t)}{dt}\right)^2, \quad (16)$$

$$r(t)\frac{d^2\varphi(t)}{dt^2}+2\frac{d\varphi(t)}{dt}\cdot\frac{dr(t)}{dt}=$$

$$=\frac{3C_r\rho}{4r_m\rho_m}\left(\frac{V_0}{r_0}-\frac{d\varphi(t)}{dt}\right)^2 r^2 sign\left(\omega_0-\dot{\varphi}\right). \quad (17)$$

Setting certain values for the magnitudes:

$$0,5\le C_r\le 1;\ 0,5\le C_\varphi\le 1,\ \rho=1,\ldots,\ r_m=0,05\ м,$$

$$\rho_m=2\ ,\frac{кг}{м^3},\ V_0=4\ ,{}^{м}\!/_{с},\quad r_0=0,8\ м,$$

we can determine the instant time of material particle contact with the apparatus casing walls with provision that:

$$r(t_k)=r_a,$$

where: r_a – the radius of apparatus casing.

The velocity of material particle motion about the axis *Oz* is depicted by the equation:

$$\dot{z}(t)=\sqrt{\frac{4r_m\rho_m g}{3C_z\rho}}\cdot\frac{e^{\sqrt{\frac{3C_z\rho g}{r_m\rho_m}}t}-1}{e^{\sqrt{\frac{3C_z\rho g}{r_m\rho_m}}}+1}. \quad (18)$$

Solving this differential equation, in view of the initial condition that z(0)=0, we shall obtain the coordinate, on which the material particle contacts the casing wall, to accomplish this we use the condition that h=z(t_k) [20].

CONCLUSIONS

Thus, the performed theoretical analysis and suggested by us model allows [21]:

1 – to reveal the physical essence of the motion of the air, being cleansed, in the projected apparatus, to determine the influence of the forces, which affect the particle in radial direction on its motion nature;

2 – to reduce dramatically the number of experimental researches on the study of apparatus parameters influence on air cleansing efficacy and conduct them purposefully;

3 – to create fundamentally new designs of centrifugal inertia dust-catchers.

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Towards sustainable transport in Ukraine: main obstacles and directions of development

Z. Dvulit[1], O. Bojko[2]

[1] Department of management of organizations and logistics,
State Economy and Technology University of Transport
19 M. Lukashevicha st., 03049, Kyiv-49, Ukraine
e-mail: zdvulit@ukr.net
[2] Department of Economics, National Aviation University
1 Kosmonavta Komarova Ave, 03058, Kyiv – 58, Ukraine
e-mail: lv-bojko@rambler.ru

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Abstract. The paper presents the description of the different definitions of the concept - sustainable development of transport. The analysis of freight and passenger transportation in Ukraine in 2011 and composition of the park and the average age of municipal electric, sea and river vessels is studied. The volume of emissions of pollutants and greenhouse gas emissions from all transport modes in 2011 is analyzed. The framework and priorities of environmental cooperation between Ukraine and EU at the present stage are determined. Based on the concept of sustainable development and European experience the main directions of introduction of the sustainable development policy of transport in Ukraine are offered.
Key words: Ukraine, sustainable development, transport, sustainability, transport strategy

INTRODUCTION

Sustainable development is the "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This concept rests on two pillars: firstly, equity both between and within generations and, secondly, the equal status of social, economic and environmental goals. This means that it must be possible for the needs of all people to be met both now and in the future. At the same time, the Earth is to be conserved in such a way that life in conditions of dignity and security is possible for all people over the long term. This second pillar is also known as the «three-dimensional» model, as it classifies existing resources into social, economic and environmental dimensions.

Ukraine joined the sustainable development movement in 1997, when the National Commission on Sustainable Development of Ukraine was established under the Cabinet of Ministers with the purpose of ensuring the solution of problems of the social and economic development, environmental protection and rational use of natural resources in Ukraine.

On 24 December 1999 the Verhovnaya Rada of Ukraine (Supreme Council of Ukraine) adopted the Concept of Sustainable Development of Settlements. This Concept defines the basic directions of the state policy on the issues of ensuring of sustainable development of the settlements, legal and economic ways of its realizationand.

Ukraine's environmental challenges are significant and present one of the most complex areas for the country to address given the pressures of continues economic growth and social transition. The only feasible response to these challenges is transition to sustainable development.

Heavy concentration of agriculture and industry has caused disastrous air, water and soil pollution. Present ecological change scales have created a real hazard to public health and pose a threat to the life of Ukraine citizens [1].

In Ukraine the transport sector plays an important role in the socio- economic development. Transport system determines the conditions for economic growth,

improving competitiveness of the national economy and quality of life.

Transport is one of fundamental sectors of national economy, and its efficient functioning constitutes a necessary condition for ensuring defense potential, protecting economic interests of the state, and improving the lives of its citizens.

Though Ukrainian transport sector meets general transportation needs of national economy, the level of its safety, quality and efficiency of passenger and freight services, energy performance, and production - induced pressure on the environment do not comply with contemporary requirements.

Technical and infrastructure upgrade for railways, airports, and sea ports; expansion of public road network according to the country's car ownership growth rates requires urgent attention.

The length of motorways almost increased for almost twenty years; their density falls considerably behind the developed countries' indicator. The motorway conditions are unsatisfactory, with 51.1% of roads not meeting requirements for smoothness, and 39.2% - for strength. The average traffic speed on the motorways is 2-3 times lower than in the Western European countries.

The system of governance and management in rail, sea, and road transport as well as road infrastructure should be reformed.

The transportation safety rate is low. Road incident rates are much worse comparing to the EU countries. Aircraft of national airlines have been many times black-listed, including a ban to fly to the EU countries. The unsatisfactory shipping safety control has resulted in black-listing of the State Flag of Ukraine, according to the Paris Memorandum (Paris MoU on Port State Control).

On the 20th of October 2010, the Cabinet of Ministers of Ukraine adopted the "Transport Strategy of Ukraine for the period up to 2020" [23] aimed at supporting sustainable and efficient transport sector operation to create conditions for social and economic development of the country, improved competitiveness of the national economy, and transport safety.

Ukraine has not yet prepared its official Strategy of Sustainable Development. However, thousands of Ukrainians have already expressed their opinions about future sustainable development goals for Ukraine by voting for the World They Want after 2015, a global consultation process launched right after "Rio+20."

RESULTS AND DISCUSSION

Sustainability is a simple concept with complex implications [6]. It reflects a paradigm shift, a fundamental change in the way problems are defined and solutions evaluated. It maintains a distinction between growth (increased quantity) and development (increased quality). It focuses on social welfare outcomes, such as human health and education attainment, rather than on material wealth, and questions common economic indicators such as Gross Domestic Product (GDP) that measure the quantity but not the quality of market activities. Because sustainability strives to protect natural resources and ecological systems, it emphasizes a conservation ethic, and so favors policies that minimize consumption of resources such as air, water and land.

Sustainability can be evaluated based on a weak standard, which allows natural capital (natural environmental resources and ecological systems) to be replaced by human capital (industrial productive capability), or a strong standard, which rejects such substitutions [18].

A weak sustainability standard allows transport to increase environmental impacts if required for economic development, or if negative impacts can be offset by other sectors, such as pollution reductions by heavy industries. A strong sustainability standard places more emphasis on impact reductions within the transport sector, and so places more emphasis on reducing motor vehicle impacts.

Transportation has significant economic, social and environmental impacts, and so is an important factor in sustainability. Sustainability supports a paradigm shift occurring in transport planning. Previously, transport was evaluated primarily in terms of mobility (physical movement), but increasingly it is evaluated in terms of accessibility (people's ability to obtain desired goods and services). Many factors affect accessibility, including mobility, land use factors (such as the location of activities) and mobility substitutes (such as telecommunications and delivery services). Accessibility-based planning expands the range of solutions that can be applied to transport problems; for example, congestion can be reduced by improving land use accessibility or telecommunications, in addition to accommodating more vehicle traffic.

Sustainable transport refers to the broad subject of transport that is or approaches being sustainable. Transportation sustainability is largely being measured by transportation system effectiveness and efficiency as well as the environmental impacts of the system [2].

Short-term activity often promotes incremental improvement in fuel efficiency and vehicle emissions controls while long-term goals include migrating transportation from fossil-based energy to other alternatives such as renewable energy and use of other renewable resources. The entire life cycle of transport systems is subject to sustainability measurement and optimization [12].

Sustainable transport systems make a positive contribution to the environmental, social and economic sustainability of the communities they serve. Transport systems exist to provide social and economic connections, and people quickly take up the opportunities offered by increased mobility [3]. The advantages of increased mobility need to be weighed against the

environmental, social and economic costs that transport systems pose.

Transport systems have significant impacts on the environment, accounting for between 20% and 25% of world energy consumption and carbon dioxide emissions [24]. Greenhouse gas emissions from transport are increasing at a faster rate than any other energy using sector [13]. Road transport is also a major contributor to local air pollution and smog [14].

The social costs of transport include road crashes, air pollution, physical inactivity, [25] time taken away from the family while commuting and vulnerability to fuel price increases. Many of these negative impacts fall disproportionately on those social groups who are also least likely to own and drive cars [15]. Traffic congestion imposes economic costs by wasting people's time and by slowing the delivery of goods and services.

Traditional transport planning aims to improve mobility, especially for vehicles, and may fail to adequately consider wider impacts. But the real purpose of transport is access - to work, education, goods and services, friends and family - and there are proven techniques to improve access while simultaneously reducing environmental and social impacts, and managing traffic congestion [4]. Communities which are successfully improving the sustainability of their transport networks are doing so as part of a wider program of creating more vibrant, livable, sustainable cities.

There are several definitions for sustainable transportation. Even so, there are common threads in most definitions of sustainable transportation based on sustainable development involving social, environmental, and economic aspects [19].

The Centre for Sustainable Transportation's (CST) definition of a sustainable transportation system is one that:

- allows the basic access needs of individuals and societies to be met safely and in a manner consistent with human and ecosystem health, and with equity within and between generations,
- is affordable, operates efficiently, offers choice of transport mode, and supports a vibrant economy,
- limits emissions and waste within the planet's ability to absorb them, minimizes consumption of non-renewable resources, limits consumption of renewable resources to the sustainable yield level, reuses and recycles its components, and minimizes the use of land and the production of noise.

The Organization for Economic Cooperation and Development (OECD) [21] defines sustainable transportation as: transportation that does not endanger public health or ecosystems and meets needs for access consistent with:

- the use of renewable resources at below their rates of regeneration,
- the use of non-renewable resources at below the rates of development of renewable substitutes.

Sustainable transportation can be supported by promoting the use of:

- more energy efficient forms of transportation such as public transit,
- alternative transportation to the single occupancy vehicle,
- low emissions vehicles,
- transportation demand management,
- active transportation, and supportive land use practices.

At its most basic, sustainability reflects a concern for indirect and long-term impacts. The concepts of sustainability and sustainable development originally focused on certain long-term environmental concerns, such as natural resource depletion and ecological degradation (including climate change), but have expanded to include other issues. Most current definitions recognize three main categories of sustainable development issues: economic, social and environmental (or ecological), and some incorporate other issues such as governance and fiscal sustainability [5, 10].

The term sustainable transport came into use as a logical follow-on from sustainable development, and is used to describe modes of transport, and systems of transport planning, which are consistent with wider concerns of sustainability. There are many definitions of the sustainable transport, and of the related terms sustainable transportation and sustainable mobility [7]. One such definition, from the European Union Council of Ministers of Transport, defines a sustainable transportation system as one that:

Allows the basic access and development needs of individuals, companies and society to be met safely and in a manner consistent with human and ecosystem health, and promotes equity within and between successive generations.

Is Affordable, operates fairly and efficiently, offers a choice of transport mode, and supports a competitive economy, as well as balanced regional development.

Limits emissions and waste within the planet’s ability to absorb them, uses renewable resources at or below their rates of generation, and uses non-renewable resources at or below the rates of development of renewable substitutes, while minimizing the impact on the use of land and the generation of noise.

Sustainability extends beyond just the operating efficiency and emissions. A Life-cycle assessment involves production and post-use considerations. A cradle-to-cradle design is more important than a focus on a single factor such as energy efficiency [11, 17].

The transport sector faces crucial challenges, i.e. a significant wear and tear of plant and equipment, in particular fleet; insufficient volume of investment required for renewing and developing innovatively the sector physical infrastructure; shortage of budget funding and depreciation payments; imperfect leasing procedure; a low level of the state’s transit potential utilization.

The share of the transport sector in the gross domestic product of Ukraine is over 9 %, the value of fixed assets - more than 17 % of the productive capacity of the country, the number of employed workers - about 7%.Ukraine has a transportation network, which includes over 21.64 thsd. km main tracks, 169.6 thsd. km of roads, 2.1 thsd. km of inland waterways, 18 maritime trade and 10 river ports, 28 airports [16].

All kinds of vehicles annually carried 1.8 billion tons of cargo and about 7.0 billion passengers. Data on shipments by mode of transport in 2011 are shown in Table. 1. Indices of cargo volume and departure (transport) of passengers by public transport, compared to previous years, we are graphically depicted in Fig. 1.

Composition of the park and the average age of vehicles as of the end of 2011 in Ukraine there were nearly 9.3 million motor vehicles, among them: cars - 6.9 million units, cargo - 1.2 million units, buses - 249 thousand units, motorcycles - 840.9 thousand units. Over 50% of the vehicle has been in operation for over 10 years, less than 20 % of the cars are in operation for 3 years.

The park and the average age of railways, according to the Ministry of Infrastructure of Ukraine [20], are:

- 2457 diesel vehicles (28 years),
- 1853 electric vehicles (36 years),
- 320 diesel trains units (about 26 years),
- 1521 electric vehicles (over 29 years),
- passenger cars from 6959 (over 27 years),
- freight cars of all types 187,339 units (22 years).

To replace the park traction rolling stock, which worked normative lifespan, Ukrainian Railways (Ukrzaliznytsia) developed a comprehensive upgrade of railway rolling stock in Ukraine 2008-2020 years. In recent years, Ukraine has tended to increase in the average age of cars in use, due to the crisis of 2009-2010, when sales of new cars fell sharply. These two trends have led to an increase in the average age of cars.

Rejuvenation of vehicles on the road going from 2005 to 2008 year when sales of new cars each year exceeded the realization of old cars. But the supply of "strength", which was the result of active sales in the pre-crisis years, is over.

Road transport causes the largest share (91%) of pollutant emissions from mobile sources, accounting for over one third of the total amount of pollutants in the atmosphere Ukraine. However, the biggest environmental threat is that transportation provides 70-90 % of the total emissions of pollutants to the air quality of most cities.

On average in Ukraine on 1 sq. km area accounts for nearly 4 tons of harmful air emissions from cars, and per capita - more than 50 kg. In Kiev, for example, vehicle emissions account for 213 tons, or nearly 96% of the total amount of pollutants in the atmosphere of the city. On 1 sq. km area in Kyiv falls 254 tons of harmful air emissions from cars, and per capita - nearly 76 kg. According to expert estimates, the total annual economic losses in the country due to the negative environmental impact of vehicles account for more than 20 billion.

The largest impact of road transport on the environment depends on the level of environmental safety design of wheeled vehicles, according to requirements of national legislation and standards and efficiency of technical regulations for admission to the operation of the vehicle.

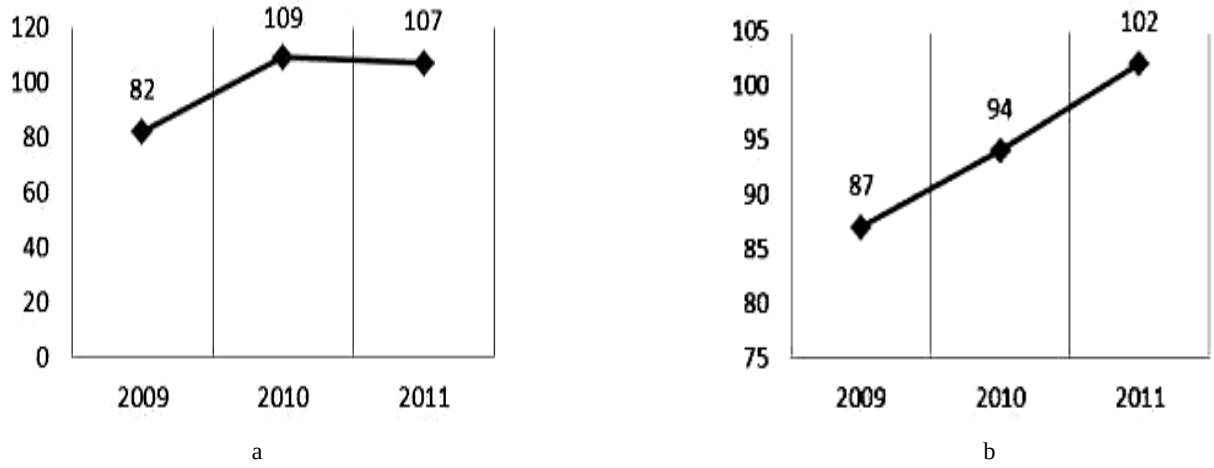
The average age of cars in Ukraine today is the same as in 2005-2006, whereas the average age of cars sold in the secondary market of Ukraine this year was 15 years old. The park and the average age of municipal electric and sea and river vessels built in the Table. 2.

Table 1. Transportation of goods and passengers by mode of transport in 2011

	Freight transportation				Passenger transportation			
	Volume		Freight turnover		Volume		Passenger turnover	
	mln. tons	%	billion t-km	%	mln.	%	billion passenger-km	%
Railway	469,3	24,9	243,9	54,7	429,8	6,2	50,6	37,7
Motor vehicles	1252,4	66,4	57,3	12,9	3611,8	51,7	51,5	38,4
Water	9,9	0,5	7,3	1,6	8,0	0,1	0,1	0,1
Air	0,1	0,0	0,4	0,1	7,5	0,1	13,8	10,3
Electric	-	-	-	-	2922,7	41,9	18,1	13,5

Table 2. Composition of the park and the average age of municipal electric and sea and river vessels

Transport modes	Total	Time of operation			
		till 5 years	from 5 to 10 years	from 10 to 15 years	more than 15 years
Sea and river vessels					
Sea vessels	910	28	24	66	792
River vessels	2040	140	23	136	1741
Municipal electric transport					
Trolleybuses	3714	703	430	238	2343
Tram trains	2412	45	75	53	2239
Subway trains	1128	108	95	46	879



a b

Fig. 1. Indices of the volumes of transportation
a – freight (to the corresponding period of the previous year, %),
b – passengers (to the corresponding period of the previous year, %).

Table 3. Volume of emissions of pollutants and greenhouse gas emissions from all transport modes in 2011

	Volume of emissions, tons	Increase (+), decrease (-) compared with 2010	The volume of emissions in 2011 to 2010, %	The distribution of emissions in 2011, %
Non-methane volatile organic compounds (NMLOS)	285580.4	-7684.0	97.4	11.4
Methane	8000.6	-174.1	97.9	0.3
Benzopyrone	174,4	10,3	106,3	0,0
Soot	34356.5	1941.6	106.0	1.4
Nitrous oxide [N_2O]	2143.2	-11.2	99.5	0.1
Ammonia	20.6	-1.1	94.7	0.0
Sulfur dioxide	30276.5	1367.6	104.7	1.2
Carbon monoxide	1842093.0	-45,957.2	97.6	73.6
Carbon dioxide	33749346,0	560476,6	101,7	-

Overall in 2011, emissions of pollutants as a result of transport and communication activities of Ukraine decreased by 0.6% compared to 2010 and reached the mark of 195.4 thousand tons, but there was a slight increase in carbon dioxide emissions to 5711 0 tons , which is 102% similar to the previous year.

The volume of polluting emissions substances and greenhouse gas emissions from all transport modes in 2011 are shown in Table. 3. According to the State Aviation Administration data [22], the number of aircraft and helicopters by the end of 2011 was 350 units. In taking measures to reduce the impact on the environment and human health from the operation of railway transport, compliance with environmental legislation, environmental security and prudent use of natural resources railroad industry in 2011 were directed more than 1 billion capital investment and current expenditure: protection of air, water, land, mineral resources, mineral and vegetable resources, waste management, industrial control implementation of the environment and so on, which is three times higher than the costs in 2010.

On the 20th of October 2010, the Cabinet of Ministers of Ukraine adopted the “Transport Strategy of Ukraine for the period up to 2020” aimed at supporting sustainable and efficient transport sector operation to create conditions for social and economic development of the country, improved competitiveness of the national economy, and transport safety.

The transport strategy covers all transport sub-sectors, including cross-sector issues such as environment, border crossing, safety, etc. The strategy aims at facilitating the integration of the domestic transport system into the European and international transport systems, and maximizing the transit potential of Ukraine. The strategy is aligned with the President’s economic reform program adopted in summer of 2010.

The strategy provides a framework for the implementation of necessary transport sector reforms. It also sets out the foundation for government-led donor coordination to develop and implement a comprehensive and prioritized investment program in the sector.

This is a positive development as it provides opportunities for mobilizing the efforts of both Government and external partners for this highly important objective.

Currently, action programs for the execution of the strategy are under preparation. The transport strategy

refers to a number of other strategic documents that will be elaborated upon, such as road safety strategy, aviation safety program, etc. It is intended that the various sub- sectoral strategies under preparation will address the shortcomings of the overall transport strategy document.

Legal grounds of EU-Ukraine relationship are based on the Ukraine-EU Partnership and Cooperation Agreement (PCA) concluded by the Parties in 1998 [8].

At the present stage the framework and priorities of environmental cooperation between Ukraine and EU are determined by a number of documents of various levels to introduce the European Neighbourhood Policy (ENP) and Eastern Partnership.

In particular, the Country Strategy Paper for Ukraine for 2007–2013 within ENP Instrument (ENPI) for sectors of infrastructure development, including environment, prioritizes strengthening of administrative capacities to formulate and implement sectoral strategies and policies, which are approximated to EU policies and legislation, and emphasizes that in environment a specific attention should be paid to support implementation of multilateral environmental agreements (MEAs).

In March 2007 the negotiations with regard to new EU-Ukraine Association Agreement commenced; they were finalized in December 2011. Since the negotiations of Ukraine-EU Association Agreement and its ratification will require several years until the full Agreement comes into force, the Parties agreed to approve Ukraine-EU Association Agenda. With changes adopted by the EU-Ukraine Cooperation Council of 15.05.2012 it contains the following tasks related to environment and climate change:

The Parties cooperate with regard to preparation to implementation of EU acquis specified in the respective annexes to the Association Agreement and to support Ukraine in:

The Parties cooperate to support Ukraine in, and to prepare for implementation of EU acquis mentioned in relevant annexes of the Association Agreement [9]:

- implementation by Ukraine of the National Environment Strategy for the period till 2020 and the National Environment Action Plan for 2009–2012 in order to be able to take measures to implement budgetary support,
- strengthening of the administrative capacity at national, regional and local levels, including through development of effective inspection and enforcement capacities,
- further development and implementation of Ukrainian environmental legislation, strategies and plans, in particular on environmental impact assessment, strategic environmental assessment, access to environmental information, and public participation,
- development of national implementation instruments in line with multilateral environment agreements signed and ratified by Ukraine and the EU, as enlisted listed in the Annex,
- implementing the Kyoto Protocol through a dialogue within the Joint EU-Ukraine Working Group on Climate Change on a new post 2012 agreement on climate change, on eligibility criteria for using the Kyoto mechanisms, and on developing measures to mitigate and adapt to climate change,
- promoting sustainable development and greening economy,
- promoting the implementation of the Bucharest Convention and its Protocols and working together with the Parties of this Convention to promote the accession of the European Union to the Convention,
- maintain a dialogue on Ukraine's participation in selected Environment Agency activities on information collection and dissemination such in the activities aiming at establishing the Shared Environmental Information System.

On 23 July 2012 the meeting of Ministers of EU Member-States and Eastern Partnership partner countries approved the Eastern Partnership Road Map that contains bilateral and multilateral dimensions.

As for Ukraine itself, through the EU Environmental Sector Budget Support (2011–2013) as well as other ENPI instruments (for instance, twinnings) to implement the environmental objectives of the Eastern Partnership Road Map the country will keep working towards approximation of environmental legislation, especially that specified in the Association Agreement.

To support implementation of the National Environmental Policy Strategy of Ukraine the Government of Ukraine and the European Union concluded in 2010 the Agreement on Financing of the Sector Budget Support Program for a total value of EUR 35 mln.

CONCLUSIONS

Given the above, we can say that Ukraine is still on indicators of sustainable development does not comply with the relevant indicators and indices. Current social and economic situation in Ukraine proves that the country hasn’t succeeded in sustainable development yet. This is mostly caused by a number of obstacles the country is facing on the way to development and introduction of the sustainable development policy:

Ukraine is still behind the developed countries in living standards indicators, level of investment attractiveness, competitiveness and sophistication of innovation environment. This challenge is explained not only by external factors but the internal Ukrainian problems as well.

Another obstacle is lack of funding for regional development. Public funding, which could promote the economic potential of regions is almost absent.

Moreover, ecological culture of the citizens of Ukraine is still rather low.

Nowadays social, economic and ecological situation in Ukraine confirms that the country has failed to change significantly the extensive type of economic development and to ensure successful transition to sustainable development. The public health crisis, extremely high material and energy consumption per unit of gross domestic product, waste generation and environmental health indicators, e.g., air, water and land pollution have very risky and systematically stable interrelated trends.

Transition of Ukraine to sustainable development in transport is complex and time consuming. Its essence is to achieve a balance between society and environment, which includes the problems of long-term development of the country, issues of changing of the consumption structure, protection, rational use and restoration of the natural resources, economic and ecological security, social, scientific-technical and regional policy, as well as the aspects of external policy.

Studying the literature about sustainable transport sector enabled us to determine the main directions of introduction of the sustainable development policy in transport are as follows:

- development of the strategy of sustainable development of Ukraine,
- ensuring of the political support to the sustainable development transport strategy,
- ensuring of the informational support to the sustainable development strategy and training of the new transport staffing potential,
- integration of the sustainable development transport strategy into another strategy of economy,
- integration of the sustainable development transport strategy into the strategy of social-economic reforms at all levels (national, regional and local),
- introduction of the mechanisms and elements of sustainable development into other sector of Ukraine economy,
- publishing of the manual on introduction of the sustainable development transport strategy oriented on the representatives of the government of all levels and the manual oriented on a wide mass of public,
- realization of the demonstrational projects of sustainable development in transport sector of economy with the purpose of demonstration of the economic effect due to the implementation of the sustainable development strategy,
- introduction of the new methodology, drafting the transport activity plans on environmental protection and rational use of natural resources, oriented on ensuring of the principles of sustainable development.
- creation of the legal base in transport sphere for transition to sustainable development,
- formation of the effective structure of environmental protection transport management,
- creation and implementation the Energy and resource saving policy in transport,
- formation of the ecological culture of personnel in transport branch.

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Variables state-based software usage model

D. Fedasyuk, V. Yakovyna, P. Serdyuk, O. Nytrebych

Software department, Lviv Polytechnic National University;
79013, Lviv, Bandery st. 28
e-mail: pavlo.serdyuk@gmail.com

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Abstract. This article describes a new mathematical software usage model, which includes the effect of the set of global and external variables values for further analysis of multi-test scenarios to improve the effectiveness of the testing software. This model is represented as a graph of transitions and a set of variables with respective sets of equivalence classes. The proposed approach is particularly relevant for computational algorithms with complex logic.
Key words: software testing process, usage model, test scenario, software reliability.

INTRODUCTION

In spite of continued research efforts in the testing and software reliability assessing fields developers have not received an effective tool for software reliability prediction before its implementation. A lot of models are proposed, but versatility has not been proven for any of them; moreover, as a rule, even a slight deviation from the typical values of the parameters for these models can lead to incorrect calculations due to a number of assumptions which are made during the modeling [1].

The main tool for software reliability analysis and improvements is its testing [2-4]. However, despite the large number of high-quality software testing techniques, even large-scale testing is unable to detect all the failures in the project, which results in significant growth of expenses on software quality assurance process with growth of the software size.

Today a series of issues that do not allow to predict software reliability accurately remain unsolved. For example, the decomposition of the software in the analysis of the characteristics of its reliability [5-6]; until now there is no clear definition of dependency of software reliability on the characteristics of the code. Also, many authors [7-9] indicate a misuse of size and complexity software metrics (Halstead, McCabe metrics) as the sole sources for the software reliability prediction in statistical models [10] for these models ignore the causal effects of human and other factors on defects in the software, because too big complexity of applications may be caused by various circumstances, including programmer's little experience in this field, etc.

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Software reliability assessment using code coverage metrics [11, 12] during software testing is currently the most common tool in practice. But in case when the test scenarios do not cover all the software functionality, then, despite the fact that the software will pass all tests, its reliability may be still low. Also, during the software development it is very difficult to keep track of the failures that occur as a result of multiple interrelated execution steps, because the number of such scenarios grows exponentially depending on the number of steps and the variability of their parameters. This type of relationship occurs through the use of external static or dynamic variables that are used in several steps of the

software scenario. Software testing often does not cover such scenarios as the time allotted for the test is limited. Failures of this type are very expensive to correct, as they often are tracked at the regression testing stage, software deployment or support. According to research at Cambridge University, the yearly cost of bugs that occur in production software is about 312 billion dollars [13]. Also, researchers have shown dependency diagram (Fig. 1) for bugs' correction cost on different stages of the software development life cycle [14]. So it is clear that it is important to keep track of such scenarios at the software development stage, which will reduce the financial and human resources required.

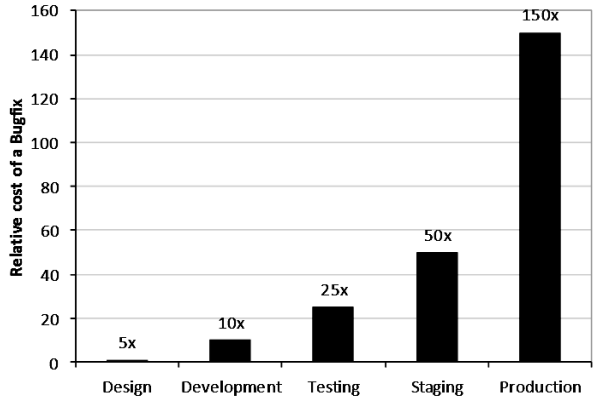

Fig. 1. Cost of fixing bugs at various stages of software delivery

In this research, we emphasize that the considered failures arise from long scenarios consist of several steps. And for them the most important aspect is usage of external variables and variables that are passed between components (as method arguments or other way), rather than the methods internal logic.

In addition, the importance of software variables usage consideration in test scenarios building process follows from the fact that many software reliability analysis models use metrics, which take into account the use of software variables. For example, Bieman J. and Kang B-K. offered class connectivity metrics that are based on direct and indirect connections between pairs of methods [15], which are implemented using the same variables. L. Ott and B. Mehra developed a class partitioning model [16], based on the variables of class instance. In addition, as it is known, complexity software metrics are divided into three main groups [17]: software size metrics; complexity metrics of software control flow; complexity metrics of software data flow. Metrics of the third group are based on an assessment of the use, configuration and data placement in the program; in particular this applies to global variables. This group includes Chapin metric [18], the essence of which is to evaluate a single program module by analyzing the usage nature of variables from I/O list; McClure complexity metric [19] based on the number of possible software implementation paths, the number of control structures and variables; metric of references to global variables [19].

Thus, the development of new methods and algorithms for software reliability assessment and testing is relevant and notable scientific task. Another important task during testing and software reliability estimation is taking into account the variables and their properties, but unfortunately, there is no model nowadays, which could investigate the effect of variables on the software reliability.

Software usage model, based on the analysis of software variables, is described in this paper. It is the basis of the algorithm for automated test scenarios generation that will improve the efficiency of software testing and investigate the influence of the characteristics of software on its reliability.

SOFTWARE USAGE MODEL BASED ON ITS VARIABLES

For building long software testing scenarios, which contribute significantly to the software cost, software usage model was developed. According to this, model considers failures that occur in later software development stages: regression testing, alpha and beta testing, software deployment. This is a consequence of a fact that such failures are usually caused by complicated scenarios, where non-standard initialization of certain variables, objects or components happens on the first steps and actual their usage takes place later on the following steps. In addition, these failures occur only while using a limited subset of variables values.

These scenarios are difficult to cover by the automated or manual testing due to the fact that each stage of a complex scenario can have a number of degrees of freedom, i.e. the possible subsets of the variables values set it uses. The corresponding number of all scenarios is the product of all degrees of freedom of each stage, which can be quite a large number. That is why some scenarios with certain subsets of variables values cannot be reproduced using the standard test scenarios.

The execution of such complex scenarios largely depends on the set of variables values that it uses. Variables in the software can be divided arbitrarily into 3 types:

1. Local – variables that are declared and used only within the method.
2. Global – public variables declared in the class or globally and can be changed by various.
3. Methods arguments – variables that are passed into the method, can be changed by method and transferred into other methods.

Failures, associated with the first type of variables, are not interesting for consideration because they do not affect the occurrence of failures in other methods. Other types of variables should be considered only during detailed multi-level methods analysis.

Each variable V^i is characterized by the number of equivalence classes E_j^i [20]. Equivalence classes are distinguished by choosing each requirement from software specification and splitting it into two or more groups. It should be noted that there are two types of equivalence classes: the correct equivalence classes representing the correct input values for variable and incorrect equivalence classes corresponding to all other possible states of the environment (i.e. wrong input values). This way one of the principles of software testing, need to focus on the wrong conditions, is being followed. For example, if the variables value according to specification is "an integer from 0 to 999 ", then there is one correct equivalence class (0 to 999) and two incorrect (values less than 0 and values bigger than 999).

The software is represented in the form of a directed graph $G=\{S, P\}$, where S – set of software methods, P – set of transitions between the respective methods. An example of such a representation is shown in Fig. 3.

The process of software execution can be modeled by the passage paths of the graph, each node of which can be presented as a method that changes the value of the set of variables values (method arguments as well as global variables), and the edges will be responsible for the sequence of method call.

Each method S^i, that would fit the node has the following properties:

1. List of variables used by the method – S_{used}^i.
2. List of variables changed by the method S_{change}^i, and appropriate change probability. This set of variables is the union of the set of variables that can be changed by the user $S_{change\_user}^i$ (variables, tested with "black box" testing), and also variables that can be changed due to internal logic programs $S_{change\_program}^i$ (variables that can be tested only with "gray box" or "white box" testing).
3. List of variables and corresponding incorrect equivalence classes S_{err}^i that can cause failure in this method.
4. List of incident arcs Pi, which in turn contain the transition probability p_{ij} to other method S^j.

Let's considering an example: given software that consists of the following methods: addContact, changeContact, inputOrder, deleteOrder. Software usage model, which is represented by a graph, is shown in Fig. 2. Nodes correspond to methods of application, and the edges weights reflect the transition probabilities between methods.

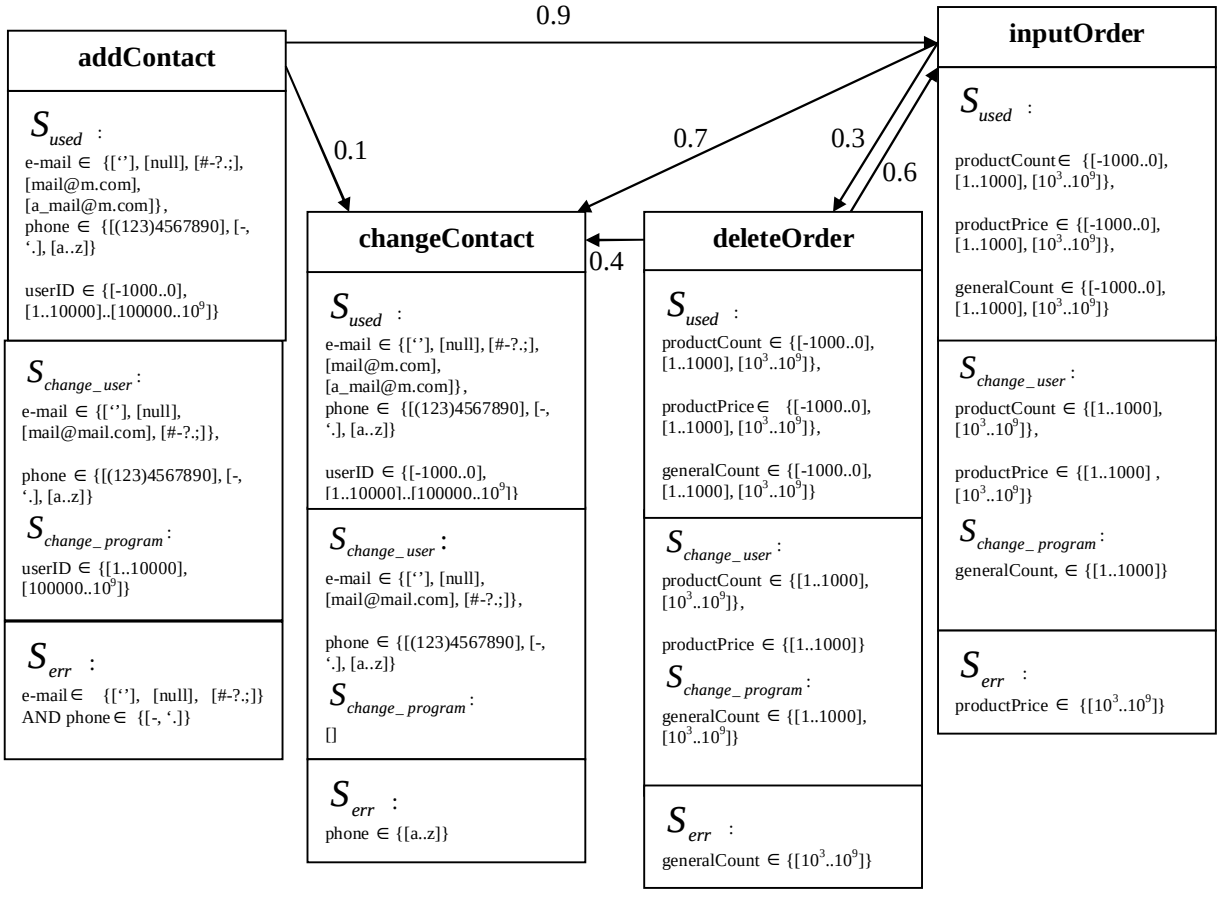

Fig. 2. Example of graph of software usage model

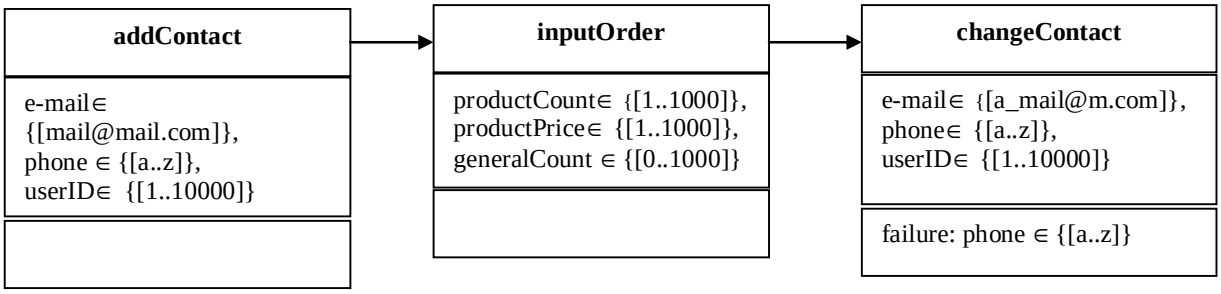

Fig.3. An example of the scenario using three steps

Let's consider the example of a simple execution scenario of two steps, where changes on the first step result in a failure on the second (Fig. 3).

On the first step in the method addContact, phone value has changed to 1 (value from the first equivalence class), leading to the failure in the method changeContact.

Obviously, such scenarios can contain a larger number of steps. Testing all of these scenarios is not possible, because their number matches the product of all equivalence classes of all variables used in test scenarios. Still, their number can be reduced by the "white" box analysis.

CONSTRUCTION OF TEST SCENARIO BASED ON SOFTWARE USAGE MODEL

A sequence of software methods executions with certain variables values will be called a test scenario or test case. The test can be executed successfully, or terminate because of a failure in some method.

Today there are three most important methods of software testing, which are analyzed by our model [21]:

1. "Black box" methods, which consider system characteristics of the programs, ignoring their internal logical structure. In sense of presented model these methods use variables, which can be changed by end-user.

2. "White box" methods – a detailed study of the internal logic and structure of the software code when complete information about the source code of the software is available. Main difference for our model point of view that these methods use internal variables (for example, significant variables using unit testing).

3. "Gray box" methods, which allow testing the software with limited knowledge of the internal structure of the program, and are based on the use of information on major functional aspects of the software. These methods use variables, which can be changed by user, database variables and others (Fig. 4).

As noted in previous section, relationships and transitions between states are represented as a graph to build test scenarios. This graph can be built by the "white box" analysis of the code that best matches the real nature of the software, or by using a "black box" approach with logging of methods calls. The last one doesn't guarantee that all of the transitions will be included. Also, the construction of the required graph can be done using "gray box" methods, which means that some variables values in methods may be redundant, nonexistent in real software.

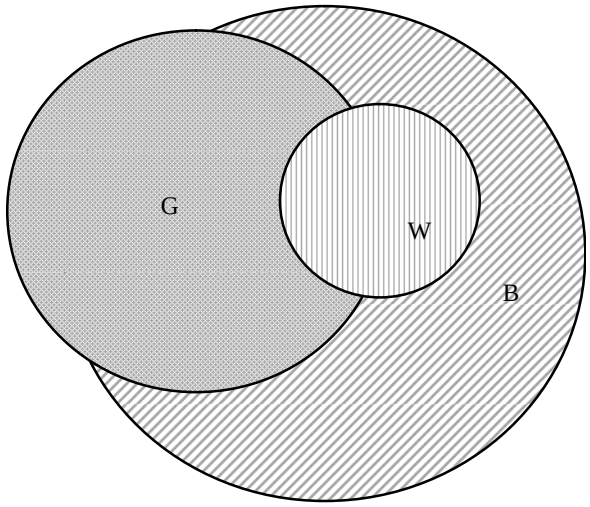

Fig.4. Sets of transition in the graph during its creation by B – "black box", W – "white box", G – "gray box", U – the set of all transitions in the graph

Consider that each test scenario consist of several steps $T = \{T_0, T_1, ..., T_n\}$, where $T_i=\{S^i, V^i\}$, V^i – a set of variables and its values, which can be changed in method S^i Variables change its values on each step of the test scenario and failure can occur during test scenario execution.

To construct a set of test scenarios the following steps are used. Let's assume that distribution of components (methods) coverage by tests should be uniform on the zero iteration of the first scenario. The zero iteration T_0 of the first scenario starts with some components S^0 randomly with probability $p_0^1 = 1/N, N -$ number of all nodes of the graph. The probability of the next step T_{l+1} in the first scenario after step l defined as $p_{l+1}^1 = 1/|P(S^i)|$, where $|P(S^i)|$ – number of all transitions from component S^i, to ensure a uniform nodes coverage.

Let $Er^j(S^i)$ – count of failures that were found on *j*-th test scenario in the S^i component. $M(S^i)$ – the set of all numbers of nodes, having a transition from components S^i.

In next scenarios coverage is based on the density of failures obtained in the previous scenario. The *(k+1)-th* scenario starts from component S^0, such that: $p_0^{k+1} = \max \frac{Er^k(S^i)}{\sum_{j=1}^{N} Er^k(S^j)}, i = 1..n$. Nodes on the next iterations in *(k+1)-th* scenario are chosen with probability $p_{l+1}^{k+1} = \max \frac{Er^k(S^i)}{\sum_{j \in M(S^l)} Er^k(S^j)}, i \in M(S^l)$.

This choice provides an ability to choose nodes in proportion to the number of failures that occurred in the previous scenario. With built sets of test scenarios the software testing efficacy can be increased to improve performance reliability.

THE EXPERIMENTAL RESULTS

To illustrate the effectiveness of the proposed approach a research on dependency of number of failures (which describes the testing efficacy under equal conditions) on the nature of testing process (e.g. number of test scenarios) and the characteristics of the software product (the number of components) for different testing strategies had been conducted.

As an illustration, a software usage model was built for some test software with the following features: the number methods in software – 300, the total number of variables – 400, the average percentage of variable methods that can be changed by user – 20% and so on. Using the algorithm described above a set of test scenarios for such usage model was constructed, which were later executed to simulate the dependence of number of software failures on various parameters.

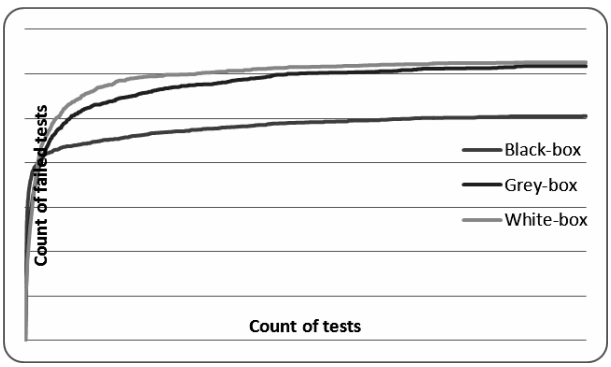

Fig.5. The graph of dependence of number of passed tests on count of failures using three testing strategies

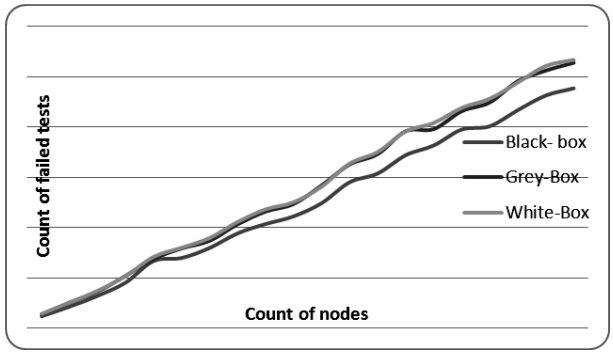

Fig.6. Dependency graph of failures count and the number of methods using three testing strategies

In order to test the adequacy of the software usage model based on its variables a simulation of nature of dependency between the number of failures on the one side and software testing process characteristics and internal characteristics of the software on the other was conducted. Thus, in Fig. 5 a dependency of the number of failures on the number of test scenarios based on different strategies for particular test software is shown.

As shown in Fig.5 most failures were found during "white box" testing, and the least during "black box", which corresponds to the reality, since "white box" strategy takes into account the software architecture and features of its failures. The graph of dependency has been proven by many researchers in this area [22, 23].

Dependency graph of the number of failures on the number of software methods, depicted in Fig.6, shows a linear relationship between the software size (the number of methods in it) and the number of failures. As shown in Fig.6, the results, obtained using the proposed model, show almost linear dependency between the count of failures and the software size for all test strategies. The same dependency of the number of failures on the software size has been described in [24], which confirms the adequacy of the proposed software usage model. The calculated coefficients of determination R^2= 0.9971 for “black-box”, R^2= 0.9998 for “gray-box”, R^2= 0.9999 for “white-box” indicate a high correlation between the software size and the count of failures for particular testing strategy. It is also clear, that the smallest total number of failures, depending on the number of software components, has been obtained during “black-box” testing, meaning that “black box” testing efficacy drops with growth of software complexity – such testing is not able to detect all defects in a complex software. This conclusion corresponds well to empirical results obtained from the industrial software development practice, where the software size definitely correlates with its functionality and complexity.

CONCLUSIONS

This paper describes a new software usage model, which allow to invastigate complex test scenario, taking into account the effect of method arguments, global and

local variables, and considering failures that occur in the later stages of software development: regression testing, alpha and beta testing, software deployment. Also, a way to generate automated test scenarios based on formal software usage model is proposed, that will allow to increase the efficacy of software testing in software industry to assure a desired level of quality and reliability. On the basis of developed model the simulation of dependency of the count of failures on the number of test scenarios and the count of software methods has been performed for different testing strategies, which confirmed the validity of the developed software usage model and efficacy of automated generation of test scenarios. This approach also was probated on the software counting complex logic and demonstrated high efficacy in the case of computational algorithms with complicated relationships of methods and variables.

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The peculiarities of an enterprise intellectual potential bearer's interaction and the identification of their goals

S. Knyaz[1], L. Holyavka[2]

1Department of Ecological Policy and Managemen of Environmental Activities,
2Department of Management and International Business,
Lviv Polytechnic National University
79013, Lviv, Bandery st. 12
e-mail: liljakholyavka@gmail.com

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Abstract. On the basis of literary sources the goals of an enterprise intellectual potential bearers are generalized in the paper.An enterprise intellectual potential functions meant for the achieving of certain results of its activity are defined, the interaction of goals, functions and results are depicted as well. The existing bearers are analyzed and the most suitable way of intellectual potential bearers interaction at an enterprise has been chosen.

Key words: Intellectual potential, intellectual potential bearers goals, intellectual potential functions, an enterprise intellectual potential interaction.

INTRODUCTION

Modern tendencies of all social spheres intellectualization have an immense impact on the peculiarities of economic systems activity of different levels as well, the basis of which are intellectual resources which in their turn form intellectual potential of the given systems. The very entity of intellectual potential is defined as a capability of a bearer of doing something, created by its intellectual resources. In one's turn any economic system (in the paper under consideration the importance has been attached to the consideration of economic system of a microlevel, in other words, of an enterprise) is created and functions for the sake of certain desired result achieving, the goals demanded by the subject of the given system. Taking into consideration the fact that intellectual potential of the subject of activity is mostly defined by the intellectual potential of its workers, its effective application to achieve enterprise goals is possible only in case of the sequence of individual and collective goals of its bearers. That is why, the most urgent are the problems connected to the identification of intellectual potential bearers goals within an enterprise activity and the investigation of possible ways, directions and models of their interaction with the aim of supplying positive results of their functioning.

MATERIALS AND METHODS

Numerous works by national and foreign researchers were dedicated to the investigation of theoretical and applied aspects of intellectual potential management. However, the analysis of researchers' thoughts testify to a partial problem consideration connected to the primary stages of intellectual potential management, including bearers' goals identification, destination and the directions of their implementation in the subject of activity. Including the authors O.Kendyuhov and Ye. Doktoruk [11, 7] dwell upon the fact that the most important goals of intellectual potential or the products of its realization management is the achieving of economic profit, especially maximization of enterprise profit. V.Petrenko [22] claims that «… the application of any kind of intellect is submitted first of all towards the function of appropriateness – the achieving of positive economic and/or social result…». Without any doubt, the achieving of positive economic effects is a priority goal of an enterprise intellectual potential application, but the question arises, whether there is the capability of

achieving such results without taking into account individual goals and motives of its major bearers which may often contradict to enterprise general goals. I. Moyseyenko [20] defines the goals according to the level of hierarchy of higher and lower levels and more complicated goals within an intellectual potential management. However, the author failed to provide an example of such goals within the system of management of the given level of potential. The researcher A.Kapterev [10], defining such goals of intellectual potential management as competence improvement, accessibility, effectiveness and innovation, one dwells on the appropriateness of accounting employees needs (according to the Pyramid of Needs by Maslow). According to practice of enterprise managing, a correct goal choice, their equality to the conditions of functioning and also the definition of ways, directions of interaction of components of systems (the very enterprise) with the aim of achieving of defined goals is a key to successful and long-term functioning at the market. Concerning intellectual potential to which such systemic characteristics as intersequence of bearers'goals are peculiar in the process of their interaction, is one of the basic principles which ensures its effective formation and application.

RESULTS AND DISCUSSIONS

As it is known, any activity must not be arbitrary, but be directed to the achieving of certain result, in other words to the goals achieving. Generally, the term«goal» in economic literature is treated as a certain exact state, peculiarity or index, which is aimed by the subject of managing within a certain period of time.

General ideas concerning the understanding of the given notion are presented in the work by V.Samulyak [24] testifies to the absence of contradictions in the existing definitions. All the definitions given by the author have a common ground and differ only by more or less extended treatment. The author himself in the given paper defines the goals of an enterprise as derived and dependable on the factors impact, desired for the goals achieving and generalizes the factors of the impact on the goals, offers the model of an enterprise and goals management. I. Markovych [18] claims that «the goals reflect exact directions of enterprise activity, representing the ground of strategic management…». The researcher also dwells on the importance of strict hierarchy and mutual submittance of long-term, short-term goals and tasks of an enterprise. The matter of interest is also the work by O. Lyulova [16], where the groups and the character of their influence on enterprise goals are given, the model of analysis of the sequence of existing subject's of managing goals. It is worth adding that apart from all the authors mentioned above [24,16,18], practically all researchers of the sphere of management attach importance to the investigation of the goals of different levels economic systems. This fact causes the need of considering the given problems on the level of the investigation of intellectual potential of an enterprise.

It is a well-known fact, that the formation and application of an enterprise intellectual potential (FAEIP) must not be a final goal for the subject of managing. Since, the main destination of intellectual potential lies in its application in the process of analysis of industrial-managing problems, the projecting of creative ways of their solution, the search of a well-grounded choice of and realization of managerial decisions. That means that within the hierarchy FAEIP is an additional goal, which submits to general goals and is one of the supplying components of their achieving. Taking into consideration the classification of the existing goals of an enterprise [24,15], it is possible to consider the FAEIP goals which according to the meaning, functions, time direction and management levels, etc. Having generalized enterprise goals into strategic, tactic and operational, we suggest concentrating on their interrelation with the intellectual potential bearers' tasks (as the chosen goals lead to the fulfillment of certain tasks for their achieving) and the functions of the given potential in the process of problem solution to gain a desired result. One should take into account the fact that within an enterprise there exist and must be sequenced collective (enterprise goals in general) and individual goals (on the level of a certain employee). To represent the given connections, the picture is given: fig. 1.

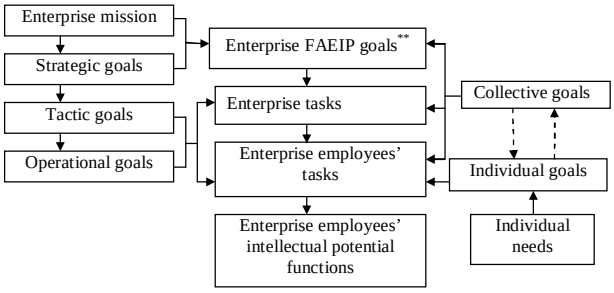

Fig. 1. The interaction of goals, tasks and functions of an enterprise intellectual potential bearers*
* – formed by the authors on the basis of sources analysis [9, 15, 16,18, 24]; ** – the formation and application of intellectual potential

Concerning the understanding of the collective goals as the ones of an enterprise n general, their character is defined at first by the specificities of a certain enterprise activity. But, at a strategic level they may be generalized as such, which are peculiar to each enterprise: profit rise, market parts, competitiveness, capitalization, etc. [24]. With the help of planning tools they are detailed into tactic and operational, defining the tasks of all managing enterprise system and each employee as well. Since intellectual potential and intellectual activity are intermediary in any industrial or

managing process, then the goals of FAEIP coincide with general collective goals and tasks of the subject of managing.

What concerns the functions of intellectual potential, the level and results of which are defined by intellectual recourses of employees and an enterprise in general, we may define the following:

– informational one [1], which lies in the enterprise supply of informational recourses and the fulfillment of generally known changing actions on them (accumulation, systematization, processing, saving, application, shift). Concerning the informational recourses, they are the core component of intellectual recourses formation. In one's turn, employees' knowledge, skills and experience are transformed at organizational level into a huge component of a general informational recourse of an enterprise. Apart from them, we should here consider the information from outer environment received on commercial or free bases, which is generated by an enterprise artificial intellect. It is also important to note that the realization of an informational function depends on such intellectual recourse of an enterprise as the system of on-duty service relations, which allows formation of the peculiarities of informational recourses exchange in the process of intellectual interaction of an intellectual employees interaction owing to the rules and procedures of an enterprise.

– analytical, being grounded on the existing intellectual recourses and arising from the previous function, it is expressed by the ability to finding and detailed investigation, analysis of actual and possible managing problems of an enterprise, formation of objective, well-grounded conclusions according to the results of their fulfillment;

– investigating one[1] ensures the creating of previously unknown and the imperfection of actual intellectual recourses, conducting of theoretical and applied research with the aim of the search of ideas, decisions, etc.

– creative one, generally lies in non-standard problem solution of an enterprise problems. Such type of intellectual recourse as individual abilities of employees. According to Yu. Kulagin, N. Statinova and others [13], the characteristics of creativity are independent activity, new project orientation and its importance in the society As well, the authors claim [13] that the problem awareness, the ability to generate original ideas, analytical abilities, creative and abstract thinking are an integral part of creative activity;

– innovational one, is mainly ensured by the fulfillment of previously described functions and is expressed by the activity connected to the creation and application of innovations. A great number of researchers [3,5,8,19,26] dwells upon the investigation of intellectual potential as a constituent part of innovational potential of an enterprise. The question of the interaction of intellectual and innovational potential in the general structure of an enterprise potential is contradictory. As, on the one hand, it is impossible to create innovations without intellectual activity, and on the other hand, actual knowledge and skills of an employee are not the guarantee of an enterprise innovational success, the achieving of which is a long-term stage and is connected to a great material-technical supply. However, taking into consideration the fact that new(not existing before) or improved knowledge, ideas, decisions and other things are the result of intellectual work, all of them possess the element of innovation that is why it is worth defining an innovational function of intellectual potential, which ensures the actuality of enterprise problems which are in the process of solution, according to modern conditions of economics development which is oriented on innovations;

– motivational, caused by the fact that the existence of certain abilities (the very potential), their understanding encourages the employees to work intellectually, in connection to the receiving of new or application of actual intellectual recourses. I other words, it means that the employees are ready make intellectual efforts for the sake of realization of an enterprise goals. It is connected to collective needs of employees, and also to the fact that owing to the intellect employees are able to realize themselves as a part of certain social groups. This understanding, to some extent rules the behavior of intellectual potential bearers and their goals. Being ready is an intention anyway, when there is an intention, then even if there is a lack of intellect possibly the person will make some effort, gain new knowledge and skills and realize one's goal.

What concerns individual employees' goals, it is generally known that they are derived from needs. The needs in their turn define the stimuli, motives and the behavior of a man for certain goals achievement. The investigation of a phenomenon of man's needs in the spheres of psychology and management have found their reflection in modern theories of motivation, that are arbitrary divided into two groups: those which concentrate their attention on the entity and the types of needs (A. Maslow, U. Ouchee, M. Tuhan-Baranovskyy and others); concentrated on the process of needs satisfaction (the theories of moral, material stimulation, V. Vroom, G. Atkinson and others.) [15]. Being based on the investigation of previously named theories and the results of investigations by N. Maksymchuk and O. Panchuk [17], let us generalize possible individual goals of intellectual potential bearers of an enterprise, which make them work intellectually according to such groups: material, connected to the amount of profit and material life conditions; professional are expressed by the wish to achieve a certain result in the profession and career prospects; social, it means the achievement of certain status among colleagues or in other social groups (admittance, respect, privities, etc); personal imperfection

goals; altruistic, when there is a leveling of personal goals for the sake of other subject's goals. Concerning probable advantages of these or those goals, in the research [22] the author claims that«the people of the economic epoch in their majority are oriented on their needs satisfaction of a higher level in a way of effective transforming of their own potential into innovational intellectual products,… personal intellectual capital…. ».

On condition of different individual intellectual potential bearers' goals the problems of their sequence between employees and collective goals onto which an enterprise activity is directed arise. The majority of researchers of the sphere of intellectual activity dwells upon a necessity of its effective moral and material stimulation. We agree, however claim that it is necessary to consider various variants of possible intellectual interaction between employees.

The problem of subject's behavior within certain system has been actively investigated in modern economics, mathematics, software developing and are combined into one scientific branch «games theory». Before analyzing actual theories and the possibility to shift their ideas onto intellectual interaction modeling within the enterprise, it is necessary to specify categorical-notional apparatus, which to some extent differs from the one peculiar to economics and management. Including, the notion "game" means «… any players' interaction, where the use of each player depends on one's own action and other players' ones as well» [25]. In the given theories the players are the participants who interact in the system. A goal set of functions which are desired for one is peculiar to each player. The achievement of goals is done owing to strategies, in other word actions done by players. On the basis of scientific sources analysis on the theme under consideration, we generalize in the tab.1 actual game theories and evaluate the possibility of intellectual interaction of intellectual potential bearers with the aim of achievement of their own goals and those of an enterprise in general as well.

Table 1. Comparative characteristics of game theories and the possibilities of their application in the intellectual potential of an enterprise interaction*

The name of a game	Short game characteristics	Possible application to enterprise intellectual potential
Non-cooperative games	Each participant acts independently and simultaneously making an effort to predict the behavior of the rest of the players. The possibility of the sequence of actions and goals and prize redistribution is excluded.	Such game behavior of intellectual potential bearers is irrational, as it contradicts general principles of enterprise functioning and considers all its employees as opponents only. The following of the given theory will lead to the situation when neither enterprise goals nor players' ones will be achieved.
Cooperative games	Players cooperate (make coalition), sequencing their strategies with the aim of maximum achievement of winner prize for coalition and its further distribution among the participants..	It is the best way of interaction of an enterprise intellectual potential interaction and their goal functions maximization.
Static games	All players act simultaneously and only once.	Within an enterprise intellectual potential bearers interaction is held in dynamics without stop, their goals achievement is gradual and demands some time which contradicts to static games principles.
Dynamic games	Players act one by one: the strategy chosen by the first player is analyzed by other players, each of them respectively chooses one's own model of behavior as of one's own goal function and also of a general coalition result. In this process active communication among players is allowed.	Such way of behavior ensures the sequence of goals and their effective achievement. Such type of a game coincide with one of the basic management principle – participation and offers a possibility to take an initiative and take an active part in task fulfillment of enterprise activity.
Coordinational (hierarchical) games	The players within the system act on respective levels. Each level has a coordinator who regulates informational space of a game and can introduce new strategies into it..	Such type of games to a major extent coincides with peculiarities of intellectual potential bearers, as it depicts the scheme of actual enterprises functioning with the existing organizational structures in them, solved problems and are an effective tool for general and individual goals achievement.
Stochatic games	The functions of a prize are unknown and random. The game consists of a majority of stages, at each of which players choose random strategy depending on the circumstances.	The given type of interaction is the best in modern state of environment changeability. However, taking into account a condition of stability of functioning of an enterprise, it can be applied only in some cases of intellectual potential bearers interaction for the solution of single tasks.
Reflexive games	The choice of behavior by each player depends on the rank of reflex ion, it means of one's thoughts about actual game and suppositions of possible strategies and opponents.	Such type of behavior is not peculiar to intellectual potential bearers interaction, it can be held when the player is a certain enterprise in general and the choice of strategy concerning the opponents is made.

* – generalized by authors on the basis of sources analysis [2,4; 6,12,14,21,23,25]

Previously given types of games models are basic and the combinations of which are accessible. For instance, cooperative games may be dynamic or static, coordination games in their entity include cooperative and dynamic ones, etc. Apart from that, described types may be classified according to duration, result prize, information, etc [19]. Major part of modern research is connected to different technologies application in cooperative games. Including European researchers [24] attach importance to the application of SR-nets in cooperative games, which lie in revealing, structuralizing and analyzing of alternative prizes for each participant of a game on other equal conditions.

What concerns the achievement of goals of intellectual interaction among the employees, it is rather desirable to apply basic grounds of coordination games. Coordinators part in the process of such interaction is defined by their ability to introduce new information recourses, new conditions and strategies into a game. Detailed explanation of functions and results of coordinators impact in socio-economic systems with the formulation and addition of certain theorems are given in the following work [18]. Within enterprise work a coordinator is a representative of an existing ruling system. Since the activity of an enterprise is held as a result of all participants interaction, we can consider the coalitions made by them(structural coalitions) as on the level of subunit, and an enterprise in general(general coalition). In this case the coordinators on the subunit level will be their chiefs and for the enterprise – a higher rank of management.

Applying the traditional for the theory of games mathematical tools and indexes [18-25], we will depict a plurality of intellectual strategies of intellectual strategies bearers ($V(S_m)$) within one structural coalition (subunit) of an enterprise (S_m), which possesses characteristic function (expresses affiliation of a separate element of general plurality to a certain subplurality):

$$V(S_m)=\max_{y_{S_m}\in A_{S_m}}\left[\sum_{y_{N\setminus S_m}\in A_{N\setminus S_m}} K_{iS_m}\left(y_{S_m},y_{N\setminus S_m}\right)\right]_{i\in S_m\ m\in N}. \qquad (1)$$

where: m – the quantity of structural coalitions (1,…,m) of intellectual potential bearers within general N-coalition (enterprise); i – individual intellectual potential bearer of structural coalition S_m (subunit employee) (1,…, n); K_{iSm} – the function of i-bearer intellectual potential of structural coalition S_m; y_{sm} – target function of structural coalition S_m $(y_1,\ldots,y_n)$; $y_{N\setminus Sm}$ – target functions of the rest of structural coalition within a general N – coalition; $y_{Sm}=(y_i)$, $i \in S_m \in A_{sm}=\prod A_i$ – vector of intellectual potential bearers actions of structural coalition of S_m.

Judging by the above mentioned utterance, the plurality of each structural coalition strategy is directed to its target functions maximization (subunit goals achievement) due to intellectual activity of i – bearer of intellectual potential of structural coalition potential and depends on existing target functions of other structural coalitions within an enterprise. In this situation, the maximization of target functions of subunits is a guaranty of enterprise goals achievement in general.

As the pic.1, targeted individual goals of intellectual potential bearers, their unities on the level of subunits and enterprises in general are interrelated as well as the functions of the above mentioned subjects, received results (prizes/ failures). Apart from this, the goals, functions and results are not single, but depicted by certain pluralities which correlate. Let, $\left\{\overset{n}{\underset{i=1}{D_i}}\right\}$ – the plurality of needs of an individual bearer of intellectual potential, which defines the plurality of one's individual goals: $\left\{\overset{n}{\underset{i=1}{A_i}}\right\}$; $\left\{\overset{m}{\underset{d=1}{A_d}}\right\}$ – the goals of an enterprise subuni, $\left\{\overset{p}{\underset{e=1}{A_e}}\right\}$ – general enterprise goals. General goals form the plurality of functions of employees', subunit and enterprise intellectual potential: $\left\{\overset{n}{\underset{i=1}{F_i}}\right\}$, $\left\{\overset{m}{\underset{d=1}{F_d}}\right\}$, $\left\{\overset{p}{\underset{e=1}{F_e}}\right\}$. The realization of functions plurality leads to certain result of the application of intellectual potential, which characterizes the degree of employees', subunits and enterprise goals achievement: $\left\{\overset{n}{\underset{i=1}{R_i}}\right\}$, $\left\{\overset{m}{\underset{d=1}{R_d}}\right\}$, $\left\{\overset{p}{\underset{e=1}{R_e}}\right\}$. The correlation of defined pluralities is done the following way:

$$\begin{cases}\left\{\overset{n}{\underset{i=1}{D_i}}\right\} \mathbf{a} \left\{\overset{n}{\underset{i=1}{A_i}}\right\},\\ \left\{\overset{p}{\underset{e=1}{A_e}}\right\}\rightarrow\left\{\overset{m}{\underset{d=1}{A_d}}\right\},\\ \left\{\overset{n}{\underset{i=1}{A_i}}\right\} \mathbf{I} \left\{\overset{m}{\underset{d=1}{A_d}}\right\},\\ \left\{\overset{m}{\underset{d=1}{A_d}}\right\}\rightarrow\left\{\overset{n}{\underset{i=1}{F_i}}\right\}\subseteq\left\{\overset{m}{\underset{d=1}{F_d}}\right\}\subseteq\left\{\overset{p}{\underset{e=1}{F_e}}\right\}\rightarrow\left\{\overset{p}{\underset{e=1}{R_e}}\right\}\rightarrow\left\{\overset{m}{\underset{d=1}{R_d}}\right\}\rightarrow\left\{\overset{n}{\underset{i=1}{R_i}}\right\}.\end{cases} \qquad (2)$$

Judging by the above mentioned correlations the plurality of needs of an individual intellectual potential bearer is reflected in the plurality of one's individual goals. In its turn, enterprise goals define the goals of each of its subunit, the latter form necessary functions of an employee's intellectual potential, which is involved into the plurality of subunits and an enterprise intellectual potential in general. The realization of the given functions causes the achievement certain results by an enterprise which influence on the results of awards for each employee. We should note that the possibility of the achieving of bearers' goals and the fulfillment of intellectual potential functions is ensured by the

condition of pluralities crossing: $\left\{\overset{n}{\underset{i=1}{A_i}}\right\}$ and $\left\{\overset{m}{\underset{d=1}{A_d}}\right\}$. Due to the lack common elements (points of crossing), the achievement of goals becomes impossible, at first of the plurality $\left\{\overset{n}{\underset{i=1}{A_i}}\right\}$. In such case, an employee will not be able to achieve desired personal results working within a subunit or an enterprise in general.

CONCLUSIONS

The uncovering of a problem connected to the goals of intellectual potential bearers and their functions possesses a great practical value in the problem of the given type of potential of an enterprise. In the process of research it has been found out the types of goals peculiar to intellectual potential bearers, including their division into collective and individual, strategic, tactic and operational. The authors also formulated the enterprise intellectual potential functions (informational, analytic, investigating, creative, innovative, motivational) and revealed their entity. The fulfillment of an intellectual potential of its functions will ensure the goals achievement of its bearers.

The most appropriate way of depicting goals interaction, intellectual potential bearers' functions of an enterprise (considering their variety) we consider the application of correlations existing between pluralities. Suggested on the basis of the theory of and mathematic apparatus of coordination games of intellectual potential bearers model within an enterprise has its practical value and reflects the most effective way of maximum realization of goals and receiving desired results of each employee' activity and of each subunit and enterprise as well.

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Considering the negative factors in enterprise management

V. Kozyk, N. Seliuchenko, V. Masiuk

Department of Business Economics and Investment,
Lviv Polytechnic National University 79013, Lviv, Bandery st. 12,
e-mail:vklymash@gmail.com

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Abstract. The article examines the processes of anti-crisis management, risk management and economic security management of the enterprise as functional subsystems of the general system of enterprise management. The views of various scholars concerning these processes are analyzed; their main stages and features are highlighted. The relation between the subsystems in times of crisis and under normal conditions is established.

Key words: anti-crisis management, risk management, economic security system, process, strategy, crisis, risk, danger.

INTRODUCTION

To avoid irregular activities and to ensure stable operation and development of the enterprise, effective management process should be adjusted. Due to the large number of internal and external factors that affect the enterprise and can cause deviations from planned indices and even threaten the crisis emergence, it is necessary to implement such management subsystems as anti-crisis management, risk management or economic security management. Each of these subsystems should be aimed at achieving the strategic goals of the enterprise. Therefore, the processes of anti-crisis management, risk management and economic security management should have clearly defined goals and objectives, methods and tools, which in some cases may coincide, but have their own specifications.

Many experts are engaged in the research of anti-crisis management, risk management and providing of economic security. However, most scientists focus on the study of one of the three functional management subsystems. So there is a question whether one of these subsystems is sufficient to address the impact of negative factors, or three subsystems must operate.

The aim of the article is to identify the features of anti-crisis management processes, risk management and economic security management of enterprise and establish relationships between them in times of crisis and under normal conditions.

THEORETICAL STUDY OF THE PROBLEMS OF ENTERPRISE MANAGEMENT IN VIEW OF THE NEGATIVE FACTORS

Any type of management activity involves performing a series of actions, the use of techniques and methods by which ensured the achievement of a specific result. The sequence of such actions, methods, techniques reflects management process. In general, it can be displayed by the following stages: 1) goal identification, 2) situation assessment, 3) problem identification, 4) taking appropriate management decision, 5) decision implementation, 6) control of decision implementation, deviations identification and making decisions concerning their elimination.

V.O.Vasylenko [16] focuses on the fact that within the general meaning of the management process, there are different types of influence formation, which reflect the features of the object and the subject of management, specific circumstances, experience and competence of the manager and personnel, other characteristics of the practical conditions of management activity. Accordingly, the management process is built on the following criteria: rationality, time-saving and resource utilization, maximum efficiency.

Given the above, we emphasize that it is possible to identify stages that are similar to the mentioned above in the processes of anti-crisis management, risk management and enterprise economic security management.

But each of these processes has its own characteristics. Therefore it is necessary to investigate these processes and identify their characteristics.

The process of anti-crisis management can be described as a series of targeted, well-defined successive anti-crisis actions. We will focus on the characteristics of these actions.

Many domestic researchers affirm that anti-crisis management could have a preventive nature, or is directed to overcome the crisis that has unfolded in the enterprise. In particular, V.O.Vasylenko [16] states that "anti-crisis management is a management that is aimed at predicting crisis, analyzing its symptoms and threats elimination of the crisis emergence. And in case of their emergence - analysis and taking quick actions of liquidation character with minimal losses and negative consequences".

Exploring the financial crisis, O.O.Tereshchenko [14] describes specific features of anti-crisis financial management as follows. Firstly, it is a set of preventive measures aimed at preventing financial crisis (systemic analysis of the strengths and weaknesses of the enterprise, evaluating the probability of bankruptcy, risk management (identification, evaluation and elimination), implementation of preventative measures, etc. Secondly, it is a financial management system, aimed at the withdrawal of the enterprise out of the crisis, including reorganization or restructuring of the enterprise.

L.O. Ligonenko [9] firstly describes anti-crisis management as a reactive process, i.e. as a set and sequence of measures to overcome the current crisis, and then - as the preventive process. Reactive process includes: diagnostics of crisis situation and the threat of bankruptcy; identifying goals, objectives and the subject of anti-crisis activity; time constraints and resource potential evaluation of the anti-crisis management process; design and implementation of anti-crisis program and monitor its implementation. The preventive process is the design and implementation of the preventive measures in order to stave off crisis.

The analysis of anti-crisis management stages, separated by L.O. Ligonenko [9], suggests to agree with the authors [19] that proposed mechanism reflects such management features as mobility in the use of resources, software and targeted approaches to implement management decisions , intensified sensitivity to the time factor, increased attention to the past and future assessments of management decisions and the use of anti-crisis criterion of quality of management decisions during their design and implementation. However, it should be noted that the sequence of anti-crisis management stages, separated by L.O.Ligonenko, doesn't contain any stage to prevent crisis in the prosperous enterprise.

N.V.Mishenina [11], investigating the problems of anti-crisis management, identifies the following stages: detection of negative internal and external factors of the environment; predicting the effects of these factors on the enterprise; evaluating the possibility of the crisis overcoming; the strategy formation of anti-crisis activity of the enterprise; design and implementation of anti-crisis program; the evaluation of anti-crisis activity.

We agree with the author [11] that in case of crisis emergence, the enterprise should identify all negative factors of internal and external environment, and to predict the consequences of their impact on the enterprise, i.e. the further development of the crisis. However, the crisis presence in the enterprise (as evidenced by the third stage) calls for a deep diagnostics of its state which, in our opinion, is not reflected in the stages of anti-crisis management.

Diagnostics of management processes is one of the most important steps. It determines the nature of management decisions and their efficiency.

V.O.Vasylenko [16] considers diagnostics as "the determination of object, phenomenon or management procedure through the implementation of complex research procedures, identifying weak links and "bottlenecks". The task of diagnostics is closely intertwined with the other two goals - prediction and analysis of origin. Prediction allows you to specify a diagnosis. The investigation of the object development also helps to understand its current state better. ... At the same time diagnostics is the starting point of the prediction, because without a clear and accurate statement of the prevailing condition it is impossible to assess the alternatives of object development".

L.O.Ligonenko [9] understands the diagnostics of the crisis and the threat of bankruptcy as the system of "retrospective, operational and target analysis aimed at identifying signs of a crisis state on the enterprise, assessment of the bankruptcy threat and possibilities to overcome the crisis."

I.A.Blank claims that assessment of crisis growth factors and prediction of possible bankruptcy should be made long before its obvious signs [2]. For this purpose, rapid diagnostics of bankruptcy is operated, which aimed at detection of early signs of crisis development of the enterprise and preliminary assessment of the extent of the crisis. In other scale crisis situation, fundamental diagnostics is mandatory that describes a system of estimating the parameters of the crisis financial development of the enterprise [2].

In our opinion, the stages, proposed by N.V.Mishenina [11], do not include evaluation of the enterprise state, problems identification and "analysis of the origin" of these problems, so there is no analysis of the crisis causes, assessment of the type and depth. The mentioned above makes it impossible to implement the next stages of anti-crisis management adequately, i.e to predict the effects of the factors on the enterprise, to evaluate the potential of the crisis overcoming, to create a strategy of anti-crisis activity and develop anti-crisis program.

The complex nature of anti-crisis management is reflected in [19]. The authors identified three types of anti-crisis management: preventive, crisis and post-crisis management. Each of these types provides individual management process.

The implementation of preventive management has two stages: scanning the environment and preventive program implementation, which prevents the internal negative factors and regulates the adjustment conditions to the external factors.

Crisis management includes diagnostics (identification of strengths and weaknesses and ranking problems), the formation (creation) of goals and objectives (analysis of management, marketing, finance, production and personnel, threats evaluation), and developing a program of anti-crisis management and its implementation (development and implementation of measures to eliminate threats, functional structures optimization and development strategy provision).

Scientists also distinguish three stages of post-crisis management: evaluation of post-crisis state (analysis of the crisis results and prediction of the possible development), activity planning (mission, strategy, goals and objectives creation of the enterprise in accordance with available resources) and implementation of the business process.

There is an interesting point of view of the German scientist U.Krystek reflected in [7] concerning the division of anti-crisis management in anticipative, preventive and reactive. O.V.Kovalenko believes that anticipative crisis management, which is implemented in the case of potential threat of the crisis, and preventive, which is administered by the presence of symptoms of latent crisis, focused on risk management and reactive crisis management, which is used in a period of deep crisis, aimed to reorganize the enterprise.

Summing up information concerning the content of the anti-crisis management process (both aimed at crisis prevention and in case of crisis of varying depth), it should be emphasized that scientists associate it with the following actions:: crisis threat prediction and threat elimination of its appearance - B. O.Vasylenko [16]; risk management with the aim of preventing the financial crisis - O.O.Tereshchenko [14]; evaluation of the threat of bankruptcy after diagnostics of the crisis phenomena - L.O.Ligonenko [9]; evaluation and elimination of threats in the case of crisis - V.I.Vorobyov, A.M.Shtanhret, O.M.Petrashova [19]; risk management in cases of potential threat of crisis and symptoms presence of latent crisis - O.V.Kovalenko [7].

The risks are the subject of risk management and threats are the objects of enterprise economic security. So, it could be stated that anti-crisis management encompasses risk management processes and threats at the stage of crisis prevention and after its overcoming, but in times of crisis it has a much broader nature. Consider these processes in details.

The process of risk management is displayed by a sequence of stages; the ultimate goal of these stages is to avoid losses or to minimize them in case of risk events.

V.V.Vitlinskyy and H.I.Velykoivanenko [17] entail the following stages of risk management: 1) information-analytical stage; all risks are evaluated, regardless of the management staff can affect them or not in case of their implementation, 2) identification; parameters of all possible risks considering management activity and company activities are determined, 3) risk analysis, which resulted in solving the question whether to engage in a certain activity with the available information about identified risks, 4) risk level reduction, which involves finding ways protection against unacceptable risk and developing a mechanism of its implementation, 5) control of possible or existing situation, 6) program implementation in case of risk, 7) analysis , conclusions and suggestions.

The authors [20] proposed the following stages of the risk management process: 1) identification and recognition (risks identification), 2) risks assessment, 3) the selection and implementation of risk management techniques, and 4) analysis of management results and probable losses.

The author [15] presents the process of enterprise risks management by five stages: 1) risk analysis; 2) the selection of methods to influence the risk; 3) decision-making; 4) direct impact on risk; 5) monitoring and adjusting the results of the management process.

Summarizing the points of view of different authors, it should be noted that the risk management process begins with the identification and assessment of the risk. Preferably the risk assessment is divided into qualitative and quantitative. Qualitative assessment is the analysis of risks types and their features, sources of risks emergence, areas of its distribution. Quantitative assessment determines such characteristics as the occurrence probability of adverse events and the magnitude of potential losses [20].

The [12] states that risks analysis can be performed in two ways: from uncovering to assessment and vice versa. The first option is considered by the authors as "pre-emptive risk management", which involves the application of preventive measures to identify possible risks and consequences of their functioning. In case of losses, it is necessary to evaluate their worth, and then to find out the reasons of occurrence.

The correct selection of influence methods on the risk plays an important role in the system of risk management. The following approaches of risk management are identified in [18]: avoidance, prevention and acceptance. In domestic literature they are described as strategies of risk management. Risk prevention requires methods of its optimization. Scientists divide such methods into external (risk sharing, exterior insurance, derivatives) and internal (limitation, diversification, provisioning, obtaining of

additional information). According to [15], the decision concerning risk management method involves the choice of several methods of risk exposure, which combination can give the most advantageous option among possible level of damage and the probability of a particular type of risk .

The final stages of the risk management process are monitoring and adjusting the results of implementation of the chosen management strategy according to new information [12], the analysis of efficiency of use of selected risk management techniques and the usefulness of other methods [20].

The authors [20], including researches of domestic scientists, emphasize that effective risk management can be achieved based on the following principles: 1) high risk for small is unjustified, and 2) you cannot risk more than your resources allow; 3) it is needed to consider the possible risk consequences.

T.L.Mostenska and N.S.Skopenko [12] included these principles, which indicate that risk analysis should precede the determination of the objectives of business activity and their comparison with the magnitude of risk and capital.

Risk delimitation, according to [18], allows risks differentiating into "serious" and "very threatening". Very threatening risks could cause a crisis which results in lower economic security even till its bankruptcy. That's why modern scientists research the problems of the risk management in terms of economic security of enterprise.

The process of risk management in the context of economic security is considered by author [8]. The basis of this process is the identification of sources of those risks types that lead to threats of the sustainable development of enterprises in case of their implementation.

The mechanism of risk management aimed at ensuring economic security is proposed in [4]. It involves the determination of influence of internal and external risks on the enterprise activity, methods application and management tools and ensures timely control to achieve optimum level of enterprise economic security.

In general, the management process of enterprise economic security is defined as a set of interrelated sequential actions aimed at enterprise state achievement in which "the probability of negative changes under the environment influence is acceptable " [3].

In [19] scientists identify two subcontracting levels of the enterprise economic security management. The first level is called the executive, which carries out continuous monitoring and analysis of the internal and external environment, and also well as formation of economic security strategy and implementation of the designed measures. The second - coordination level - performs administrative procedures concerning coordination of all departments, aimed at maintaining of economic security.

The [10] considers four stages in the management of enterprise economic security. In the first stage the mission and strategic goals of the enterprise are determined and the analysis of internal capabilities and external threats is conducted. In the second stage, firstly, the general strategy is designed, and then the priority of reactions concerning stabilization, preservation, development of competitive and innovative position or position to ensure the long-term potential is determined and finally the economic security strategy is selected. The third stage involves the implementation of the chosen strategy, and the fourth - the evaluation of its efficiency.

The authors [1,13] aver that the strategic objectives provide formation and increase of the economic potential and meet the requirements of economic security. The general strategy of the enterprise determines the types and nature of threats to its economic security, which defines the measures that should be developed to ensure the economic security.

It should be emphasized that the authors [10, 13] associate measures concerning the management of enterprise economic security with its strategic objectives, just as it should be taken into account in risk management that is highlighted above.

T.V.Haylova [6] proposes to divide management of enterprise economic security, like anti-crisis management, into preventive and crisis. The author argues that this division provides a variety of goals, objectives, functions and management techniques. Preventive management of economic security is aimed at planning of the strategic position of the enterprise development, analysis and prediction of future changes, identification of opportunities and threats. Instead, the functions of crisis management of economic security are to reduce losses using rapid response methods, attracting the necessary resources for this purpose, as well as implementation of anti-crisis measures.

The similar point of view can be traced in V.I. Franchuk [5]. He identifies three modes in which economic security system can operate: casual, high alert and emergency (crisis) state. Casual mode of the enterprise economic security system is similar to preventive anti-crisis management. It is aimed at risks and threats prevention of the internal and external environment. High alert mode is typical in case of certain threats. In this case, security forces or Crisis Group may be involved to terminate the threat. In state of emergency operational management of the enterprise goes to Crisis Group, and security service is subordinated to Crisis Group. In this case, even external security forces, such as the State Security Service or the Internal Affairs agencies may be involved. So the casual mode should have a preventive nature concerning influence of negative factors (threats and risks). According to the author, in high alert mode (when the threat is in action) and in state of emergency (in times of crisis), enterprise security service and external security forces may be involved.

It should be emphasized that the internal security service and external subjects of economic security can apply specific methods of preventing or overcoming the impact of threats. Such methods may include, for example, economic intelligence service (economic spying), force methods etc.

The authors [19] indicate that in the anti-crisis management system economic security should be formed even during the enterprise foundation. According to them, it is important to turn attention not only to the current job, but also to development of the economic security strategy, formation and training of anti-crisis groups and improvement of the economic work in general.

APPROACHES TO THE MANAGEMENT OF INFLUENCE OF NEGATIVE FACTORS ON ENTERPRISE IN VARIOUS CONDITIONS

Given the conducted analysis of risk management processes and economic security management, it can be stated that the strategic objectives of the enterprise activity determine the risks and threats, admissible risk level and acceptable economic security level. Moreover, the lower the risks level of the activity of business subject is, the higher is the level of economic security. Hence, risk management and management of enterprise economic security are connected with each other, and should coordinate and direct their actions to achieve the strategic goals of the enterprise.

In our opinion, under normal conditions, a functional subsystem of the general system of enterprise management that is aimed at elimination or mitigation of the negative factors on it can be anti-crisis management (anti-crisis group) or enterprise economic security system. Creating these two subsystems simultaneously is impractical. Risk management should be subordinated to the anti-crisis management or economic security system. Implementation of risk management only doesn't give an opportunity to use specific techniques and tools of economic security system and thus effectively influence on all negative factors and phenomena, such as illegal and selfish actions of physical persons or legal entities. The proposed approach to the management of negative factors impact (threats and risks) during crisis prevention or after its overcoming is shown in Fig. 1.

The stage of the crisis overcoming is more complex, it requires the use of specific anti-crisis approaches, methods and tools. That's why in times of crisis anti-crisis management runs enterprise management. However, in this case both the enterprise and the process of anti-crisis management are exposed to various negative factors of external and internal environment. So anti-crisis management, implementing anti-crisis strategy should delegate certain tasks and functions to economic security service and risk management in order to overcome the crisis effectively, to prevent their further development and a threat of bankruptcy. This approach is shown in Fig. 2.

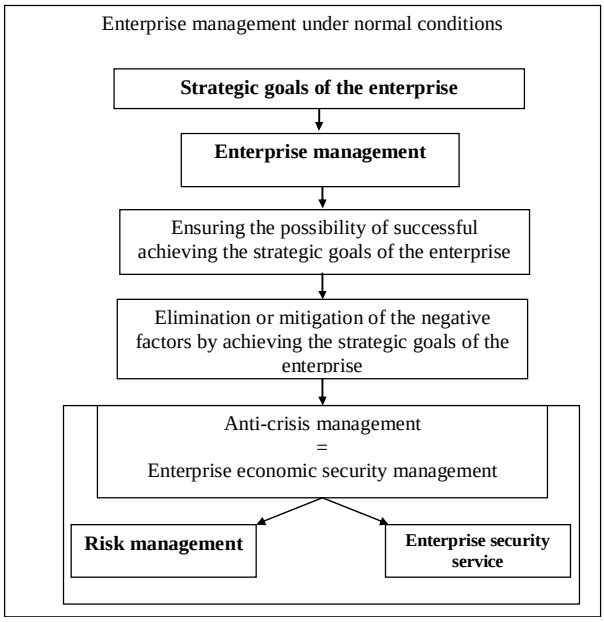

Fig. 1. Interconnection of anti-crisis management, risk management and enterprise economic security system under normal conditions*
Source: elaborated by authors

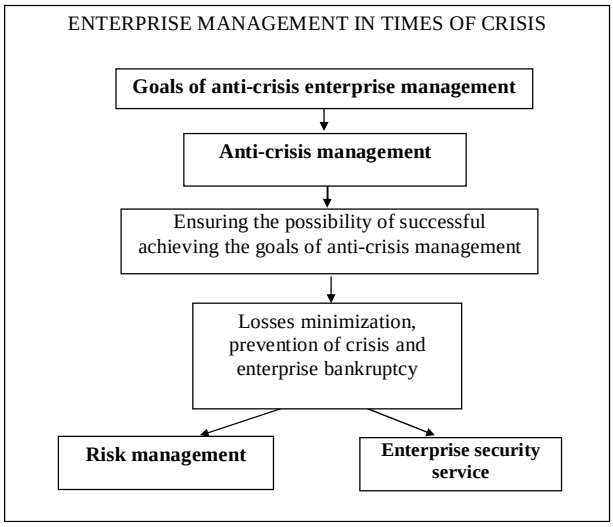

Fig. 2. Interconnection of anti-crisis management, risk management and enterprise economic security system in times of crisis*
Source: elaborated by authors

CONCLUSIONS

1. The process of enterprise management should be aimed at achieving the strategic goals of the enterprise and should be built in a way to maximize time savings, the enterprise resources (financial, material, labor, informational) and to achieve the best results. The processes of anti-crisis management, risk management and economic security should be built according to these principles.

2. The basis of anti-crisis management process is the crisis prevention or the crisis overcoming. The

process of risk management should focus on the selection and implementation of management solutions, most winning between risk probability and the potential level of damage. Enterprise economic security management provides early detection and threats elimination. It allows providing the appropriate level of economic security and sustainable development of the enterprise.

3. The strategic goals of enterprise determine the potential risks and threats, admissible risk level and acceptable level of economic security. Risk management and enterprise economic security management are connected with each other, so have to direct and coordinate their actions to achieve the strategic goals of the enterprise. For an impact on negative factors these management subsystems use techniques and tools which in some cases may coincide, but have their own specific features.

4. Under normal conditions, a functional subsystem of general system of enterprise management that is aimed at elimination or mitigation of the negative factors on it can be anti-crisis management or enterprise economic security system. Creating these two subsystems simultaneously is impractical. Risk management must have a subordinate character to them.

5. In times of crisis, anti-crisis management runs enterprise management. During the anti-crisis program implementation, anti-crisis management should delegate certain tasks and functions to economic security service and risk management. The processes of anti-crisis management, risk management and economic security should be aimed at achieving goals of anti-crisis strategy.

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Cross-border cooperation of enterprises: essence and significance

O. Kuzmin[1], I. Kravchenko[2]

[1]National University "Lviv Polytechnic"
Director of the Institute of Economics and Management
79013, Ukraine, Lviv-13, Metropolitan Andrey str., 5; 4th pavilion, office 410
okuzmin@lp.edu.ua
[2]Odessa National Economic University
Lecturer of International Economic Relations Department
65082, Ukraine, Odessa, Preobrazhenskaya str., 8, office 215
yevhenkravchenko@gmail.com

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Abstract. In the last decade the development of cross-border cooperation in the context of economic integration and internationalization processes becoming increasingly important for Ukraine, which follows the Western vector of integration. Systematic development of cross-border cooperation is not possible without considering all of its components and levels. The article highlights a vision of complicated economic phenomenon – the cross-border cooperation of enterprises, which combines the two important economic categories – cross-border cooperation and entrepreneurship by its self. There considered the fact that cross-border cooperation is an important tool for economic development and competitiveness increase of enterprises, located in border areas.
Key words: cross-border cooperation (CBC), international entrepreneurship, foreign economic activity (FEA) of enterprises, cross-border cooperation of enterprises.

INTRODUCTION

Under the modern conditions of the expansion of globalization, internationalization and integration processes, the cross-border cooperation become an important factor in the intensification of economic development, the competitiveness increase and the convergence of both the regions and the enterprises that are in the border areas. Cross-border cooperation offers the number of potential opportunities to the enterprises: the access to world markets and the possibility of occupying its niche; the upgrade of production facilities; the risks' diversification, improved access to finance; etc. That's why, it is necessary to research this phenomenon.

The purpose of this research is to determine the nature of such phenomenon as cross-border cooperation of enterprises and expand its role in the modern economic relations.

MATERIALS AND METHODS

Referring to the studies of the foreign and Ukrainian scientists, important theoretical and practical aspects of the research of cross-border cooperation were done by following foreign scholars: D. Smallbone [15;16], F.Welter [15;16], M.Bufon [3], as well as by domestic ones: N.Mikula [10;11], Y.Kish [6], V.Pyla [13], I.Zhurba [20] and others. In turn, since the beginning of market economic transformation in Ukraine, to the study of entrepreneurship as a component of economic relations contributed such an outstanding national scholars as O.Kuzmin [7], V.Heyets [5], Y.Makohon [9] and others.

A lot of publications of both foreign and domestic scientists has devoted to the research of mega-, macro- and mesolevels of cross-border cooperation. However, microlevel of cross-border cooperation, which involves the cross-border cooperation and the trade between enterprises of border areas of neighbouring countries, has not researched enough that leads us to consider several terms related to each other in order to explain the nature of cross-border cooperation of enterprises.

In order to ensure the achievement of the article's purpose, we used a few important methods. First one is

the dialectic method, which is applied for justifying the preconditions for the study of cross-border cooperation in Europe and Ukraine. The following ones are the analysis and synthesis methods, which are called on study of conceptual and the categorical apparatus and the “cross-border cooperation of enterprise” term. The equally important are the theoretical synthesis and the formal logic methods. They aimed at the study of the hierarchy of cross-border cooperation of enterprises. In addition, the graphical method, this allows having a schematic representation of the theoretical and practical research results. Thus, such approach allows understanding the cross-border cooperation of enterprises, its essence and significance.

RESULTS OF THE RESEARCH

According to the Law of Ukraine "About the cross-border cooperation" (2004), cross-border cooperation (CBC) is a special field of international and intergovernmental relations, which, is a joint action, aimed at establishing and deepening economic, social, scientific, technical, environmental, cultural and other relations between local communities and their representative bodies, local executive authorities of Ukraine and local communities and relevant authorities of other states within the competence defined by their national law [18].

Considering the cross-border economic cooperation, it can be conditionally divided into four levels it is carried out and regulated at: mega-, macro-, meso-and microlevel (see fig. 1).

Cooperation between enterprises is the initial level of cross-border cooperation the hierarchically higher levels of cross-border cooperation are based on. It a priori indicates the importance of this phenomenon. However, a complete understanding of this concept is not possible without the determination of its place in the theory of entrepreneurship.

Until recently, the economic theory of international entrepreneurship was considered as an organic combination of two components – the Entrepreneurship by its self and the International Business. In recent years, it was identified another important component – the cross-border cooperation of enterprises.

For all those reasons, it is possible to form a hierarchy of "cross-border cooperation of enterprises" term and to determine the place and the role of each element in the system of economic relations (see fig. 2).

The basic element of this hierarchy is the core – the entrepreneurship, carried out within national borders, i.e. domestic business, which under certain specified conditions, can move to the next level – the level of cross-border cooperation of enterprises.

Cross-border cooperation of enterprises or as it is called by foreign scholars – cross-border entrepreneurship is hierarchically lower than the foreign economic activity of enterprises. This situation can be explained in the best way by the example from the practice. For example, the enterprise that operates within Odessa region (Ukraine), which is borderline, exports a set of goods to the enterprise, located in the Tulcea county (Romania), which is also borderline. These relations can be regarded as both the cross-border cooperation of enterprises and the foreign economic activity of enterprises. However, if the enterprise, which is located in the Odessa region, will decide to export to the middle of Romania, for instance, Alba county, these relations can be classified only as foreign economic activity of enterprises. It is because the main feature of cross-border cooperation of enterprises, what in turn distinguish the term "cross-border cooperation of enterprise" from the term "foreign economic activity of enterprises" is that the cross-border cooperation is possible only if there is a common border.

Spatial location of enterprises on both sides of the common border only at first sight may seem like a limitation. In fact, the presence of a common border makes it possible not only to generate financial and industrial groups (holding companies, consortia, strategic alliances, joint ventures), but also new organizational forms such as cross-border clusters, cross-border partnerships and associations that are not possible under the conditions of foreign economic activity, but only within the framework of cross-border cooperation. Moreover, common infrastructure, business environment, etc. act as a potential platform for joint economic development and prosperity.

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Foreign economic activity is an economic category, which covers primarily functions performed by such entities as companies, organizations, enterprises, associations and others. According to the Law of Ukraine "Foreign Economic Activity" (1991), foreign economic activity can be interpreted as an activity of economic entities of Ukraine and foreign business entities, based on the relationship between them, which can take place in Ukraine and beyond [17].

Thus, foreign economic activity of enterprises is a sphere of economic activity associated with international production, scientific and technical cooperation, export and import of products, the entrance to the external market. Foreign economic activity of the enterprise is the part of the general economic activity and thus, is interrelated with it and is jointly motivated by the enterprise. At the same time, foreign economic activity has considerable specificity, which is what it carried out at different international levels in conjunction with economic entities of other countries [14].

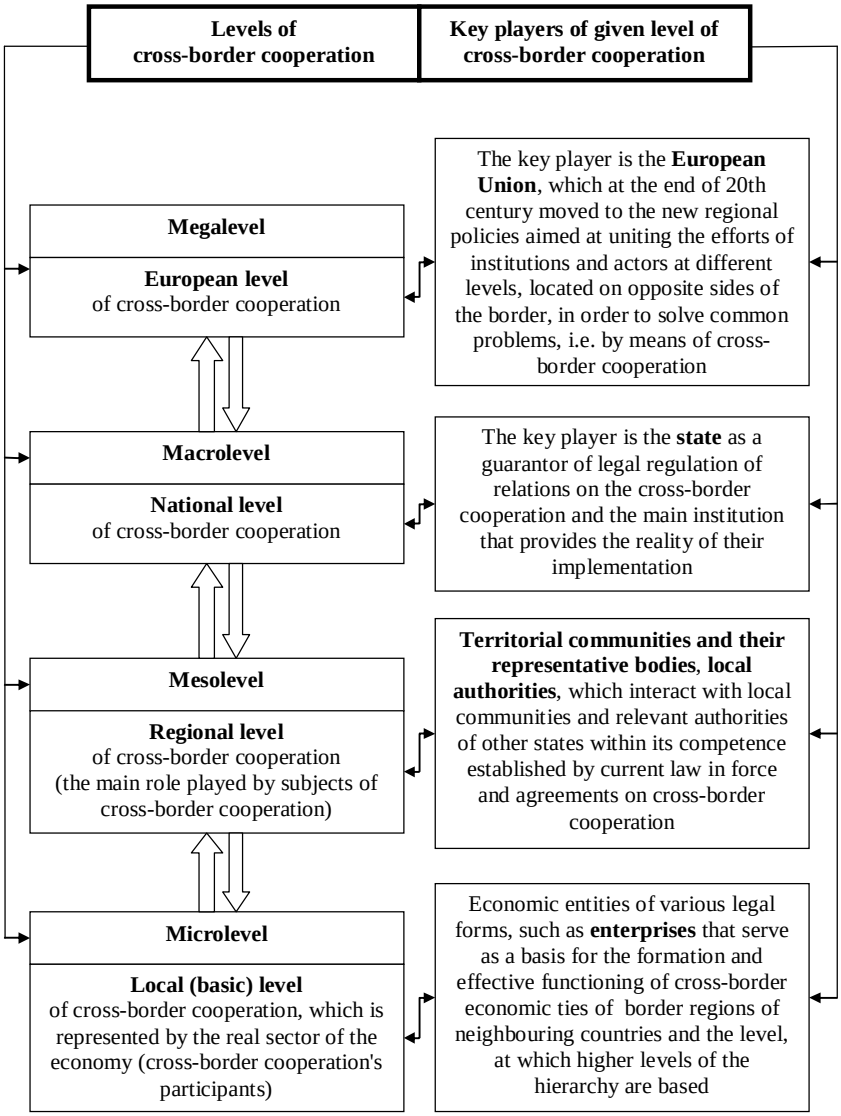

Fig. 1. Levels of cross-border cooperation
Source: authors' own research results

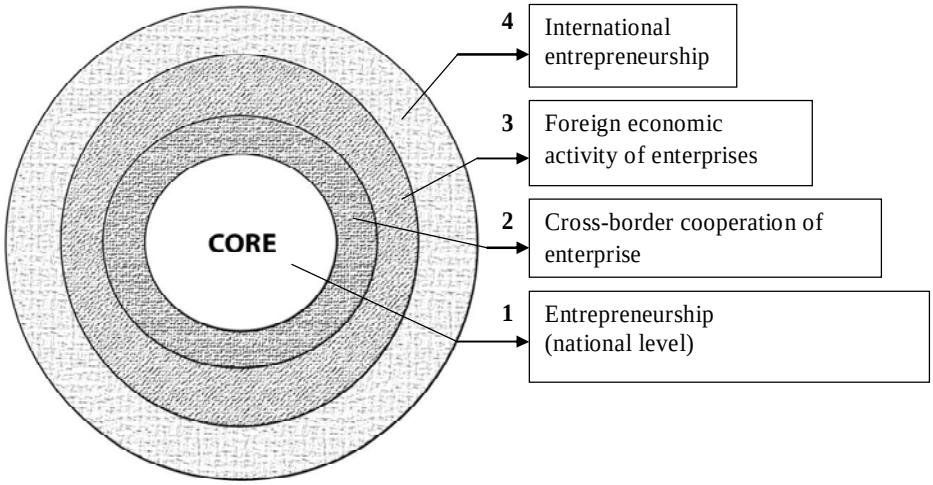

Fig. 2. The hierarchy of term "cross-border cooperation of enterprises"
Source: authors' own research results

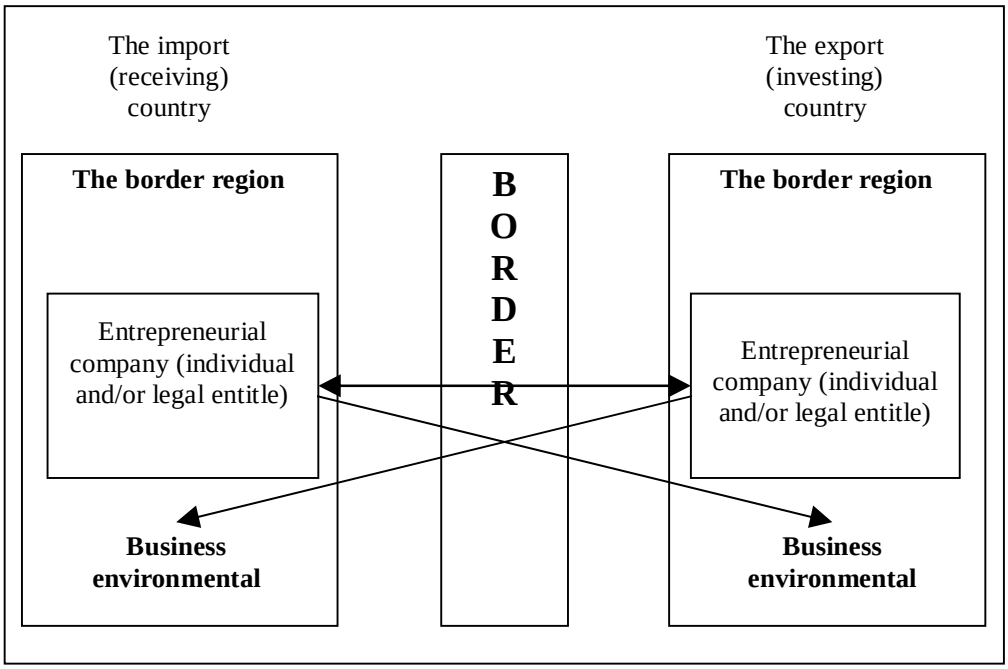

Fig. 3. The mechanism of functioning of cross-border entrepreneurship
Source: developed by authors on the base of [19].

The hierarchically highest term is the "international entrepreneurship" one. It is also called the international business. The international entrepreneurship is an organization of business, which from the very outset aims to gain competitive advantage from the use of resources and to sale the performance results (products) to several countries. That's why, it is a search, enactment, evaluation and exploitation of opportunities – across national borders – to create goods and services in future. It examines and contrasts how, by whom and in what way these opportunities are used across national borders [12].

In addition, the international entrepreneurship, as a phenomenon, reflects the whole complex of external relations (economic, social, organizational), related to the organization of the business by the entrepreneurs, the production of goods, works or services and receiving desired result in the form of profits. International entrepreneurship objectively reflects the system of relations that occur globally in business between entrepreneurs, with customers, suppliers, banks, the government, represented by the appropriate authorities, employees and other entities of the world market. Herein, international entrepreneurship reflects the nature of the trade relations that are implemented based on the economic laws of the world market (demand, supply, competition) and all instruments of commodity production and circulation. Thus, international entrepreneurship is a free economic activity in various spheres of the world market, which is performed by the entitles of foreign economic relations in order to meet the needs of specific customers and society as a whole for goods, works, services and to realize a profit [19].

Thus, after the consideration of the hierarchy of entrepreneurship's performance from the core to the final level, we can state that cross-border cooperation of enterprises is a specific form of foreign economic activity of enterprises, which covers the part of the border trade (export and import), defined as foreign trade, which is carried out by the legal entitles and individuals that are registered in the border area of the country to meet their own needs or the needs of the population of the border area through cross-border markets on the basis of international agreements or related documents, and other relationships associated with international production and scientific and technical cooperation. Otherwise stated, in order to be considered as cross-border cooperation the following condition must be satisfied: enterprises should carry on business in the border regions of neighbouring countries that have a common frontier (fig. 3).

As it is shown in Figure 3; state border performs a specific function in the development of economic relations between economic entities, namely: it transfers the relationship on cross-border cooperation from the horizontal level (when entrepreneurs work together at the same level without any restrictions) into vertical one, and so forming mechanism of barriers, the essence of which is the need to overcome the obstacles that generates the very existence of the border between enterprises. Consideration of the border in this regard is appropriate because it provides an opportunity to analyse the cooperation of enterprises operating in cross-border areas and belonging to different national economies.

On the economic plane, it is advisable to analyse the boundary in two dimensions: as a direct line of intersection and as the spatial environment, as well as the complex dynamic system, which mediates the cooperation of the enterprises across the state border.

On the one hand , the border is seen as a set of legally or in fact an artificial line (on land and water), and a vertical surface that passes on this line (in the depths, waters and airspace) that define the spatial limits of the territory of the state and its fields of their economic sovereignty. In this case, the main characteristic of the border stands its insight for cross-border interactions – the international movement of goods and services, factors of production (international labour migration, international capital flows and international technology transfer). On the other hand, the boundary is considered in terms of the consequences of its existence as a barrier to communication adjoining border areas and relationships of enterprises located and operating within its framework. In other words, the border acts as a specific institution that carries out specific functions within the cross-border region [2, 181–182].

Thus, along the border creates a special type of space, characterized by different intensity of interaction between enterprises in neighbouring countries, including the intensity of cross-border flows between them [1, 240].

The presence of this specific space mediates the existence of various cross-border business ties, including the important place occupied by cross-border economic relations.

Knowing the fact that the basis of cross-border economic relations of any enterprise is export-import operations, it is important to identify indicators that characterize the state of cross-border cooperation of enterprise. This is the coefficient of cross-border cooperation in export ($C_{E\,CBC}$) and import ($C_{E\,CBC}$):

$$C_{E\,CBC} = \frac{E_{CBC}}{E}, C_{I\,CBC} = \frac{I_{CBC}}{I}, \qquad (1; 2)$$

where: E_{CBC} and I_{CBC} – the volume of exports and imports over a particular period of time on the cross-border territories, UAH;

E and I – the total volumes of enterprise's export and import over a particular period of time, UAH.

After the obtained results from the formula mentioned above, we can determine the excess of export growth compared with the growth of imports in the cross-border market. It is possible to calculate the ratio of cross-border exports ahead of imports (C_A):

$$C_A = \frac{C_{E\,CBC}}{C_{I\,CBC}}. \qquad (3)$$

If C_A > 1, this characterizes advancing exports over imports in cross-border trade and, therefore, the presence of a positive trade balance. When C_A < 1 – should be expected the negative trade balance. The indicator Index C_A should be applied to each of the enterprise involved in cross-border cooperation, and then to conduct the comparative analysis of cross-border markets for which it is most significant.

In order to improve methods for assessment of cross-border cooperation of enterprises is proposed to carry out the analysis based on empirical data and to find the interdependencies between the features that characterize the process under study. For these purposes it is recommended to use mathematical model approaches such as correlation and regression analysis, cluster analysis and factor analyses. They can be used to determine the strength and direction of interaction between the studied factors. Methods of mathematical statistics allow finding a prediction error, building of prognostic models of cross-border cooperation and trade in the medium and long-term duration. The method makes it possible to determine how rapidly and to what extent needed a particular kind of product or service, to establish priorities, and export- import potential of the enterprise. The calculation of the proposed indicator is carried out according to the formula:

$$C_{it} = \frac{\sum C_{ijt}}{Ci_{tot}\,t} \times 100, \qquad (4)$$

where: C_{it} – the ratio of import/export of *i*-type of products (services) for cross-border market of the *j*-enterprise to all *i*-products of the enterprise in *t* time; C_{ijt} - the volume of import/export of *i*-type of products (services) for cross-border market of the *j*-enterprise in *t* time; $Ci_{tot}\,t$ – the volume of imports / exports of *i*-type of products (services) for the whole of the enterprise in *t* time.

The calculation results show to what extent the studied enterprise is integrated into cross-border trade markets [8].

Thus, the analysis of cross-border cooperation of enterprises through shared indicators in this study will help to get a full description of the status and prospects of development of a single enterprise or group of them in the border region.

CONCLUSIONS

1. Cross-border cooperation of enterprises is a phenomenon of modern economic relations arising in the operation of enterprises and their interaction in the border region. Investigation of this level of cooperation is particularly relevant in the context of usage of cross-border cooperation of enterprises as a tool not only for competitiveness increase and for economic development of individual enterprise, but also as a prerequisite for the accelerated internationalization and the integration.

2. State border performs a specific function in the development of economic relations between economic entities and leads to the forming of mechanism of barriers, the essence of which is the need to overcome the obstacles that generates the very existence of the border between enterprises.

3. In order to get the realistic state of cross-border cooperation of enterprises and to forecast its prospects, it is necessary to apply some methods, including the mathematical statistics.

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Transformation of Development Model of National Economies at Conditions of Postindustrial Society

O. Kuzmin[1], O. Pyrog[1], L. Melnik[2]

Lviv Polytechnic National University,
1 Educational-Scientific Institute of Economics and Management,
2 Educational-Scientific Institute of Postgraduate Education
S. Bandery St., 12, Lviv, Ukraine, 79000
e-mail: okuzmin@ukr.net, pyrog_ov@i.ua

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Abstract. The article considers the results of transformation of development model of national economies at conditions of postindustrial society. Determine the structural changes of national economies of postindustrial societies (the U.S., EU) and Ukraine at the period of 2001 – 2012. Substantiated that for development of Ukrainian national economy at terms of postindustrial society must stimulate the development of intellectual economic activities.

Key words: economic model, model of economic development, transformation, sectorial model of the national economy, postindustrial society, national economy.

INTRODUCTION

The development of the world economy at the late 20th – beginning of 21th century is characterized by rapid and significant changes (global economic, social and environmental transformations) of both positive and negative nature under the influence of scientific, technological and social progress at almost all areas of social activity. Innovative breakthrough at the field of information and communications technologies has provided unprecedented opportunities for doing business globally, promoted the formation of new geopolitical relations. At the same time, there is a growing threat of pollution due to the anti-environmental activities of economic agents. All this together led to the emergence of new models of civilizational development (global economic development and development of national economies).

At development models of national economy under the conditions of postindustrial society, there are significant changes: transformation of role of the state in management of development, transition from intermediate industries to high-tech industries. Thus, the leading countries of the world economy are constantly improving their development models of national economies, which primarily involve structural and technological transformation of the national economy with the most efficient way of usage of all factors of production under conditions of the postindustrial society.

THE AIM OF THE ARTICLE

Issues of national economy development under postindustrial conditions are explored by both Ukrianian (O.I. Amosha [15; 18], V.M. Geyets [21], Y.V. Kindzerskiy [10], M.O. Kyzym [13], L.G. Melnyk, V.P. Seminoshenko, A.A. Chukhno [3]), and foreign scientists (D. Bell [2], V.E. Devtntiev, M. Edelman [1], M. Gillis [5], V.L.Inozemtzev [9], G.V. Kolodko [11], M.P. Todaro [20], J. Shumpeter [19]). However, questions of the transformation of development models of national economies under the conditions of different types of societies remain badly researched.

The aim of this article is the empirical research of the transformation of development models of national economies at conditions of postindustrial society.

THEORETICAL ASPECTS OF DEVELOPMENT MODEL OF NATIONAL ECONOMIES

In the historical process of social development, there were formed classical and modern development models of national economy. Models of national

economies reveal similarities of theoretical and empirical content, which remain unchanged for a long time and are beyond the influence of seasonal factors.

O.I. Soskin defines "economic model", on a basis of general methodological parameters, such as "abstract and informative description of the real state and prospects of development of system of relations that form the skeleton of the economy on a (micro-, meso-, macro-, global) level, using verbal or logical-mathematical (or both) methods of expression" [16, 39]. The author argues that any economic model that is studied or proposed system must include the system of relations between such economic forms (processes, events) as a form of property, sectors of economy, regulatory mechanisms, methods, principles and forms of economic activity, that form the skeleton of the economy.

At foreign literature, "economic model" is defined as "a simplified description of reality, designed to produce hypotheses about economic behavior that can be proven" [12; 14]. An important feature of an economic model is necessarily subjective in justification, because there is no objective indicators of economic activity.

Given the variety of interpretations of the category "model of the national economy", we studied its semantics and as the result, proposed to define it as economic-mathematical description of the development of national economy, which determines the laws of functioning and on the basis of certain tendencies makes it possible to predict the trajectory of development and identify ways to achieve it.

Among the variety of development models of national economies, the most urgent, under conditions of emergence of postindustrial society, is a sectorial model that reflects the historical process of transformation of society according to technological criteria and reflects process of natural, radical, progressive, structural and technological changes in a national economy of country, which provide a transition to a qualitatively new level of development of society. During the 20th century, theoretical principles of sectorial model of national economy have undergone significant changes and evolved from two-sectorial model (A. Lewis) to three-sectorial (K. Clark, J. Furaste) and five-sectorial (D. Bell, V. Inozemtzev, A. Chukhno) models. Sectorial development model of national economy (sectorial theory, theory of structural transformations) was the base for industrial society.

Upon studying theoretical principles and taking into account the results of empirical research, proposed to interpret "sectorial model of the national economy development" as an empirical model that allows to explore the structural changes at the national economy in accordance with social needs and technological approach, that is based on the leading role of the productive forces at society development, and to establish relations between the structural elements and to forecast future periods. It should be emphasized that the sectorial model of national economy development at terms of postindustrial society makes it possible not only to assess structural changes by the technological criteria but also to take into account the social needs and determine human's place in the economic system and his importance at the development of society.

RESEARCH OF DEVELOPMENT MODELS OF NATIONAL ECONOMIES AT CONDITIONS OF POSTINDUSTRIAL SOCIETY

To analyze sectorial models of national economy development, the types of economic activities were divided into five sectors with regard to their technological intensity and in accordance to international and national classifications: Primary Sector (S_1) includes agriculture, forestry and fisheries; mining industry and the development of mining; Secondary Sector (S_2) includes manufacturing industry; supply of electricity, gas, steam and conditioned air; water supply, sewerage and waste management; construction; Tertiary Sector (S_3) includes transport, warehousing, postal and courier services; wholesale and retail trade, repair of motor vehicles and motorbikes; arrangement of temporary housing and catering; Quaternary Sector (S_4) includes financial and insurance services; real estate services; administrative and support services; public administration and defense, compulsory social insurance; Quinary Sector (S_5) includes information and telecommunications; education; professional, scientific and technical activities; healthcare and social assistance; arts, sports, entertainment and recreation.

Thus, the basis of the national economy of postindustrial society consists of economic activities that produce goods with high proportion of intellectual contribution and actively introduce innovations, therefore new class of employees, who actively use their intellectual abilities, emerges. In such national economy, information and innovation are resources that contribute to trends and dynamics of the development of industries, which define information as main limiting factor in production of an efficient economic system.

The results of studies on the transformation of sectorial models of national economy.

Countries with postindustrial societies have quinary structure of the national economy, which has a high priority for Quinary (S_5) and Secondary (S_2) Sectors in the form of high-tech material and immaterial productions and in the same time have decrease in Primary (S_1) and Tertiary (S_3) Sectors and expansion of the Quaternary (S_4) Sector. At sectorial models of national economy development at postindustrial societies, there is constant growth of high-tech industries, which is also concentrated in the manufacturing industry. For example, in the U.S. up to 80% of national economy growth is achieved by development of high-tech industries [21; 22].

Table 1. Comparative analysis of sectorial models of national economy development of postindustrial society during 2002-2012

Sector	The United State of America	Countries of EU
Main Trend	gradual increase in sectors of immaterial production (Quaternary, Quinary Sectors) by reducing in the material production sector (Primary, Secondary) – by 3.3-3.4 percentage points	
Primary Sector (S_1)	consistently occupies the smallest share in the national economy of country (1.0%)	occupies the smallest share in the national economy of country (1.7%) and gradually reduces (by 0.5 percentage points during the studied period)
Secondary Sector (S_2)	share of manufacturing (12.7%) is gradually decreasing, by 1.8 percentage points during the studied period, mainly due to the reduction in low-tech activities	share of industrial activities (14.97%) is gradually reducing, by 2.0 percentage points during the studied period, mainly due to reduction of low-tech manufacturing industries and fixation of production specialization
Tertiary Sector (S_3)	the share decreases during the studied period (18.0%)	there is a gradual reduction of the share by 0.8 percentage points during the studied period
Quaternary Sector (S_4)	it is the foundation of the national economy with the largest share – 34.2%	holds the largest share of the national economy (29.0%) with trends of growth (by 2.1 percentage points)
Quinary Sector (S_5)	during the studied period, the share gradually increased by 1.9 percentage points	during the studied period, the share in national economies of EU gained 1.3 percentage points

Note: compiled by the authors based on the results of their own research

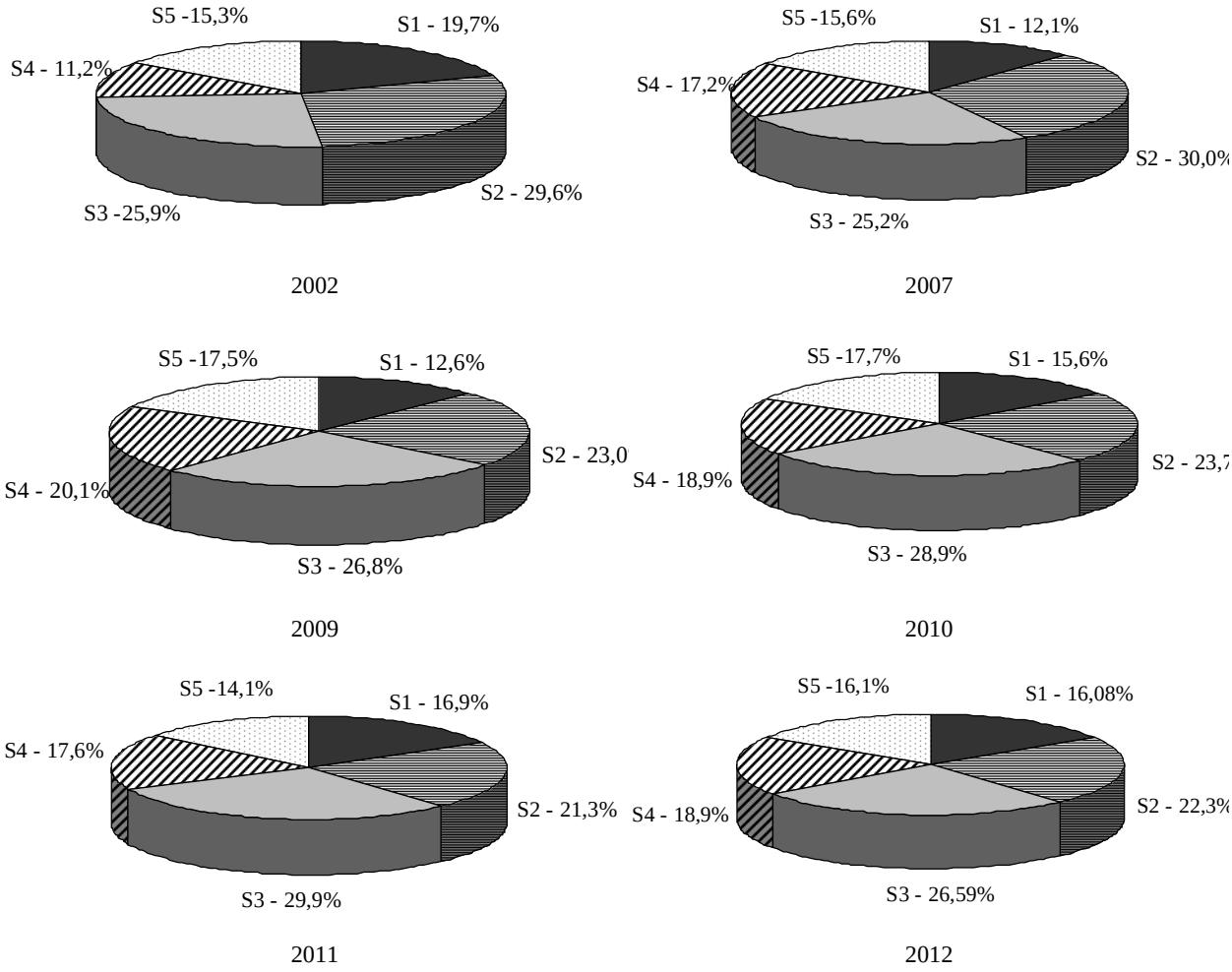

Fig. 1. Structure of sectorial model of Ukrainian national economy during 2002-2012
Legend: S_1 – Primary Sector; S_2 – Secondary Sector; S_3 – Tertiary Sector;
S_4 – Quaternary Sector; S_5 – Quinary Sector
Note: compiled and calculated by the authors according to the data [6-7; 17]

Industry remains the leading type of economic activity of the real sector of national economy as it accounts for over 27% of gross value added that is incompatible with the leading role of services that is inherent for postindustrial society. However, it is necessary to consider that internal structure of manufacturing industry of Ukraine has a "bias" towards heavy industry: steel and energy sector. During 1990-2010 period, the share of mechanical engineering, which is the basis for high and intermediate tech economic activities, fell almost in 3 times at industrial production structure: from 31% to 10.9% [8, 108], while the metal industry that is raw and intermediate tech economic activity, increased in 1.5 times, from 11% to 17.5% [8, 108].

Results of research of dynamics of the national economy of Ukraine in the framework of the sectorial model and investigation of impact of economic activities on the development of the country during 2001-2012 period gave us reason to believe that:

– economic development of the national economy of Ukraine was ensured by the traditional for industrial society economic activities, such as: mining and processing industry, which belong to the Primary (S_1) and Secondary (S_2) sectors;

– indicator of the gradual formation of the information society is gradual growth of the value of sphere of immaterial production, such as: financial and insurance services, real estate services, administrative and support service; despite of the priority of the economic activities of industrial society in the national economy;

– share of economic activity in the structure of the national economy does not influence on its importance for the development of the national economy. For instance, an increase by 1% at the financial and insurance services, which occupies 5.12% at the structure of the national economy, stimulate the growth of only 0.2989% of the national economy, while an increase by 1% at the transport, warehousing, postal and courier services, which have 8.53% share will bring growth by 0.8330%;

– economic activities that determine the development of the information society, such as: telecommunications and information, education, professional, scientific and technical activities, healthcare and social assistance, are capable to stimulate the development of the national economy of Ukraine.

To ensure the development of the national economy of Ukraine at the level of the information society, structural and technological transformations of the national economy must be introduced in two stages:

– Stage 1 – Achievement of the economical development level of Poland. Ukrainian national economy should grow steadily each year within 6.1-6.7 % range due to the Secondary (3.15-3.87 % with share of 31.7 %), Quaternary (12 53-12.94 % with share of 18.5-18.8 %) and Quinary (3.89-4.32 % with share of 19.2 %) Sectors;

– Stage 2 – Achievement of the level of EU countries (Germany, France). Ukrainian national economy should grow steadily each year within 5.2-5.4 % range due to the Quaternary (10.76-11.00 % with share of 29.0 %) and Quinary (2.32-2.51 % with share of 23.7 %) Sectors. Moreover, reduction of Primary (in 8 times – from 15.6% in 2010 to 1.7%) and Secondary (down to 24.8%) Sectors should be done. It is established that elimination of low-tech industries reduces the share of the Secondary Sector at the national economy.

CONCLUSIONS

As the results of the research of structural changes at the sectoral models of national economies at terms of postindustrial society can form the following conclusions:

1) development of national economies of postindustrial societies (the U.S., EU) is provided by the rapid growth of high-tech material and immaterial productions;

2) development of Ukrainian national economy for the period of 2001 – 2012 was provided by traditional economic activities of industrial society – mining industry and manufacturing;

3) in spite of decisive importance of economic activities of industrial society for the development of Ukrainian national economy, during the researched period, sphere of immaterial production (financial and real estate services, leasing, engineering and support of entrepreneurs), which is typical for postindustrial society, becomes more important;

4) to provide the development of national economy at terms of postindustrial society, development of the following economic activities, such as: information and telecommunications, education, professional, scientific and technical activities, healthcare and social assistance, should be stimulated.

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Innovation model for energy effective investigations of air conditioning systems for cleanrooms

V. Labay, D. Harasym

Department of Heat, Gas Supply and Ventilation,
Lviv Polytechnic National University;
79013, Lviv, St. Bandery str., 12; e-mail: wlabay@i.ua

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Abstract. Innovation mathematical research model of the central straight flow air conditioning system for cleanroom in order to computer's estimation its energy effective by virtue of exergetic output-input ratio depending on different factors, which have influence on its work, was presented in this article. The dependence of exergetic output-input ratio for chosen air conditioning system on parameters of external air was defined thanks to this model.

Key words: exergy balance, air conditioning systems, cleanrooms, energy efficiency.

INTRODUCTION

In modern technologies, which are related to energy transformation, namely in the air conditioning systems, important place are occupied by objects creation and improvement of which requires the use of innovation thermodynamics. Classic apparatus of this science is often insufficient to solve new tasks; it is necessary not only to its further development, but its combination with the elements of a systematic approach and economy.

Under the influence of these requirements the exergy method has been designed in the last decades [6-10]. Its main idea is to introduce, along with the common, fundamental concept of energy, the additional indicator – *exergy,* which allows considering the fact, that the energy depending on external conditions may have a different value for practical use.

The calculations of balances and different characteristics of technical systems, air conditioning systems in particular, taking into account the exergy enables the easiest and clearest way to solve many scientific and technical problems. They help to remove frequent errors that are found and associated with ignoring the qualitative side of change.

The feature of the central straight flow air conditioning system is that the starting substance, which is processed in it – is the outside air, the parameters of which may vary as the temperature and the relative humidity (moisture content and specific enthalpy, relatively). Supplied and indoor air reached necessary temperature and humidity as a result of the air conditioning systems work. Outside air is the external environment for air conditioning systems, the parameters of which may vary depending on location and time. That's why outside air is taken as external environment – as its dry part and its water vapor, which is in the air. Reducing the cost of energy, consumed by air conditioning systems (ACS), dictates the need of its optimization, which can be fully achieved by virtue of exergetic analysis, that takes into account not only the quantity, but also the quality of the energy spent [7, 8, 11-14, 16, 18, 19].

DESCRIPTION OF OBJECT THAT IS ANALYZED AND INNOVATION RESEARCH MODEL

The aim of air conditioning is to keep up the certain parameters of air in some limited space (in this case, in cleanroom). Usually temperature t_{in} and relative humidity φ_{in} of air are regulated, but in cleanrooms a concentration of dust particles x_{in} in air is also regulated [1-5].

As an example, we can consider central straight flow air conditioning system for cleanroom, which is shown in Fig. 1. The work of such system depends on the dominant environmental (external) conditions, i.e. on temperature and moisture content in air of external environment. Environmental air is taken via central conditioner through the air-intake shaft 6, is cleaned in the filter of outside air 7, then passes through the air heater of

first heat 8, is politropical cooled and drained in the air washer 9, is heated in the air heater of second heat 10 and after that this air is supplied in a cleanroom through the air supply filter 11 in the central air conditioner via the fan unit 12 and air ducts 5 and also via air supply filters 4 at the entrance to the room.

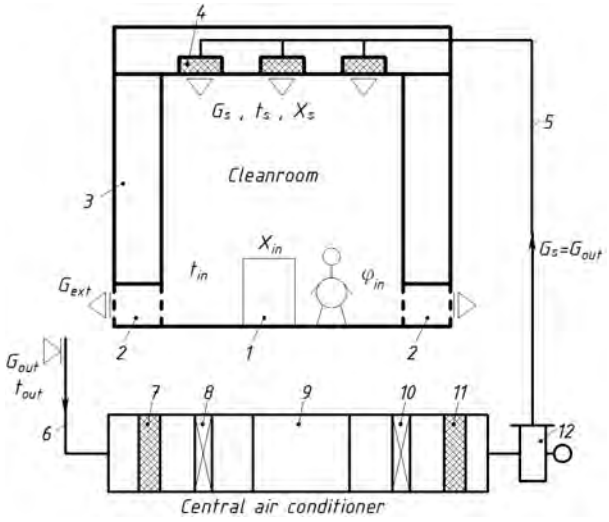

Fig. 1. Basic scheme of the central straight flow air conditioning system for cleanroom: 1 – technological equipment, 2 – air exhaust channels, 3 – gateway premises, 4 – filters of air supply to the room, 5 – air supply duct, 6 – air-intake shaft, 7 – filter of external air, 8 – air heater of first heat, 9 – air washer, 10 – air heater of second heat, 11 – air supply filter in the air conditioner, 12 – fan unit

Lets consider the work of this air conditioning system in the warm period of year, when moisture content $d_{in} < d_{out}$ and temperature $t_{in} < t_{out}$. Fig. 2 shows in the coordinate system *I, d* the sequence of air parameters change, which is passing through the different equipment of central straight flow air conditioning system for cleanroom in the warm period of year. In researches mass productivity of air conditioning system G = 10000 kg/hr is accepted, that was counted by the number of dust particles, parameters of outdoor air varied within: t_{out} = 26-42°C; d_{out} = 9,3-15,9 gr/kg (specific enthalpy: I_{out} = 49,8-83,2 kJ/kg; relative humidity: φ_{out} = 27-54 %, accordingly), barometric pressure: p_{out} = 1010 hPa, parameters of indoor air, respectively: t_{in} = 23-30°C; φ_{in} = 50 % (d_{in} = 8,8-13,4 gr/kg; I_{in} = 45,5-64,4 kJ/kg, accordingly); temperature difference between the inside and the supplied air depending on excess heat in the cleanroom: $\Delta t_S = t_{in} - t_S$ = 1,5-6,0°C; slope coefficient of excess heat and moisture assimilation in the cleanroom by the supplied air via air conditioner: ε = 9946-16858 kJ/kg; water temperature (coolant temperature) for the air washer initial: t_{w_I} = 7,0-14,9°C; final: t_{w_F} = 9,8-17,3°C; heat transfer agent (water) temperature for the heater of second heat initial: t_{heat} = 70°C; final: t_{rev} = 42°C.

The sequences of changes, that occur with moist air, which passes through the various equipment of air conditioning system, are shown in Fig. 2. Construction on the *I-d* – diagram was made in accordance to [11]. Air parameters in the characteristic points of the process (Fig. 2) were determined by the adopted values of the parameters for outdoor air and were calculated on the proposed mathematical model by the known analytical dependency for moist air.

Amount of the cold for air treatment in the air washer (cooling capacity of air washer) in the warm period of year was defined by the equation:

$$Q_C = G_S \cdot (I_O - I_K) \times 0,278 \text{ , W,} \qquad (1)$$

and amount of the heat for the second air heating in the warm period of year was defined by the next equation:

$$Q_2 = G_S \cdot (I_{S_1} - I_K) \times 0,278 \text{ , W,} \qquad (2)$$

where: $I_O = I_{out}$, I_K and I_{S_1} – specific air enthalpy at the corresponding points of processes, that cause the change of moist air state in the central straight flow air conditioning system in the warm period of year on the *I-d* – diagram (Table 1), kJ/kg.

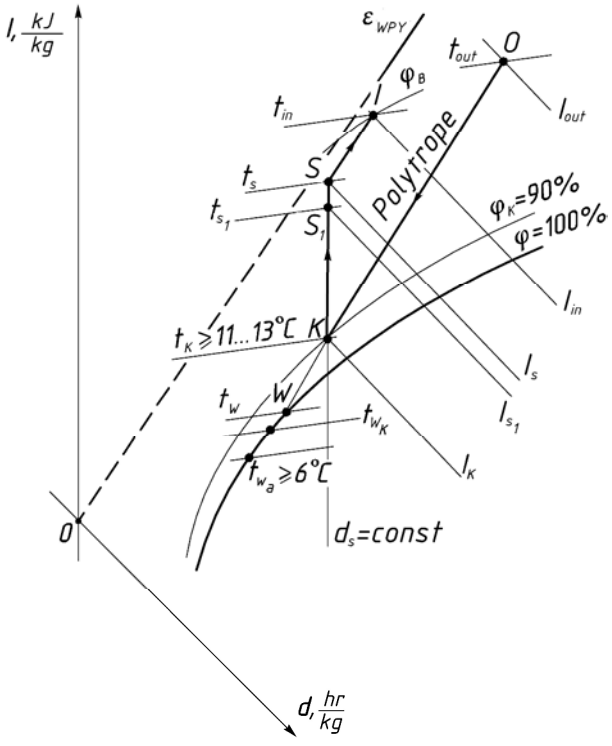

Fig. 2. The image of the process of changing the moist air state in the straight flow air conditioning system in a warm period of year on the *I-d* – diagram: *OK* – the process of polytropic air treatment (cooling and drying) $G_{a.w} = G_S$ in the air washer; KS_1 – the air G_S heating process in the air heater of second heat; S_1S – the air G_S heating by 1 °C in the fan and the supply air duct; *SI* – the process of excess heat and moisture assimilation in the cleanroom by the supplied air G_S via the air conditioner

The aim of this work was to create the innovation mathematical research model of the central straight flow air

conditioning system for cleanroom in order to computer's estimation its energy effective by virtue of exergetic output-input ratio in dependence from different factors, which have influence on its work. Material, heat (energy) and exergy balances of the system were made up in this model, which take into account all the possible variants of its work in real conditions.

The concept of exergetic output-input ratio was used for the rational excellence assessment of the air conditioning system, which was defined as the ratio of air exergy increase in air conditioned premises E_{out} to the exergy of air conditioning system transmission E_{in}, which was spent on maintaining the process [6-10, 12, 13, 15-20]:

$$\eta_e = \frac{E_{out}}{E_{in}}. \quad (3)$$

The exergetic output-input ratio, which characterizes the efficiency of the central straight flow air conditioning system work for cleanroom in the warm period of year, was defined by the equation:

$$\eta_e = \frac{\Delta E_{SI}}{\Delta E_{a.w} + \Delta E_{heat} + N_{use}^{c.w} + N_{use}^{h.w} + N_{use}^{fan} + N_{use}^{RM}}, \quad (4)$$

where: $\Delta E_{SI} = E_S - E_I$ – exergy reduction of conditioned air in the cleanroom, W; E_S and $E_I = E_{in}$ – exergy of supplied and indoor air in the cleanroom, in accordance, W; $\Delta E_{a.w} = E_{w_I} - E_{w_F}$ – exergy change of water in the air washer (exergy growth of air in the air washer, relatively), W; E_{w_I} and E_{w_F} – exergy of water in the air washer with it initial and final temperatures, relatively, W; $\Delta E_{heat} = E_{heat} - E_{rev}$ – exergy change of heat transfer agent (hot water) in the air heater of second heat (exergy reduction of air in the air heater of second heat, relatively), W; E_{heat} and E_{rev} – heat carrier exergy in a feeding and reverse jets of the air heater of second heat, relatively, W; $N_{use}^{c.w}$ – consumed power via the pump of cold water for the air washer, W; $N_{use}^{h.w}$ – consumed power via the pump of how water for the air heater of second heat, W; N_{use}^{fan} – consumed power via the fans engine of the accepted central air conditioner, W; N_{use}^{RM} – consumed power via refrigeration machine for the central conditioner, W.

The values, included in the equation (4), were defined as follows:

$$\Delta E_{SI} = G_S \cdot (e_S - e_I) \times 0,278, \text{ W}, \quad (5)$$

where: e_S and $e_I = e_{in}$ – specific exergy of supplied and indoor air in the cleanroom (Table 1), relatively, kJ/kg;

$$\Delta E_{a.w} = G_{a.w} \cdot (e_K - e_O) \times 0,278, \text{ W}, \quad (6)$$

where: $e_O = e_{out}$ and e_K – specific exergy of outdoor air and cooled and drained air in the air washer (Table 1), relatively, kJ/kg;

$$\Delta E_{heat} = G_S \cdot (e_K - e_{S_1}) \times 0,278, \text{ W}, \quad (7)$$

where: e_{S_1} – specific exergy of air, that was heated in the air heater of second heat (Table 1), kJ/kg.

If it is necessary to find a specific exergy of water under a certain absolute temperature T_w, then it can be defined as follows:

$$e_w = c_w \cdot \left(T_w - T_0 - T_0 \cdot \ln \frac{T_w}{T_0} \right), \text{ kJ/kg}, \quad (8)$$

where: $c_w = 4.19$ kJ/(kg·K) – water specific heat (at constant pressure).

If it is necessary, the exergy change in a thermal process can be determined by the equation:

$$\Delta E = Q \cdot \left(1 - \frac{T_0}{\overline{T}} \right), \text{ W}, \quad (9)$$

where: Q – heat flow, which takes place in the thermal process, W; $\overline{T} = 273 + 0.5(t_1 + t_2)$ – absolute average temperature in a thermal process, K; t_1 and t_2 – initial and final temperature in the thermal process, °C.

The power consumption of fans electromotor for air transport was determined by the equation:

$$N_{use}^{fan} = N_{set}^{fan} \cdot \eta_{fan}, \text{ W}, \quad (10)$$

where: N_{set}^{fan} – installed fans motor capacity of the adopted central air conditioner, W; η_{fan} – fans output-input ratio. $N_{use}^{c.w}$ and $N_{use}^{h.w}$ were similarly determined.

Taking the coefficient of the energy class of refrigerator E.E.R. = 2,8, its power consumption were determined by the equation:

$$N_{use}^{RM} = \frac{Q_C}{E.E.R.}, \text{ W}. \quad (11)$$

The specific enthalpies of moist air were calculated as follows:

Specific exergy of moist air at certain points of the processes, that characterize the work of the central straight flow air conditioning system, are determined by the following equations:

$$e = e_{ph} + e_{ch}, \text{ kJ/kg}, \quad (12)$$

where: e_{ph} and e_{ch} – specific physical and chemical exergy in relation to outdoor air (environment), respectively:

$$e_{ph} = \left(\overline{c}_{d.air} + \overline{c}_{vap} \cdot \frac{d}{1000} \right) \cdot \left(T - T_0 - T_0 \cdot \ln \frac{T}{T_0} \right), \text{ kJ/kg}, \quad (13)$$

$\overline{c}_{d.air}$ = 1,005 kJ/(kg·K) and $\overline{c}_{vap}$ = 1,86 kJ/(kg·K) – average specific heat (at constant pressure) of dry air and water vapor, respectively;

T_0 and T – the absolute temperature of the outdoor air (environment) and air in a certain point in the process, respectively, K ($273 + t = T$);

$$e_{ch} = T_0 \cdot \left[\left(R_{d.air} + R_{vap} \cdot \frac{d}{1000} \right) \cdot \ln \frac{622 + d_0}{622 + d} + R_{vap} \cdot \frac{d}{1000} \cdot \ln \frac{d}{d_0} \right], \text{ kJ/kg}, \quad (14)$$

$R_{d.air}$ = 0,287 kJ/(кг·K) and R_{vap} = 0,462 kJ/(кг·K) – the gas constant of dry air and water vapor, respectively; d_0 and d – the moisture content of the outdoor air (environment) and air in a certain point in the process, respectively, hr/kg.

The calculation results of the moist air specific exergy in a certain points of the processes, which characterize the work of the central straight flow air conditioning system, are summarized in Table 1.

It should be noted that we have not been taken into account exergy loss, associated with the loss of aerodynamic pressure of air stream, which are relatively small and can be neglected, losses in the environment also are not accounted, besides it is accepted that the process of humidification in the air washer occurs polytropic. The parameters, which characterize the state of the air at all points of the processes for the given central air conditioning system, are summarized in Table 1.

RESULTS OF THE RESEARCH WORK

Substituting the obtained estimated values in a equation (4), the values of exergetic output-input ratio η_e for the specified air conditioning system depending on external temperature conditions were calculated, namely: temperature t_{out} and moisture content d_{out} of outdoor air served them in the form of appropriate dependencies on the Fig. 3 and on this basis analysis was made.

Analyzing the obtained research data on a Fig. 3 the following conclusions can be reached.

The general increase of outdoor air t_{out} from 26 to 42°C, namely in 1.62 times more, according to the general increase of moisture content of outdoor air d_{out} in a row 3 from 10.3 to 14.9 hr/kg, namely in 1.45 times more, leads to a significant growth of exergetic output-input ratio value η_e from 0.26 to 2.30, namely in 8.85 times more or at 785 %. It should also be noted (Fig. 3), that the increase of moisture content of outdoor air d_{out} from 13.9 to 15.9 hr/kg, namely in 1.14 times more, when the temperature of outdoor air t_{out} = 42 °C, leads to a slight decrease of exergetic output-input ratio η_e from 2.44 to 2.18, namely in 1.12 times less or at 12 %, which can be ignored if necessary. So the chosen air conditioning system should be preferably used at higher temperatures of outdoor air, that is, for example t_{out} = 42 °C, that will make possible to gain the highest exergetic output-input ratio η_e, which means to gain the most advantageous economical variant of exploitation of chosen air conditioning system.

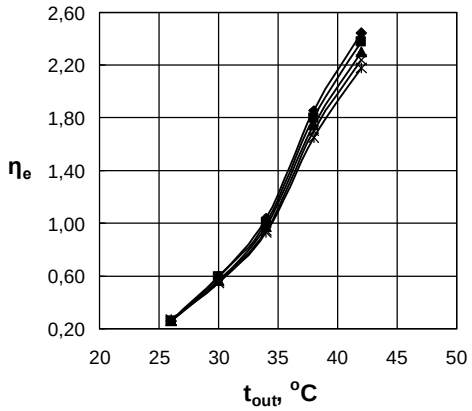

Fig. 3. The dependence of exergetic output-input ratio η_e of the central straight flow air conditioning system for cleanroom on temperature t_{out} and moisture content of outdoor air: row 1 ♦ – d_{out} = 9,3-13,9 hr/kg; row 2 ■ – 9,8-14,4; row 3 ▲ – 10,3-14,9; row 4 ✕ – 10,8-15,4; row 5 ✳ – 11,3-15,9

It should be noted (Fig. 3), that there is one law of change the exergetic output-input ratio, when the temperature of outdoor air t_{out} is from 26 to 34°C, and when the temperature of outdoor air t_{out} is from 34 to 42°C – another. This is because the indoor temperature of the air in the clean room is taken differently to outside air temperature t_{out} = 30°C and above it. That's why lets consider these changes separately.

Table 1. Parameters of points, those describe the state of moist air during the work of central air conditioning system

Points on the *I-d* – diagram	Temperature t , °C	Specific enthalpy I , kJ/kg	Moisture content d , hr/kg	Relative humidity φ , %	Specific exergy e , kJ/kg
O	26-42	49,8-83,2	9,3-15,9	27-54	0,0-0,0
I	23-30	45,5-64,4	8,8-13,4	50-50	0,0173-0,2707
S	21,5-24,0	43,5-57,3	8,6-13,0	54-69	0,0385-0,5904
S_1	20,5-23,0	42,4-56,2	8,6-13,0	57-74	0,0559-0,6542
K	13,3-19,7	35,1-52,8	8,6-13,0	90-90	0,2870-0,8925

So, the general increase of outdoor air t_{out} from 26 to 34°C, namely in 1.31 times more, according to the general increase of moisture content of outdoor air d_{out} in a row 3 from 10.3 to 12.7 hr/kg, namely in 1.23 times more, leads to a significant growth of exergetic output-input ratio value η_e from 0.26 to 0.98, namely in 3.77 times more or at 277 %. It should also be noted (Fig. 3) that the increase of moisture content of outdoor air d_{out} from 11.7 to 13.7 hr/kg, namely in 1.17 times more, when the temperature of outdoor air t_{out} = 34 °C, leads to a slight decrease of exergetic output-input ratio η_e from 1.04 to 0.93, namely in 1.12 times less or at 12 %, which can be ignored if necessary. At the same time the average rate of change of exergetic output-input ratio η_e at this initial section $\Delta\eta_e / \Delta t_{out}$ is 0.09 1/°C.

Respectively the general increase of outdoor air t_{out} from 34 to 42°C, namely in 1.24 times more, according to the general increase of moisture content of outdoor air d_{out} in a row 3 from 12.7 to 14.9 hr/kg, namely in 1.17 times more, leads to a significant growth of exergetic output-input ratio value η_e from 0.98 to 2.30, namely in 2.35 times more or at 135 %. At the same time, the average rate of change of exergetic output-input ratio η_e at this section $\Delta\eta_e / \Delta t_{out}$ is 0.165 1/°C, that is in 1.24 times more, namely in 84 %, than at initial section.

The dependencies (Fig. 3) we have obtained in the form of analytical equations for temperatures of outdoor air t_{out} = 26-34°C:

$$\eta_e = 0{,}1841 \cdot t_{out} + 0{,}1990 \cdot d_{out} - 0{,}0075 \cdot t_{out} \cdot d_{out} - 4{,}5645$$

$$\eta_e = 0{,}1841 \cdot t_{out} + 0{,}1990 \cdot d_{out} - 0{,}0075 \cdot t_{out} \cdot d_{out} - 4{,}5645, \quad (15)$$

and for t_{out} = 34-42°C:

$$\eta_e = 0{,}3187 \cdot t_{out} + 0{,}2585 \cdot d_{out} - 0{,}0093 \cdot t_{out} \cdot d_{out} - 9{,}1135. \quad (16)$$

The maximum error of calculations by the equation (15) is 16.4 % and by the equation (16) – 1.7 %.

So the exergetic analysis of the central straight flow air conditioning system for cleanroom, which was performed on innovation mathematical research model, which was created by authors, provided the opportunity to thoroughly estimate the dependence of exergetic output-input ratio η_e this system on temperature t_{out} and moisture content d_{out} of outdoor air.

CONCLUSIONS

Innovation mathematical research model of the central straight flow air conditioning system for cleanroom in order to computer's estimation its energy effective by virtue of exergetic output-input ratio depending on different factors, which have influence on its work, was described in this article. The dependence of exergetic output-input ratio for chosen air conditioning system η_e on temperature t_{out} and moisture content d_{out} of outdoor air was presented. It is shown that the chosen air conditioning system should be preferably used at higher outdoor air temperatures, namely, for example t_{out} = 42°C, that will give the opportunity to gain the highest exergetic output-input ratio η_e, which means to gain the most advantageous economical variant of exploitation of chosen air conditioning system.

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Formation of optimal model of regulation of the banking system of Ukraine

S. Lobozynska

Bank and Insurance business Department
Ivan Franko L'viv National University,
e – mail: lobozynska.sophia @yahoo.com

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Abstract. The basic principles of regulation of banking activity, worked out by the Basel committee on questions of supervision and regulation of banking activity, were investigated. The advantages and drawbacks of pro-cyclical and countercyclical models of regulation of banking activity were examined. The expediency of realization of regulation on the basis of individual estimation of particular banks and also estimations of risks that have system character was proved. It was recommended to implement the principle of countercyclical regulation in Ukraine taking into account the business cycle of economy.

Key words: principles of effective banking supervision, supervision on the basis of individual estimation of risks, supervision on the basis of estimation of system risks, countercyclical regulation, pro-cyclical regulation.

INTRODUCTION

The extremely rapid increase of active operations of banks, the advancement to the financial market of the wide range of banking services, the insufficient concentration of banking capital, the imbalance of long-term assets and liabilities in terms of volumes and terms of payment, the absence of the proper transparency of banking sector and necessary level of corporate management lead to the increase in risks in the activity of banks. Thus, the investigation of question about reformation of the system of regulation of financial market is worth attention and is of current concern.

The problems of organization of the proper system of regulation of financial market are covered in works of foreign and domestic authors. So, in the publications of Petryk O. [9], Pons J. [10], Reinhart K. [11] the attention is paid to impossibility of the system of regulation of banking market to prevent the development of a crisis effects. It induces the range of scientists, namely: Borkivets N. [4], Lisna R. [4], Simanovskyj A. [12], to search the ways of solving the problem

On the other hand, in the publications of such domestic scientists, as Bregeda O. [5], Savluk S. [5], Karcheva G. [7], Koval O. [8] the possibilities of the increase of efficiency of regulator processes are examined by the input of international principles of organization of regulation and supervision in domestic bank practice; the adopting of experience of application of methodological tools of regulation of financial markets. However, considering the further difficult situation of banking market of Ukraine the aim of our research is development of optimal methodology of realization of the banking regulation in Ukraine that would allow opportunely discover and protect domestic banks from the possible threats.

MATERIALS AND METHODS

Methodological basis of the banking regulation and supervision on a world scale is formed by the normative documents developed by the Basel committee. The most essential of them are: Key principles of effective bank supervision, that became the answer of international community to the threats of bank crisis at the end of XX century; Basel concordat (principles of supervision of subdivisions of foreign banks, that defined the concerted principles of mutual relations of international banks with the central banks of host countries); Basel agreement of a capital, that provides international converging of measuring of capital and standards of capital.

In August of 1987 the Basel committee published "Key principles of effective banking supervision", that became the basic source of recommendations for development of national banking laws of countries that formed the national banking systems or reformed them, in accordance with the world standards of organization of banking activity.

After the implementation of the key principles of effective banking supervision by some countries the International Monetary Fund and the World Bank at the request of the Basel Committee made the estimation of efficiency of the national systems of banking supervision [14, 16, 17, 19]. Such research showed controversial interpretation of positions of key principles of banking supervision by the national body of the banking regulation. Taking it into account, the working group of the Basel committee in 1999 made "The methodology of key principles", that contained the detailed explanation in relation to their application. The base principles of effective bank supervision are those minimum requirements without inhibition of which supervision cannot be considered strong and effective. Key principles were implemented in legislation and created bases of the existent system of banking supervision not only for EU but also for many other countries of the world.

The principles consist of 25 positions that can be grouped according to such directions : conditions for an effective banking supervision (principle 1); licensing and structure (principles 2-5); prudential norms(principles 6-15); methods of current banking supervision (principles 16-21); standards of accounting (principle 22); measures of the observant reacting (principle 23); interbank international activity (principles 24-25). Exactly these principles are stage-by-stage implemented in the system of regulation of banking activity in Ukraine and form the foundation of the regulatory process. However, modern threats of financial stability force regulatory authorities to make methodological structures in the regulation of banking activity with the aim of taking into account tendencies and cycles of economic processes.

RESULTS AND DISCUSSIONS

By the previous estimation of the General mission of IMF and World Bank from 30 principles of the Basel committee (taking into account, that 1st principle has six constituents estimated separately) Ukraine fully or mostly obeys 25 [366, p. 28]. In particular, it concerns the increase of norm of adequacy of regulatory capital, the input of tougher economic norms which regulate loan transactions with related parties, the severe requirements to form backlogs for loan operations, the introduction of the system of estimation of risks during realization of supervision, the creation of legal base on questions of fight against money laundering received in a criminal way and by financing terrorism.

The achievement of more complete compliance of Basel principles largely depends on the acceptance by Ukrainian Parliament the corresponding laws and also development and acceptance of changes of the legislation of Ukraine which will allow to settle such questions : providing of plenary powers of National Bank of Ukraine in relation to refusing of delivery the banking license or permission for acquisition of the substantial participating in a bank if it is impossible to define the structure of ownership and real owners of bank (principles 3, 4); determination at legislative level of requirements for the banks in relation to the systems of their risk management and principles of corporate management (principles 3, 7, 17, 22); input of requirement to the parent companies of financial groups in relation to presentation of statements on the consolidated basis and about activity of separate participants of group, and also providing effective risk management (principles 21, 24).

Further implementation of the marked principles must take place in connection with realization of institutional changes in a macroeconomic environment because a bank supervision can be effective only when it is carried in the mode of the balanced and stable macro-economic politics and well-developed financial infra-structure, with presence of effective market discipline and mechanism able to provide the proper level of system protection to the participants of bank market.

However, the basic document of committee is the Basel agreement concerning the convergence of systems of bank regulation regarding capital measurement and standards which are applicable for the capital. In particular, in 1988 recommendation about "International convergence of estimation and standards of capital" ("Basel I") was released, it contained minimum requirements for activity of banks. It was directed to increase the strength and stability of the international banking system, and also to provide a unified database of prudential regulation [1].

Dynamic development of banking market required the improvement of existent norms of bank supervision. "Basel I" was subjected to sharp criticism for absence in the norms of regulation positions for consideration of risks which were taken by banks in the process of activity. Therefore, requirements are too stringent and burdensome to banks which work with financially stable borrowers and which have quality system of risks management. Such criticism has begun since "Basel I" was accepted and until its decade attained the apogee. Taking this into account, in 1998 consultations concerning the conclusion of new agreement were begun, which led to the acceptance of "Basel II" in 26.06.2004. This document declared a transition from the principle of universalization to the principle of individualization of regulation taking into account the specifics activity of each individual bank and shift of emphasis of normative requirements related to economic capital [2].

In "Basel II" were established new requirements for sufficiency of capital of credit organizations. This approach was based on three supports in relation to determination of sufficiency of capital, namely: minimum requirements to the capital of credit organizations; supervisory process and market discipline.

In basis of conception of economic capital stands an idea of dependence of rational level of capital from the level of possible losses which are not covered by current income. In other words, losses which should cover the economic capital are determined by a risk level which was taken over by a bank, and quality of risks management. Such capital is named sensible to risk.

"Basel II" within I and II component suggested to supervisory authorities to apply stress-testing oriented at the evaluation of financial stability of banks on condition of unfavorable environment of activity (pessimistic scenario of development). At the same time in a component I was offered a horizon of estimation of requirement in the capital of credit institution for the term of 1 year which orient banks at the optimistic scenario of development of events. Such horizon conduces to the increase of assets and accumulation of risks. The methodology embedded in the "Basel II" is somewhat contradictory, that influenced certain blanks in the national systems of the banking regulation and supervision. In particular, in part of active support of macroeconomic politics the increase was not in time identified by authorities of prudential regulation and was not prevented massive threat to systemic crisis [2].

The breakaway from the conservative regulation, which would combine stress-testing and the horizon of estimation of capital, oriented to the cycle, would lead to the orientation of banks on a future crisis, that would result in the increase of capital base. Taking into account, that in "Basel II" period time horizon of 1 year is offered, "Basel II" formed methodology of supervision on the basis of estimation of capital according to risks in the phase of the economic growth.

Although methodology contained stress-testing which bank regulators actively used in the process of their activity, it could not prevent the dynamic increase of risk assets in banking structures, which eventually led to the financial crisis. Connecting the optimal loading on the capital of banks and support of the economic growth in the sphere of finance, regulator has moved from a relatively neutral position on the cycle of capital regulation to pro-cyclical, which is inconsistent with the general concept of regulation. Therefore, the international community faced the question about developing new methodological approaches to the regulation of credit institutions. Existing trends indicate a preference for countercyclical regulation as opposed to pro-cyclical, whose methodology of implementation was laid in the liberal version of the "Basel II".

The methodology of countercyclical policy is actively discussed in academic circles. It certainly has its advantages and disadvantages. The countercyclical regulation is interpreted as an element of macro-prudential regulation, which should complement microeconomic regulation. Regulators of "Group of 20" macro-prudential regulation recognized as priority direction of improving the regulatory system.

The developers 'Basel III' had the task to improve the methodological basis by the provisions counter-cyclical regulation and to develop the best mechanism which is able to provide effective achievement by this system of practical results – more moderate, but at the same time more resistant economic result.

The countercyclical policy of regulation has not been sufficiently tested in practice yet. Opponents of this methodology doubt the efficiency of its application. In particular, there are arguments which show not after its favor [12]: introducing stricter requirements for financial stability of banks in terms of economic growth, the regulator triggers banks to implement aggressive policies, guided by an aspiring to obtain even greater profits, leading to an increase in risks and deteriorating financial condition in the future; countercyclical model of regulation applies to independent participation in the system of micro regulation along with monetary and credit, tax and fiscal policies.

This leads to additional correction of actions of different elements of macro regulation. In case of uncoordinated use of instruments it can cause negative macroeconomic effect; lack of opportunity to predict with great accuracy the economic imbalances in the financial systems of the world leads to difficulties in determining the timeliness of use of instruments of prudential regulation of countercyclical direction; countercyclical regulation will contribute to the overall system of banking regulation certain elements of asymmetry. For example, the traditional banking regulation focused on risks of particular banks and countercyclical – on systemic stability through regulation of the economic cycle by introducing prudential requirements for banks [15]. Without taking into account the risks of specific banks, this type of regulation can have a more negative effect on the activity of conservative banks, rather than benefit from the inhibition of risks of banks which conduct unbalanced policy of asset and liability management [13].

So, despite the financial crisis, regulators of national systems of banking supervision are looking for new alternative ways to build an effective methodological base of regulating the banking system, which would ensure the financial stability of the banking systems in different phases of the business cycle.

CONCLUSIONS

In our opinion, the methodological basis of the formation of the national system of banking regulation and supervision should be based on an individual assessment of the risks of individual banks and

assessment of the risks that are systemic in nature. In Ukraine a two-tier system of banking regulation and supervision should be built. The first level would include the development and use instruments with the help of which it could be possible to regulate individual financial stability of banks, specific individual risks (of unsystematic character) of banking institutions, covering transformed into individual risks of systemic origin.

The second level of regulation would be appropriate to aim at regulation of systemic stability, whose risk factors have systemic (macroeconomic) causes. The formation of the second level provides creation of mechanism to ensure systemic stability, which would allow solve the problems of stability under stress of system origin.

The regulation of individual resistance should be carried out by determining the basic parameters of activity of the credit institution on the basis of empirical data. For example, the capital requirements of banks can be determined by analyzing reports on actually incurred expenses arising out of individual risk (unsystematic reasons). The source of such costs is the individual shortcomings of risk management, covering flawed lending standards, investment, failure of standards of lending to connected persons, bank insiders, excessive risk concentration, unreliable accounting and reporting, manipulation by indicators of the level of risk. Such regulation should be neutral to the phase of the business cycle and used during recession and in a phase of economic growth.

However, it would be appropriate to introduce differentiation in determining the prudential requirements for banks depending on the level and quality of risk management. Requirements for bank capital should be determined according to its ability to cover individual risks of unsystematic nature. In particular, the regulatory burden on the bank with a low-risk and quality management system should be significantly lower than the normative certain level.

Conversely, for banks with significant deficiencies in risk management and poor quality of their management should be determined normative values of capital which are higher than average defined norm of adequacy of capital [21]. In this approach, risk assessment and quality its management should be provided with an appropriate level of transparency (clarity) and business risks of the bank to the regulator and the market. At the same time administrative and criminal responsibility of management and beneficial owners of the bank for unfair business practices and inadequate transparency should be established, covering liability for misrepresentation in registers.

The second level of regulation should to be realized through a mechanism to ensure the financial stability of the banking sector, which should include a system of macro-prudential analysis of the financial stability of the banking segment and creating a centralized insurance fund to provide financial support to banks affected by adverse conditions in the global financial markets. Such regulation should take into account the phase of the business cycle: during recession to apply incentive actions to expansion and in a growth phase – restrictive.

The system of macro-prudential analysis should include calculating of financial firmness indicators of the banking system to provide information about its strength and vulnerability, as well as for the timely use of instruments to limit the probability of crisis arising [16]. To calculate the financial soundness indicators of the banking system it is necessary to create aggregate reports on financial results and reserves of assets and liabilities of the banking system. Such reporting is necessary for future stress testing of financial stability of the banking sector.

The monitoring of financial stability of the banking system should be built on timeframes: daily, weekly, monthly, quarterly and yearly. Periodical monitoring of an indicator is determined by the frequency of updating the information base and expediency of monitoring for these or other parameters in the corresponding timeframes [20].

The macroprudential analysis of bank stability should be implemented in such directions: assessing the level of capitalization, evaluation of the quality of the loan portfolio, evaluation of liquidity, quality assessment and risk of assets, evaluation of resistance and quality passive base, evaluation of the efficiency of activity).

Carrying out continuous monitoring of the financial stability of the banking system in specified directions, regulatory authorities will be able to timely react to the challenges of internal and external threats, preventing and minimizing the losses of the banking sector from the financial crisis.

The second component of the mechanism to ensure the financial stability of the banking sector – is the creation of insurance stabilization fund to assist the largest banks. This fund should be directed at reducing (reasonable compensation) risks of loss of financial stability of the bank, which were caused by a systemic crisis.

To do this, at the legislative level an additional income tax for the banks (which according to the NBU classification belongs to the first group of banks by volume of their assets), the consequences of bankruptcies which threaten financial security and stability of the country, as they have priority for obtaining the assistance from the regulator the banking system through the mechanism of refinancing and nationalization. In addition, asset and liability management is carried out in the largest banks worse than in small banks, where centralized system management with the use of balanced methods is usually implemented. Deductions on this tax should be directed to accumulation of targeted stabilization fund.

Introduction of additional income tax for the accumulation of the trust fund will prevent unreasonable increase in assets of banking institutions and uncontrolled growth of risks on active operations of banks. The quality of risk management in such a bank can be improved by differentiating tax rates depending on the quality of risk management in the bank.

Payments from the purpose reserve need to be conducted on the basis of expert estimates losses under conservative methods. In this case, the main task of the regulator should be the development of methods of identification and separation of losses caused by deficiencies in the management (which is not covered by the fund), and losses that banks have suffered as a result of a systemic crisis (which are covered by the fund).

The amount of insurance, which exceeds the amount of tax deductions for full-time participation in the purposed stabilizing fund, can be considered as a contribution of the state in the share capital of the bank. Thus additional financial and organizational options for effective restructuring of banks can be created, which without external help cannot continue to work under system stresses.

Thus, building a system of banking regulation in accordance with the outlined provisions would promote the systematic stability and would enable to achieve the main goal of regulation: when the growth of bank assets is carried out not by a cost of decrease of financial stability of banks and the insurance of financial stability does not prevent the growth of banking business.

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Types of interrelation and information streams between the bodies of formation and management share institutions with joint investments

I. Oleksiv, I. Shpakovych

Department of management and international business,
Lviv Polytechnic National University
79013, Lviv, Bandery st. 12
e-mail: irkosp@gmail.com

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Abstract. The given paper presents the results of the research of the entities that manage share institution with joint investments and take part in its formation and functioning, in particular Management Company, Monitoring Council, investors, and an investment consultant was offered as an additional participant at the financial market. It was determined that there should be the licensed activity, the result of employing: the increase of the liability and objectivity of the regulation's expertise of the investment fund, minimizing risks for investors that will help to provide more effective investment process. The general system of the state regulation of the activity of such funds at the financial market was described , interrelations between the subjects of the investments, the order of taking decisions was set to define the strategic aims and choose appropriate investment projects, the direction of the financial and property assets. Their place in the given system as interrelations was characterized. Types of the information streams between the subjects of the investment fund were defined and described their interrelations. Every subject's functional purpose was determined, and also the typical functions for share institutions with joint investments, namely general-social and protective function for investors' economic interests, informational and regulating. The general level and the tendencies of current investment market in Ukraine were examined, taking into the account international experience and the dynamic of internal market, further recommendations are attached on the improvement of regulatory basis of the financial market for extending types of investment funds and financial instruments for engaging as many investments into the Ukrainian financial market as possible.

Key words: share institutions with joint investments, investors, Management Company, supervising committee, investment consultant.

INTRODUCTION

Investment is one of the most necessary preconditions of the development of different spheres of the national economy. There are different means of investments such as property, shares, stock, private enterprising, pension funds etc.

One of the most efficient and powerful mechanisms of engaging and accumulation of investments in the countries with highly-developed economics is share institutions with joint investments. In Ukraine investment funds are gaining popularity, though they play an important role in the investment sphere of economics in our country. Due to the fact that share institution of joint stock (further called SIJI) can accumulate a bigger part of the investment resources, so in prospect they may become the main source of innovation investment, prioritized spheres in economics etc. Mutual investment serves as a mediator between an investor and the entity of investments. The following accumulating process is characterized by a great number of entities, participating in the fund formation and its management. That is why to increase the productivity of the work of the fund it is up-to-date to analyze the environment and fund entities interrelations and their functions.

MATERIALS AND METHODS

Analyzing resources [1, 2, 3, 4, 5, 6, 7, 8], it was found out, that native and foreign scholars devoted a lot of works to the issue of SIJI and its entities.

V. Yeryomenko described the duties of the management companies abroad, in the works by K. Pavlyuk the objectives and the principles of functioning are observed , the sources of formation and the "directions of resource expenditure of the Investment Fund" of Ukraine [5], Y. Porodko is researching the peculiarities of the functioning of SIJI and its advantages "as one of the alternatives of investment" [6]. N. Tkalenko examined the role of SIJI in the native economy [7], M. Novykova observed the aptness of incorporation of investment funds in the system of the country development innovation [8]. S. Knyaz described methods for selecting investment strategies [9]. A great number of works devoted to the sphere of mutual investment were presented by such scholars as O. Kampi, I. Lytvyn, V. Gurova, B. Fridmen, A. Pigu, J. Gerli, G. Shreder, U. Sharp etc. Though further work out and improvement of the functional purpose and localization of each entity of SIJI in the process of interrelation are required.

The purpose of the given article is to determine the functional allocation of each entity of SIJI and their localization in such system.

RESULTS AND DISCUSSION

The understanding entity functions, which are formed and managed by SIJI is possible if their general interrelation system correlates. Analyzing research material [1, 10, 11] and practical work of fund and investment markets, there was created the general description of the system of interrelations and information streams, which form and manage SIJI (Picture 1).

The infrastructure of SIJI entities is formed and managed Picture 1, such institutions as: JISI and Management Company (MC), supervising committee and an investment consultant. Investors are not included in such system, because they are a source of initial financing of SIJI, by means of getting investment certificates imitated by this fund. As a result of their investment into innovations, securities, building constructions, deposits, property, corporation rights etc investors get the profit from dividends, security rate profits, property.

The registration of the stock market is held by the National Committee of Securities and Stock Market (NCSSM). The registration ends up with the assigning of the code to the fund and its registration to SIJI, which is run by a specialized department of the Committee. The sponsor of SIJI is a company that runs the assets (MC) and performs all necessary activities to register the share of the investment fund, hold the emission of the investment certificates and ensure its fulfillment.

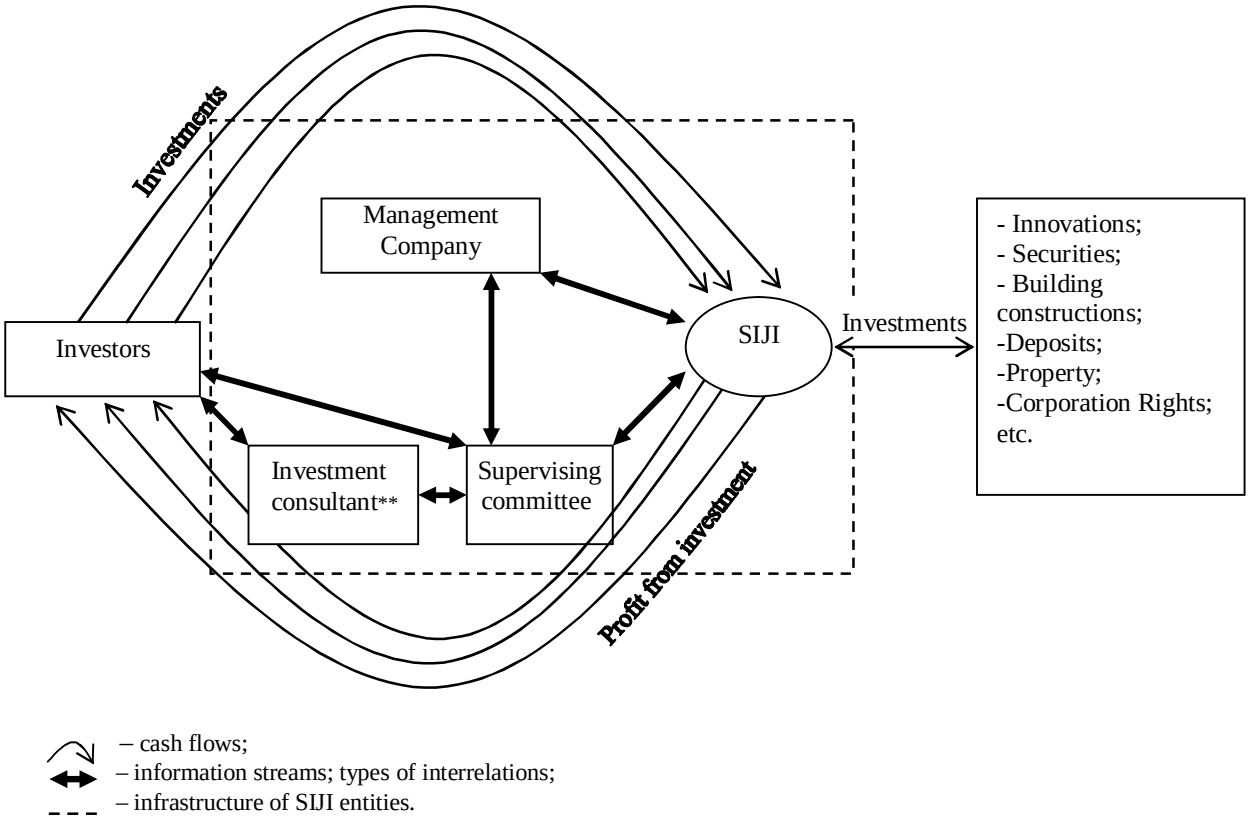

Fig. 1. The system of interrelation and information streams of entities which are formed and managed SIJI*
*Resource: created by the author analyzing research material [1; 3; 10; 11; 12; 13; 14]
**Suggested involving investment consultant

Practically all financial, legal and economic operations of SIJI are performed by MC – a legal body, created in the form of a stock company and a private joint stock company with their statute fund no less than 7 000 000, 00 mln UAH that works professionally in managing the assets of SIJI according to the license, given by the Committee and cannot combine this business with other kinds of professional activities at Stock Market. The investment funds function via MC. The asset management is the only kind of running business for such enterprises. MC is the main member of the stock market, which interrelates with the investment funds and performs the following functions regarding SIJI [1, 2, 3, 5]:

- creating share SIJI. Performing expert evaluation of the efficiency of SIJI,
- management of the investment funds' assets by planning fund's activity, organizing business between the entities, that are form and manage SIJI, staff motivation running investment fund, monitoring effective fund work and regulating deviations in fund's activity,
- searching entities to invest and get the profit from it,
- filling in funds' activities by means of releasing and placing the securities of SIJI, searching under rites to invest fund certificates among the investors,
- analyzing securities and other instruments, that belong to investment fund assets, and calculates clear fund assets,
- choosing licensed members of stock market, that trade securities and keep them, signs contracts on profitable conditions. The contracts are signed with enterprisers-partners with which MC has dealt already, that are reliable and offer favorable conditions,
- performing accounting and tax audit of SIJI ,
- reporting to the state organs, NCSSM, State Tax Office, State Department of Financial Monitoring and other organizations on SIJI activity for the certain period of time,
- providing SIJI activity. Performing management of the assets of SIJI. Determining strategic policy of the fund realizing it. Estimating main aspects of SIJI functioning. Forming and providing for the investment policy of SIJI [15],
- considering the factors, that influence the formation and further activity of SIJI.

Examining the investment climate in the country, investment activity and social standards of living, legislative regulations of the investment policy etc. The contribution to the assets of SIJI is made by legal bodies and individual entrepreneurs. Their aim is to get profits from certain kind of investment. On forming joint stock company, the founders remain the only members of the fund and follow their interests. As a rule, when the joint stock company is founded by SIJI members, their relations, industrial activity and business projects are corporative. On forming open investment fund, it imitates investment certificates, which can be sold at non regulated market or via stock markets or can be bought by depositors [1]. As a result of the above mentioned operations by the members of SIJI become all bodies that have bought the securities imitated by this fund. The quantity of the members is not limited. In the process of fund activity the fund committee can be founded by SIJI members. They also appoint the head of this committee. According to the contract about the cooperation between SIJI and MC, the head of the committee monitors MC activity regarding the fund and is entitled to adopt and cancel the decisions about fund assets. The head of the committee signs fund's purchase contracts of the securities, contracts on fund's operations with other assets, and a contract with the keeper of the securities. Analyzing state and non-state organizations, that have supervising committees of SIJI with the following suggested functions [1; 16]:

- assertion of forming, liquidation and reorganization of SIJI,
- giving offers to MC as to priorities of the investment activities,
- making decisions by MC as to the investment fund,
- working out the system of measures regarding support and improvement of SIJI activity,
- analyzing the activity of MC, managing the assets of SIJI and making offers SIJI,

Based on analyzing the functional purpose of the various socio-economic subjects to work the following features that are relevant for mutual funds:

- general-social function – estimates activity direction to satisfy investors' interests. The following function aims to strengthen SIJI business activity as a basis of the investment interrelations, increase business capacity of the fund and the length of its existence, to preserve "economic-financial resources for providing the realization of its aims"[17]. In this way all necessary conditions are created for the fund to fulfill all business projects. It is up-to-date while forming favorable conditions for the investment fund development and strengthen depositors' interrelations stipulated by realization the legislative norms. General-social function bears not only economical but also social effect [17, 18, 19, 20],
- the function that protects investors' interests – aims to protect personal data of each depositor. In investing in SIJI, the data of the entrepreneurs and legal depositors are being collected. Such information is confidential and is forbidden to be spread without member's agreement apart from the cases foreseen by the Law of Ukraine "About Personal Data Processing". That is why investment funds are to protect personal data and secure them from illegal processing, including their loss, illegal or accidental erasing, and illegal access

to them [20]. This function stands for depositors' rights to reduce the level of criminal cases. Economic content of this function stands in the protected economic information about the investors, their trust in the investment fund, whereas the investment fund's attraction is rising [18, 20, 22],

- informational function – aims to organize and provide regular access to the informational system about business activity of investment funds. SIJI are open to state organs (Tax Office, The National Committee of the Securities and Fund Market, Self-Regulated Organizations) that are checking legitimate activity of the fund and requirement to the fund and its investors that are interested in taking risks and profitability of fund operations, fund's ability to pay out the interests. To give free access to the information about the state of the investment fund and the operations performed aims to make certain decisions or realizations of depositors' plans [18; 20; 22],
- regulating function – aims to eliminate certain factor, that appeared (for example to regulate interrelations between depositors resulting in the conflict of non profitable investments). The given function was created to preserve the stability of the fund as an entity of business interrelations by means of supporting necessary correlation between different elements to remove and manage possible deviations from the planned functional process. This function is aimed to remove fund's activity drawbacks [15, 18, 20].

The peculiarity of the suggested system of entities forming and managing SIJI is to involve an extra body, that is – a investment consultant that allows to:

1. To provide the effectiveness of the procedure of an independent expertise of regulations and the emission prospect. MC is a body that is interested in involving investments to get the profit from the fulfilled work.
2. To reduce investors' risks. The investment consultant is independent from MC and other participants of the investment fund, and correspondingly is entitled to give an objective and actual evaluation of a suggested project.

An investment consultant can be hired both temporarily and permanently to consult the members of the fund. In particular, it would be efficient for a consultant to be a member of the observing committee of SIJI. An investment consultant is to act according to the law and follow the principles of just trade considering investors' interests.

The economical consequences of hiring an investment consultant stand in the improvement of the effectiveness of the decisions regarding the emission of the investment certificates of SIJI, in the form of an invested capital, optimizing risks from acquired assets.

On the basis of analyzing more economically developed countries in the sphere of social investment, there can be differentiated certain functions typical to the investment consultant:

- Evaluation and expertise of investment projects – the aim of holding such expertise is to determine the economical vital activity and appropriateness of such projects, preventing economically non-profitable SIJI. It includes complex evaluation of practical and methodological aspects, backgrounding the project and evaluating its level of non-profitability or profitability in general [23, 24].
- Managing investment portfolios, that include one or more tools – the given function allows to form the investment portfolio of SIJI and perform its restructuring if investment conditions change to preserve the invested money and make it profitable. The economic content stands in preserving investment attraction of an existed fund [14, 25].
- Giving investment recommendations regarding financial tools – an investment consultant after having performed the evaluation and acquired experience in the process of his/her work can give recommendations as to any business project, consult investors in the sphere of the capital structure of the investment fund, business strategy and other issues concerning joining and capital intake, division [24]. The role of the following function is to minimize the risk appearance in the work of SIJI and increase its effectiveness.
- Non allowance of abusing by MC depositors' assets. MC is a concerned entity to involve investments at the market, resulting in managing the fund, it gets profits-interests or shares for the fulfilled services [1, 3].
- Evaluating the risks of profitability, time prospects – the evaluation of a possible loss of investments (securities' rate value loss, currency rates fluctuations, decreasing of economical situation or eminent's bankruptcy with invested capital, deterioration of the economical situation in the country in general etc) [26]. Forecasting the level of profitability or losses and prospective of a business project at different periods of time.

On the basis of researching and analyzing marketing experience of SIJI, legislative acts, material resources and participants functions [2, 6, 10, 11], that form the infrastructure of the investment fund, in table 1 there depicted different types of information streams and the content of interrelations between the entities of SIJI.

Uniting elements such as MC, Supervising Committee, investment consultant, investors, and their close interrelations form the structure of the investment fund. The given characteristic of information streams and the types of interrelations characterizes the interrelations between the entities that form and manage SIJI, their influence on the fund and their functions.

Table 1. Information streams and types of interrelations between the entities that form and manage SIJI*

№ link	Interrelation entities	Information streams	Description of interrelations
1	Investors; Supervising committee	Information on the fulfilled work; Comments and suggestions;	Supervising committee reports on investors about the fulfilled work and accepts comments and suggestions regarding fund's activity and its elements
2	Investors; investment consultant	Information about the prospect of SIJI	Getting order to perform independent expertise on formation
3	Investment consultant, supervising committee	Information based on the results of business projects' evaluation	Cooperation based on evaluating each business project offered for SIJI. Supervising committee is a customer, investment consultant – performer (evaluating)
4	Supervising committee; SIJI	Sharing the results of evaluation	Monitoring SIJI activity, adoption or rejection from all the projects
5	Supervising committee; MC	Information on the scheduled or fulfilled work	MC reports back to the supervising committee and accounting for the fulfilled work. Supervising committee accepts or refuses suggested investment projects, gives its offers
6	SIJI; MC	Information about SIJI work	Fulfillment of all approved business projects; monitors investment activity; searches the entities of the investment; imitates investment certificates for SIJI

*Material source: made up by the author on the basis of analysis [1; 2; 6; 7; 10; 15; 27; 28] and the functions of entities, that form and manage SIJI.

CONCLUSIONS

On the basis of the research in the article, it may be asserted, that nowadays the market of SIJI in Ukraine has reached quite sufficient development level in terms of functioning entities, legislative and technical security of its activity, however the structure of SIJI market is not perfect enough to minimize the risks and requires further development and improvement. MC runs practically all the managing business, investing and deals with the strategic policy of the fund. Hence, MC is an interested entity of the existing system to involve investments, as such a company gets profits, as a rule, in the amount of certain percentage from the sum of involved investments for the managing assets services of the fund, that monitors MC, though in most cases fund members are not prepared enough in terms of legislative and financial regulations of the investment activity and cannot usually arrive with rational solutions. That is why, we consider that it would be appropriate to involve the investment consultant that would give an independent expertise of the investment projects and consult depositors as to the risks, assets profitability, short and long term planning, avoid non legitimate actions from MC while monitoring investors' assets.

Thereby, taking into consideration the international experience, considerable increase in the tools at the financial market of Ukraine and a range of investment funds, we came to the conclusion that investment consultant involvement will give vast opportunities to investors to invest their means profitably, allow to perfect interrelations between its elements, aimed to provide favorable conditions for investment funds and performing investment activity.

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An application of the fuzzy set theory and fuzzy logic to the problem of predicting the value of goods rests

O. Rybytska, M. Vovk

Department of Higher Mathematics, Lviv Polytechnic National University.
79013 Lviv, Stepana Bandery str., 12
e-mail: olga.rybytska@gmail.com

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Abstract. Applying the fuzzy set theory and fuzzy logic, we construct a mathematical model for predicting the value of unrealized goods rests and demonstrate this model on an empirical example showing good correlation with the real data.
Key words: fuzzy set, fuzzy logic, linguistic variable, fuzzy knowledge base.

INTRODUCTION

Modern problems of mathematical modeling in economics are related with the presence of incomplete information and the necessity to make economical predictions in the situation of uncertainty. In such situation the apparatus of classical logic is inapplicable [3], [5], [8], [18]. In contrast, such problems can be effectively resolved with help of the fuzzy logic created by Lotfali A. Zadeh in 60-ies of XX century. In today's increasing complex and uncertain business environment, financial analysis is yet more critical to business managers who tackle the problems of an economic or business nature. Knowledge based on formal logic and even experience becomes less sufficient. This volume systematically sets out the basic elements on which to base financial analysis for business in the new century. In dealing with rapid and unpredictable changes in technological and business conditions, it postulates a growing reliance on the opinions of experts instead of past data or probabilistic forecasts, which is a radical change but may yield fruitful results. For this reason, much emphasis is devoted to the problem of aggregation of the opinion of experts in the financial field, with the object of limiting, wherever possible, the subjective component of the opinions and making sure that the decisions have the best guarantee of reaching the desired objectives [10].

Methods of fuzzy logic and fuzzy set theory are widely used in the modern mathematical economics (see [2], [6], [19], [20]). Fuzzy sets and fuzzy logic have been applied virtually in all branches of science, engineering, and socio-economic sciences [1]. The principal notion of the theory is that of a linguistic variable. As defined by L.Zadeh [16] "By a ***linguistic variable*** we mean a variable whose values are words or sentences in a natural or artificial language. For example, ***Age*** is a linguistic variable if its values are linguistic rather than numerical, i.e., ***young, not young, very young, quite young, old, not very old and not very young,*** etc., rather than 20, 21, 22, 23."

In this paper we shall apply the methods of fuzzy logic to predicting the value of rests of preparates for chemical defense of plants and will elaborate an algorithm for predicting the value based on the apriori knowledge of an expert.

PROBLEM STATEMENT

We shall assume that the value y of a goods rest depends on the values of certain variables $x_1, x_2, ..., x_n$, and the dependence will be described by a function:

$$y = f(x_1, x_2, ..., x_n). \quad (1)$$

In order to apply methods of fuzzy logic, we shall fuzzily all the variables and turn them into the linguistic terms:

$$U_i = \left[\underline{u_i}, \overline{u_i}\right], \quad i = \overline{1,n}, \quad (2)$$

$$Y = \left[\underline{y}, \overline{y}\right], \quad (3)$$

where: $\underline{u_i}, \overline{u_i}$ denote the smallest and the largest value of the variable x_i and $\underline{y}, \overline{y}$ the minimal and maximal value of the output variable y.

For calculating the function f in (1) we shall consider the input parameters x_i, $i = \overline{1,n}$ and the output parameter y as linguistic variables defined on the universal sets (2), (3). Qualitative terms for evaluating the linguistic variable $x_1, x_2, ..., x_n$ will be taken from the term-set A_i and for the linguistic variable y from the term-set D. For constructing the term-sets one can apply the method suggested in [9].

For each term $a \in A_i$ from the term-set A_i we define a compatibility (membership) function $m_a : U_i \to [0;1]$ (trapezoid, triangle, etc.. [7, 11, 13] built on the base of expert knowledge. The function m_a describes the measure of compatibility of an element $x_i \in U_i$ with the term a. Analogously, to each term $d \in D$ we assign a compatibility function $m_d : Y \to [0;1]$ describing the measure of compatibility of $y \in Y$ with the term d.

Determining linguistic terms and the corresponding compatibility functions for evaluating input and output variables is the first step (called the fuzzification) in constructing a fuzzy model of the investigated object, [20].

The next step is the creation of a database of fuzzy expert knowledge [9], [17]. Let for the function (1) we know N rules describing the relation between the inputs and outputs.

According to the modeling principle from [15] we suppose that:

$$N < |A_1| \cdot |A_2| \cdot \mathbf{K} \cdot |A_n|,$$

i.e., the quantity of experimental data is less than the total number $|A_1| \cdot |A_2| \cdot \mathbf{K} \cdot |A_n|$ of all possible combinations of terms of input variables. This information can be collected in the *knowledge database*, which is a table containing N rows of length $(n+2)$ each. The k - th row of the table has form:

$$a_{k1}, a_{k2}, ..., a_{kn}, w_k, d_k,$$

where: $a_{ki} \in A_i$, $d_k \in D$ and $w_k \in [0;1]$ is a real number expressing the certainty of an expert about the correspondence of the output term d_k to the input terms $a_{k1}, a_{k2}, ..., a_{kn}$. A typical knowledge table looks as follows.

Based on the knowledge table, for any fixed values $x^* = (x_1^*, x_2^*, ..., x_n^*)$ of the variables $x = (x_1, x_2, ..., x_n)$, we can calculate a compatibility function $l_{x^*}(d) : \mathrm{D} \to [0;1]$ by the formula:

$$l_{x^*}(d) = \max_{d_j = d} \left(w_j \cdot \min_{1 \le i \le n} m_{a_{ji}}(x_i^*) \right). \qquad (4)$$

Table 1. A typical knowledge table

No	Input variables						Weigh t	Output variable
	x_1	x_2	…	x_i	…	x_n		
1	a_{11}	a_{12}	…	a_{1i}	…	a_{1n}	w_1	d_1
2	a_{21}	a_{22}	…	a_{2i}	…	a_{2n}	w_2	d_2
…	…	…	…	…	…	…	…	…
N	a_{N1}	a_{N2}	…	a_{Ni}	…	a_{Nn}	w_N	d_N

Here we assume that $\max \varnothing = 0$.

Next, we use the function $l_{x^*}(d)$ to mix the compatibility functions $m_d : Y \to [0;1]$, $d \in D$, to produce the compatibility function $m : Y \to [0;1]$ for the accumulative output variable z:

$$m(z) = \max_{d \in D} \min \left(l_{x^*}(d), m_d(z) \right). \qquad (5)$$

To find the predicted value of the output variable y in the interval $[\underline{y}, \overline{y}]$, we can defuzzify the compatibility function $m : Y \to [0;1]$, e.g., by calculation its center of gravity :

$$y^* = \frac{\int_{\min}^{\max} z m(z) dz}{\int_{\min}^{\max} m(z) dz}, \qquad (6)$$

where: min and max are the left and right ends of the interval $[\underline{y}, \overline{y}]$ of the support of the fuzzy set of the output variable y.

We apply this scheme to the problem of predicting the value of unrealized goods of certain type of some trade firm selling preparates of chemical defense of plants at the end of some trade season.

An expert established that essential factors that influence on the goods rest Y are: x_1 (*"rest"*) – the rest from the previous trade season (in U.S. dollars); x_2 (*"new purchase"*) – the cost of new purchases (in U.S. dollars); x_3 (*"margin"*) – the average value of the trade margin (in percent); x_4 (*"term"*) – length sale of the product (the presence of the product on the market, in years). Universal set for the described variables defined as follows: $U_1 = [0;600000]$; $U_2 = [20000;1500000]$; $U_3 = [0;50]$; $U_4 = [0;10]$. Universal set for the predicted value coincides, obviously, with $Y = U_1$.

For each input and output variables we built term-sets:

$A_1 = \{"small","medium","large","critical"\} = \{S,M,L,C\}$,

$A_2 = \{"small","medium","large"\} = \{S,M,L\}$,

$A_3 = \{"small","medium","large"\} = \{S,M,L\}$,

$A_4 = \{"short","medium","long-term"\} = \{S,M,L\}$,

$D = \{"small","medium","large","critical"\} = \{S,M,L,C\}$.

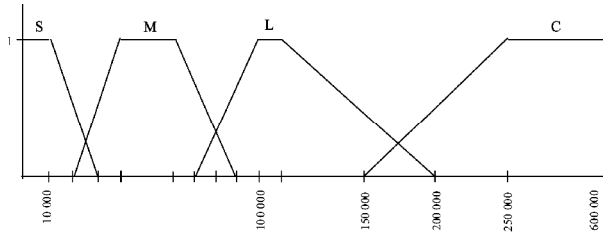

Fig. 1. The compatibility function of the linguistic variable “rest”

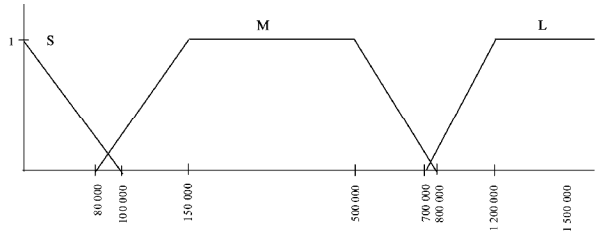

Fig. 3. The compatibility function of the linguistic variable ”new purchase"

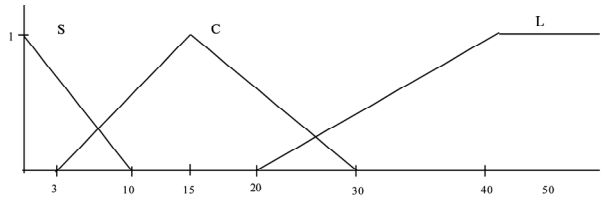

Fig. 2. The compatibility function of the linguistic variable "margin”

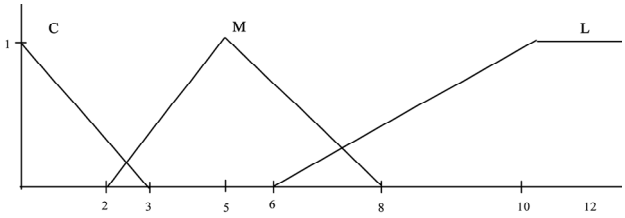

Fig. 4. The compatibility function of the linguistic variable "term"

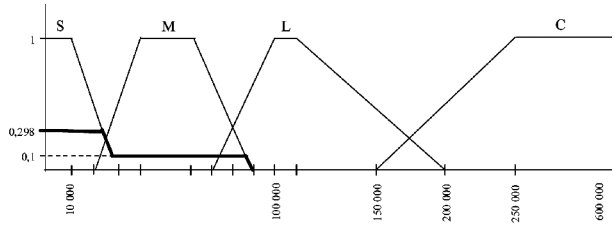

Fig. 5. The graph of the the compatibility function for the accumulative output variable

Table 1. The knowledge table

Number of input combinations (logical rules)	Input variable				weight	Output variable
	x_1	x_2	x_3	x_4	w	y
1	S	S	S	S	1	S
2	L	S	S	M	0,9	
3	L	S	S	L	1	
4	C	S	S	M	1	
5	S	S	L	L	0,7	
6	S	M	L	M	0,7	
7	M	S	M	M	0,8	
8	M	S	M	L	0,8	
9	M	M	M	M	0,7	
10	L	S	M	L	0,9	
11	L	S	L	L	0,5	
12	M	S	L	L	1	M
13	S	M	M	M	1	
14	S	L	L	M	0,8	
15	M	M	S	M	0,8	
16	M	L	S	L	0,7	
17	M	L	M	M	0,7	
18	L	M	M	M	0,7	L
19	L	M	M	L	0,5	
20	L	M	L	L	0,3	
21	C	M	L	L	0,8	
22	S	L	M	M	0,9	
23	S	L	M	S	1	
24	M	L	S	S	1	
25	M	L	M	L	0,8	
26	S	L	L	M	0,8	C
27	S	L	L	L	0,9	
28	M	L	L	M	0,9	
29	M	L	L	L	1	
30	L	L	L	L	1	

Based on the expert's opinion, we built the following compatibility functions for the terms of the input and output variables.

The next step is defining the knowledge table.

The following calculations are carried out for these commercial enterprises Season Sales 2013: $x_1^* = 80000$; $x_2^* = 36000$, $x_3^* = 22$, $x_4^* = 9$. In this case, the variable x_1^* refers to the terms "*medium*" (with compatibility function, $m(x) = 1 - \frac{1}{30000}(x - 60000)$, so $m(x_1^*) \approx 0,33$ or "*large*" (with compatibility function $m(x) = \frac{1}{30000}(x - 70000)$, so $m(x_1^*) \approx 0,33$; x_2^* refers to the term "small" (with compatibility function $m(x) = 1 - \frac{1}{100000}x$, so $m(x_2^*) = 0,64$); x_3^*- to the terms " *medium* " (with compatibility function $m(x) = 1 - \frac{1}{15}(x - 15)$, so $m(x_3^*) \approx 0,53$) or "*large*" (with compatibility function $m(x) = 1 - \frac{1}{20}(x - 20)$, so $m(x_3^*) \approx 0,1$); x_4^* – to the term "long-term" (with compatibility function $m(x) = \frac{1}{4}(x - 6)$, so $m(x_4^*) \approx 0,75$). Calculating $w_j \cdot \min\limits_{1 \le i \le n} m_{a_{ji}}(x_i^*)$ one can see that nonzero values occur only in the rows numbered by 8,10,11 (which corresponding to term S) and 12 (corresponding to term M).

Calculating the values $l_{x^*}(d)$ for: $d \in D = \{S, M, L, C\}$ using (4),

$$l_{x^*}(S) = \max\{0,8\min\{0,33;0,64;0,53;0,75\},$$
$$0,9\min\{0,33;0,64;0,53;0,75\},$$
$$0,5\min\{0,33;0,64;0,1;0,75\}\} =$$
$$= \max\{0,264;0,3;0,05\} = 0,3,$$

$$l_{x^*}(M) = \max\{\min\{0,33;0,64;0,1;0,75\}\} = 0,1,$$

$$l_{x^*}(\mathrm{L}) = 0; \quad l_{x^*}(\mathrm{C}) = 0.$$

The compatibility function (5) :

$$m(\mathrm{z}) = \max_{d \in D} \min\left(l_{x^*}(d), m_d(z)\right),$$

has the following form:

$$m(z) = \begin{cases} 0,3 \ , & if\ w \in (0;24000), \\ 1 - \frac{1}{20000}(z - 10000), & if\ z \in (24000;28000), \\ 0,1 \ , & if\ z \in (28000;87000), \\ 1 - \frac{1}{30000}(z - 60000), & if\ z \in (87000;90000). \end{cases}$$

The graph of the function $m(z)$ looks like (Fig. 5).

The precise value of the output variable y^* can be found as the result of defuzzification of $m(z)$ calculating its gravity center (6):

$$y^* = \frac{\int\limits_{Min}^{Max} zm(\mathrm{z})dz}{\int\limits_{Min}^{Max} m(\mathrm{z})dz},$$

$$\int\limits_{Min}^{Max} zm(\mathrm{z})dz = \int\limits_{0}^{24000} 0,3zdz +$$
$$+ \int\limits_{24000}^{28000} z\left(1 - \frac{1}{20000}(\mathrm{z} - 10000)\right)dz +$$
$$+ \int\limits_{28000}^{87000} 0,1zdz + \int\limits_{87000}^{90000} z\left(1 - \frac{1}{30000}(\mathrm{z} - 60000)\right)dz =$$
$$= 353865180,$$

$$\int\limits_{Min}^{Max} m(\mathrm{z})dz = \int\limits_{0}^{24000} 0,3dz + \int\limits_{24000}^{28000}\left(1 - \frac{1}{20000}(\mathrm{z} - 10000)\right)dz +$$
$$+ \int\limits_{28000}^{87000} 0,1dz + \int\limits_{87000}^{90000}\left(1 - \frac{1}{30000}(\mathrm{z} - 60000)\right)dz = 13588,5.$$

Finally, the predicted value of the goods rest equals $y^* = \frac{353865180}{13588,5} = 26041,5$, which is sufficiently close to the real rest of the goods, equal to 25200 dollars.

REMARK

The proposed method can be improved by modifying the weight coefficient in knowledge table (based on real observations) and adding new input variable and new dependences. However, for a large number of variables constructing the knowledge table become a difficult task because of the known psychological bound of human brain to keep at most 7 ± 2 notions simultaneously. In this case it is reasonable to organize the input variables into an embedded tree structure [13].

CONCLUSIONS

In the paper we suggested a mathematical model for predicting the value of goods rests based on fuzzy logic approach. Using the expert's knowledge table we constructed a compatibility function whose defuzzification yielded the value of the output parameters (equal to the predicted value of the goods rest)

This model is more open and clear then multifactor discriminant models because is based on the expressions in a natural language.

Using rules to make decisions in the fuzzy logic models allows to take into account expert's knowledge to avoid incorrect classification [4], [12],[16].

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Mathematical models for occupational injuries analysis at the enterprises of the state forestry committee of Ukraine

L. Tysovsky[1], V. Stepanyshyn[2]

[1] Institute of Engineering Mechanics, Automation and Computer-integrated Technologies,
Lviv National Forestry University of Ukraine: e-mail: tlo 10@ukr.net
[2] Institute of Power Engineering and Control Systems,
Lviv Polytechnic National University
79013, Lviv, Bandery st. 28, e-mail: vasyls65@ukr.net

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Abstract. The paper focuses on the mathematical models for the study of occupational injuries at the enterprises of the State Forestry Committee of Ukraine over a period of ten years. The major conditions and causes of the accidents have been indicated. The relationship between individual pairs of variables that influence occupational injuries has been determined on the basis of correlation and regression analysis. The correlation dependences of the frequency of occupational injuries on individual factors have been obtained. Using the methods of multifactor analysis, the relationship between the number of injuries and workers' occupations as well as types of works has been established. The results obtained can be used for enhancing the efficiency of safety measures at the enterprises of forestry with the aim of reducing the rate of injury.
Key words: occupational injuries, correlation and regression analysis, methods of multifactor analysis.

INTRODUCTION

Every year two million people die on the planet Earth because of accidents and occupational diseases [1]. Annually 270 million accidents and 160 million cases of occupational diseases are registered. According to the data provided by the WTO such situation causes a 4 % loss of the gross national product of the world economy. From what has been mentioned above it follows that the study of the causes, consequences and circumstances of occupational injuries and formation on the basis of their results a set of measures to prevent and reduce the rate of injuries in any area of human activity is the task of particular importance. Following the recommendations given by the UNO and the WTO, each state forms its regional systems of administering labour protection. Conceptual foundations of administering labour protection and the national development concept in the field of administering labour protection are considered in the papers [1, 2].

The analysis of domestic and foreign scientific literature indicates quite clear tendency towards increasing the number of publications concerning the analysis of the causes and consequences of occupational injuries. In the publication [3] in particular the analysis of the occupational injuries causes conducted by the State Supervision Committee on Labour Protection is provided. The statistics of the causes of injuries in the anti-fire protection departments is presented in the paper [4]. Besides it should be noted that there exist many sectors of the national economy of Ukraine (forestry in particular), in which comparative dynamics of injuries and the mechanisms of their increasing or decreasing are not investigated enough.

Setting the problem and identifying the main causes of injuries. The aim of the paper is to investigate the state of occupational injuries at the enterprises of the State Forestry Committee of Ukraine and to develop mathematical models of the state estimation of labour protection in the field of forestry in general and the risk of damaging people's health and the loss of working ability as a result of being injured at work in particular. In the article [5] the systematic analysis of the occupational injuries at the enterprises of the State Forestry Committee of Ukraine has been conducted. It is based on the annual state statistical observation form №7 RIW "Report on injuries at work (2000-2009). Besides the major causes and factors leading to the accidents have been singled out. The results of the statistical analysis are presented in Table 1.

Table 1. Statistical data on occupational injuries at the enterprises of the State Forestry Committee of Ukraine

Year	Number of injuries	With lethal outcome	Freq-uency coeff-icient	Number of the dead	Logging ths m^3	Total-expenses, hrv.	Expens es per person.	Number of workers	Total controls	Control per person.
2000	167	13	1,7	0,14	9559	3267337	34	95260	4747	14,2
2001	142	13	1,5	0,14	11026	7892286	83	94999	4984	14,9
2002	174	10	1,9	0,11	10153	8622998	95	91016	5358	16
2003	146	16	1,6	0,18	11048	10680591	119	89580	5894	17,6
2004	129	9	1,5	0,1	12117	13150914	149	88000	6696	20
2005	132	16	1,5	0,18	12094	15378119	177	87027	7661	23
2006	154	12	1,9	0,15	12747	17712303	221	80064	8156	25
2007	129	16	1,7	0,21	13403	22262021	297	74931	9411	28,1
2008	93	9	1,4	0,13	12393	22124869	330	67058	10336	30,7
2009	80	10	1,3	0,16	11475	22687737	374	60668	10399	31,1

Year	Occupations(positions)						Professional work experience				Types of works					
	Logger	Driver	Machine-tool operator	Hooker	Workman	Others	1-5 years	5-10 years	10-15 years	More than 15 years	Log-ging	Trans-porting	Low-storing	Wood-working	Repairing	Others
2000	58	35	33	18	9	14	77	35	22	33	56	34	18	31	15	13
2001	54	27	31	17	6	7	89	19	17	17	50	29	16	30	9	8
2002	59	31	33	19	13	19	90	34	21	29	59	33	18	41	15	8
2003	54	26	27	15	14	10	76	28	18	24	46	26	15	32	13	14
2004	44	25	23	13	9	15	62	29	17	21	44	20	12	36	6	11
2005	53	22	25	11	8	13	79	18	14	21	45	27	15	20	11	14
2006	57	29	26	14	13	15	96	25	16	17	55	32	17	18	13	19
2007	45	26	23	13	11	11	71	24	15	19	53	26	13	15	11	11
2008	25	19	10	10	16	13	58	13	10	12	39	21	10	10	7	6
2009	25	18	10	5	16	6	37	19	11	13	33	15	7	10	8	7

The analysis of the injuries dynamics during the period under investigation shows that the number of injuries has a wave-like character. It increases in 2000-2002, 2004-2006 and decreases in 2002-2004 and beginning since 2006. The recession in 2002-2004 is caused by the improvement of the normative base concerning safety measures at the national level in connection with the adoption of the Law of Ukraine "On Labour Protection" in a new wording. Also, the enterprises have begun to implement measures to fulfill the National Program of improving safety status, occupational health and working environment in 2001-2005, approved by the Resolution of the Cabinet of Ministers of Ukraine of October 10, 2001 № 1320.

From 2004 to 2006 under the condition of constant volume of logging and reducing the number of employees by 10% the occupational injuries were increasing including those with the lethal outcome. To some extent this can be explained by the emotional disturbance of society at that time.

And since 2006 we are noticing a gradual decreasing of occupational injuries and it is due to the arranging of the system of administering labour protection in forestry. In 2005 NRALP 02.0-1.04-05 "Rules for labour protection for the workers of forestry and forest industry" and NRALP 20.0-1.02-05 "Rules for labour protection in the woodworking industry" were developed. As a result they significantly increased financing of expenses on safety measures in general as well as financing per worker in particular. Besides the above mentioned, a number of additional measures to improve safety and reduce injuries at the industry enterprises had been conducted.

However, in spite of the measures taken at the enterprises injuries remain high. Also we should keep in mind the fact that human life is priceless.

Summing up the statistics mentioned above, it can be stated that every million cubic meters of wood harvested accounts for one human life and every seven hundred workers accounts for one accident at work. The major conditions that caused the occupational injuries at the enterprises of the State Forestry Committee of Ukraine are:

– in the process of logging operations: stalling trees, pruning branches, bucking wood whips, skidding and loading wood,

– in the process of transporting: transporting wood whips and assortments,

– in the process of low-stocking works: unloading and stacking wood,

– in the process of woodworking: cutting trees for their wood,

– in the process of ancillary works: metal-working, metal-forging, sharpening, welding, tire mounting works.

A detailed analysis of the impact of various factors (total work experience, seniority, profession, age of the

injured people, time of year and time of day) on the coefficient of frequency of injuries is provided in the publication [5]. However, it should be noted that the processing and compiling information about the causes of occupational injuries is not yet allowing the assessment of the conditions and labour protection and to give a preference to particular measures and means or use them in a complex. In order to achieve this you must have some quantitative indexes of risk or safety assessment at workplace. Thus, the need to develop a certain integral criterion that would assess the impact of all production factors (organizational, technical, psychological, subjective, etc.) and give an idea of the scope of the social and economic losses of the enterprise because of injuries and occupational diseases. Currently, more and more often a professional risk is being chosen in the role of such parameter. The foundations of this approach are considered in the papers [6-10], in which the methodology and the identification assessment examples of the professional risks at workplaces and in the whole industry are presented.

CALCULATION MODEL OF CORRELATION AND REGRESSION ANALYSIS

It is clear that the overwhelming majority of the causes of occupational injuries are of random (scholastic) nature and therefore it is reasonable to use the methods of mathematical statistics [11-14]. In this case the frequency coefficient of injuries can serve as an example of the use of risk as the probability of an adverse event. Under such circumstances it would be recommended to use the methods of correlation and regression analysis, which can establish the existence of a certain quantitative or functional relationship between two random variables and its density. Here are the basic dependences concerning this problem.

Suppose that two random values *x, y* after conducting *n* independent tests assume the value (x_1,y_1), (x_2,y_2),…, (x_n,y_n). Hence the existence of correlations between these values are found by means of the correlation coefficient r determined in the following manner:

$$r = \frac{\overline{xy} - \bar{x}\cdot\bar{y}}{s_x \cdot s_y}, \qquad (1)$$

where: $\overline{xy} = \frac{1}{n}\sum_{i=1}^{n} x_i y_i$ – the average value of the product of two correlated quantities,

$\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$, $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$ – the average values of these quantities,

$s_x = \sqrt{x^2 - (\bar{x})^2}$, $s_y = \sqrt{y^2 - (\bar{y})^2}$ – the average square (standard) deviations of the corresponding quantities,

$\overline{x^2} = \frac{1}{n}\sum_{i=1}^{n} x_i^2$, $\overline{y^2} = \frac{1}{n}\sum_{i=1}^{n} y_i^2$ – the average value of the squares of the correlated quantities.

Let us notice that in the given case s^2 is the variance of a random quantity (measure of variance).

The correlation coefficient r is a characteristic of density connection between the investigated quantities and it changes within the range of $-1 \le r \le 1$. In case that $r=0$, there is no correlative connection between two random quantities, thus they are independent. In case that $r=\pm 1$, we observe linear functional connection between two random quantities. The direct connection exists when *r* obtains positive values, it means that with the increasing of the independent variable *x* the dependent random quantity y increases too. If r has negative values we observe reciprocal connection, thus with the increasing of the independent variable x the dependent random quantity y decreases.

If the independent variable X – factor causing occupational injuries, and Y – frequency coefficient of injuries, then there exists a certain functional relationship for non-zero correlation coefficients between these values Y = f(X). It is the most advisable to present this relationship as a polynomial of the fourth order, i.e:

$$y = f(x) = a_o + a_1 x + a_2 x^2 + a_3 x^3 + a_4 x^4 \cdot \qquad (2)$$

Polynomial coefficients a_i (i = 0,4) are determined by means of the method of least squares. Its essence is that the most likely value of parameters gives the minimum function:

$$S = \sum_{i=1}^{n} \left[y_i - f(x_i, a_o, a_1, a_2, a_3, a_4) \right]^2. \qquad (3)$$

Under the necessary condition of the minimum functions of several variables:

$$\frac{\partial S}{\partial a_o} = 0; \frac{\partial S}{\partial a_1} = 0; \frac{\partial S}{\partial a_2} = 0; \frac{\partial S}{\partial a_3} = 0; \frac{\partial S}{\partial a_4} = 0 \cdot \qquad (4)$$

to determine five unknown coefficients of the polynomial a_i (i = 0,4) we obtain a system of five linear algebraic equations:

$$\begin{cases} a_o n + a_1 \sum_{i=1}^{n} x_i + a_2 \sum_{i=1}^{n} x_i^2 + a_3 \sum_{i=1}^{n} x_i^3 + a_4 \sum_{i=1}^{n} x_i^4 = \sum_{i=1}^{n} y_i, \\ a_o \sum_{i=1}^{n} x_i + a_1 \sum_{i=1}^{n} x_i^2 + a_2 \sum_{i=1}^{n} x_i^3 + a_3 \sum_{i=1}^{n} x_i^4 + a_4 \sum_{i=1}^{n} x_i^5 = \sum_{i=1}^{n} x_i y_i, \\ a_o \sum_{i=1}^{n} x_i^2 + a_1 \sum_{i=1}^{n} x_i^3 + a_2 \sum_{i=1}^{n} x_i^4 + a_3 \sum_{i=1}^{n} x_i^5 + a_4 \sum_{i=1}^{n} x_i^6 = \sum_{i=1}^{n} x_i^2 y_i, \\ a_o \sum_{i=1}^{n} x_i^3 + a_1 \sum_{i=1}^{n} x_i^4 + a_2 \sum_{i=1}^{n} x_i^5 + a_3 \sum_{i=1}^{n} x_i^6 + a_4 \sum_{i=1}^{n} x_i^7 = \sum_{i=1}^{n} x_i^3 y_i, \\ a_o \sum_{i=1}^{n} x_i^4 + a_1 \sum_{i=1}^{n} x_i^5 + a_2 \sum_{i=1}^{n} x_i^6 + a_3 \sum_{i=1}^{n} x_i^7 + a_4 \sum_{i=1}^{n} x_i^8 = \sum_{i=1}^{n} x_i^4 y_i. \end{cases} \qquad (5)$$

Having solved the received system of equations, we obtain estimates a_i (i = 0,4) of the coefficients of approximating polynomial (2). In the publication [15] the expressions for the variance of all investigated values and confidence intervals for the coefficients of the interpolating polynomial are provided.

CALCULATION MODEL OF MULTIFAKTOR ANALYSIS

In practice, it often happens that one determining factor depends on several different factors, among which you can not set a clear connection. In this case it is advisable on the basis of the methods of multifactor correlation and regression analysis [16-20] to develop a mathematical model of the process or phenomenon, which would give an opportunity to assess the degree of influence on each studying resulting figure entered into the model of factors.

The construction of multifactor regression models presupposes the following steps:

1. Selecting all possible factors influencing the rate (or process) under investigation. If it impossible to determine the quantity of some factors or their statistics is not available, they are eliminated from further consideration.

2. Choosing a form of regression or multifactor model which consists in finding such an analytical expression which would best reflect the link between factor characteristics with the resultant one, i.e. the choice of function:

$$\hat{Y} = f(X_1,X_2,X_3,\dots,X_n), \qquad (6)$$

where: $\hat{Y}$ – resultant variable function, $X_1,X_2,X_3,\dots,X_n$ – factor variables.

An important issue in this case is the choice of the analytical form for the function f, which links existing factors with the resultant variable function. This function better than the others reflects the real relationships between the studied parameters and factors. Empirical study of such functions using a graphical analysis of relationships for multifactor models is unsuitable. Suppose that any function of many variables can be reduced to a linear form by logarithm or change of variables, then in practice the multiple regression equation assumes the linear form:

$$\hat{Y} = a_0 + a_1X_1 + a_2X_2 + \dots + a_nX_n, \qquad (7)$$

where: $a_0,a_1,\dots,a_n$– equation parameters to be determined.

If for each factor, including the resultant variable the values of n are known $\hat{Y}_j,X_{1j},X_{2j},\dots,X_{nj}$, j=1,2,…,m then using the standard procedure of the least squares method to estimate the parameters of regression equations we obtain a system of linear algebraic equations:

$$\begin{cases} a_o m + a_1\sum_{j=1}^{m} x_{1j} + a_2\sum_{j=1}^{m} x_{2j} + \dots + a_n\sum_{j=1}^{m} x_{nj} = \sum_{j=1}^{m} y_j, \\ a_o\sum_{j=1}^{m} x_{1j} + a_1\sum_{j=1}^{m} x_{1j}^2 + a_2\sum_{j=1}^{m} x_{1j}x_{2j} + \dots + a_n\sum_{j=1}^{m} x_{1j}x_{nj} = \sum_{j=1}^{m} x_{1j}y_j, \\ \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots\dots \\ a_o\sum_{j=1}^{m} x_{nj} + a_1\sum_{j=1}^{m} x_{nj}x_{1j} + a_2\sum_{j=1}^{m} x_{nj}x_{2j} + \dots + a_n\sum_{j=1}^{m} x_{nj}^2 = \sum_{j=1}^{m} x_{nj}y_j. \end{cases} \qquad (8)$$

The received system of n +1 equations with n +1 unknowns $a_0,a_1,\dots,a_n$ can be solved by linear algebra. For a large number of equations it is recommended to use the Gauss' method of main element choice [21] the procedure of which is well algorithmizated. Since the matrix of this system of linear algebraic equations is symmetric , there is always a solution, and the only one. If the number of equations is small, it can be successfully used for solving the reciprocal matrix method [22].

3. Checking the adequacy of the received model. You must calculate:

– the remains of the model, i.e. the differences between the observed and calculated values:

$$u_i=y_i-\hat{y}_i=y_i-(a_0+a_1X_{1i}+a_2X_{2i}+\dots+a_nX_{ni}), \quad i=1,2,\dots,m, \qquad (9)$$

– relative error of the remains and its average value:

$$\delta_i=\frac{u_i}{y_i}\cdot 100\%, \qquad \delta=\frac{\sum_{i=1}^{m} d_i}{m}, \qquad (10)$$

– the average error variance of disturbances:

$$\sigma_u=\sqrt{\frac{\sum_{i=1}^{m} u_i^2}{m-n-1}}, \qquad (11)$$

– coefficient of determination:

$$R^2=1-\frac{\sum_{i=1}^{m} u_i^2}{\sum_{i=1}^{m}(y_i-\bar{y})^2}, \qquad (12)$$

– multiple correlation coefficient R, which is the main indicator of the density correlation of the generalized index with the factors:

$$R=\sqrt{1-\frac{\sum_{i=1}^{m}(y_i-\hat{y}_i)^2}{\sum_{i=1}^{m}(y_i-\bar{y})^2}}. \qquad (13)$$

If the value of R is close to 1, the relationship between the indicator and the factors is considered to be dense. Multiple correlation coefficient R is the main characteristic of the density of the relationship between the resultant variable and the set of factor variables . Note that we consider the correlation coefficient in the cases when the regression equation is a linear function. In the case of a nonlinear regression function the concept of correlation ratio is introduced, which is given by the same equation, but characterizes the degree of approximation of the regression equation to the data of observation.

In some cases in the course of the study of multifactor processes it is recommended to investigate in advance the degree connection between individual factors in pairs. If all paired connections are close to an average linear, then there is every reason to believe that the multiple connection is linear too. To determine the density of the link between two of the factors under

investigation (excluding their interaction with other variables) paired correlation coefficients are used. The method of calculation of these coefficients and their interpretation is similar to the one used for calculating the linear correlation coefficient for the case of one-factor connection. However, in the real world all values are usually interrelated. The density of such a relationship is determined by partial correlation coefficients that characterize the extent and impact of one of the arguments on the function, provided that the other independent variables remain constant. Depending on the number of variables whose influence is excluded, the partial correlation coefficients can be of a different order: with the exclusion of the influence of one variable we obtain a partial correlation coefficient of the first order, with the exclusion of the influence of two variables – the second order, etc. However, as a rule, the pair correlation coefficient between the function and the argument is not equal to the corresponding partial coefficient.

Expressions for calculating the correlation coefficients of arbitrary order are provided in the paper [23].

4. Verifying the statistical significance of the obtained results:

– checking the adequacy of the model as a whole: but check the original hypothesis H_o: all coefficients of the multiple regression equation (7) are equal to zero:

$$a_i=0 \qquad (i=1,2,\ldots,n).$$

For alternative H_i exists at least one coefficient ai which is non – zero.

Verification is performed by means of Fisher's statistics n and m-n-1 degrees of freedom:

$$F= F=\frac{R^2}{1-R^2}\frac{m-n-1}{n}, \qquad (14)$$

where: n – the number of factors included in the model, m – total number of observations, R – coefficient of multiple correlation.

Using the Fisher's tables we find critical value F_{kr} of n and m–n–1 degrees of freedom, setting in advance the confidence level (1–α) 100%. If $F> F_{kr}$, then a built model is adequate. If the model is inadequate, it is necessary to return to the stage of model building and probably introduce additional factors or switch to a non-linear model.

– verifying the significance of the coefficient of multiple correlation R.

Check the performance of the null hypothesis H_o: R=0 by means of t–statistics:

$$t=\frac{R\sqrt{m-n-1}}{\sqrt{1-R^2}}. \qquad (15)$$

The calculated value of statistics is compared with the tabulated one t_{tabl} (α/ 2; m–n–1), were α – chosen level of significance , m–n–1 – the number of degrees of freedom. If $| t |> t_{tabl}$ it is possible to conclude about the reliability of the correlation coefficient.

– calculation and interpretation of regression parameters dependence.

The regression equation being known one can not determine which of factors most affect the resultant variable, since in most cases the coefficients of the regression equation have different dimensions and therefore are not comparable. On this basis one can not determine which of the factor variables has the greatest scope for changing the effective rate, because the regression coefficients do not take into account the variation factor variable.

In order to identify comparative connection and influence of individual factors and the provisions they contain, calculate the partial elasticity coefficients ε, and β (beta) and (delta) – coefficients [23].

Partial elasticity coefficient indicates the average percentage by which the resultant variable with the factor shift by 1% for the fixed values of other parameters is changed.

β– coefficient (standardized regression coefficient) is used to determine the factors that have the greatest scope for improving the resultant variable.

Δ– coefficient shows the share of contribution of the factor under consideration into the total effect of all selected factors.

Notice that increasing the number of factors that are introduced in the multiple regression model allows you to determine additional resources of the resulting variable.

ANALYSIS OF OCCUPATIONAL INJURIES AT THE ENTERPRISES OF THE STATE FORESTRY COMMITTEE OF UKRAINE

Using the above described mathematical tools of statistical modeling and modern tools of Microsoft Excel spreadsheet [24-26] the analysis of occupational injuries at the enterprises of the State Forestry Committee of Ukraine has been conducted.

The methods of one-factor correlation and regression analysis were mainly employed to investigate the relationship between injuries frequency coefficient (including those with the lethal outcome) and the main factors that determine the state of injury in the field, namely: the volume of harvested wood, the costs of labor protection per worker and the number of inspections, surveys (prescriptions) per worker in labour protection.

As an example the relationship between the frequency coefficient of occupational injuries and costs per worker was analyzed. The correlation coefficients in this case are quite small (0,439 – for general injuries, 0,3298 – injuries with the lethal outcome), indicating the absence of a linear relation between the studied variables. It is shown that in the considered case it is recommended to present the correlation curve in the form of a polynomial of fourth order (Fig. 1, 2).

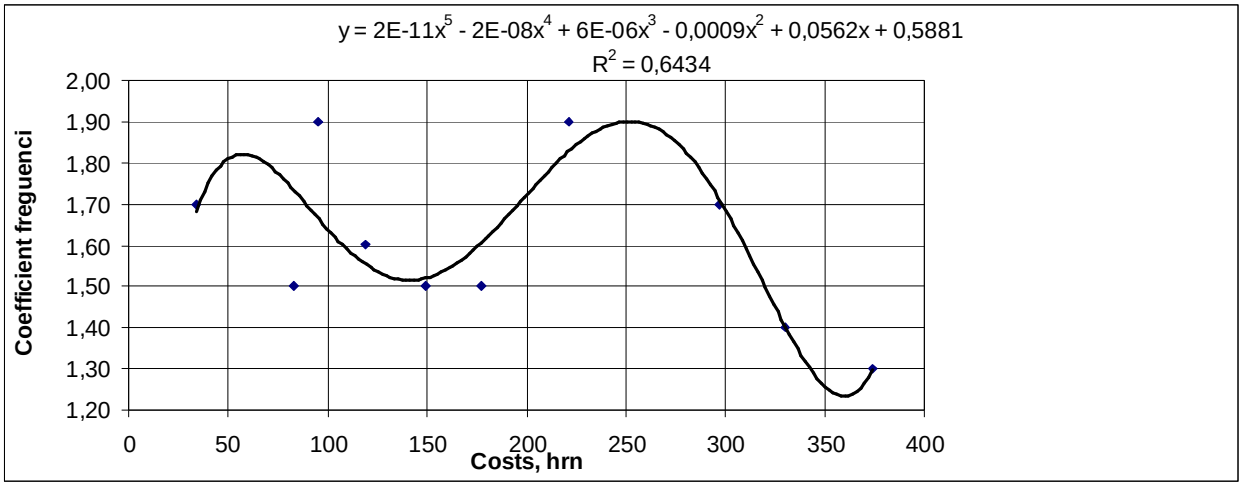

Fig. 1. Dependence of the frequency coefficient of injuries on the costs spent per worker

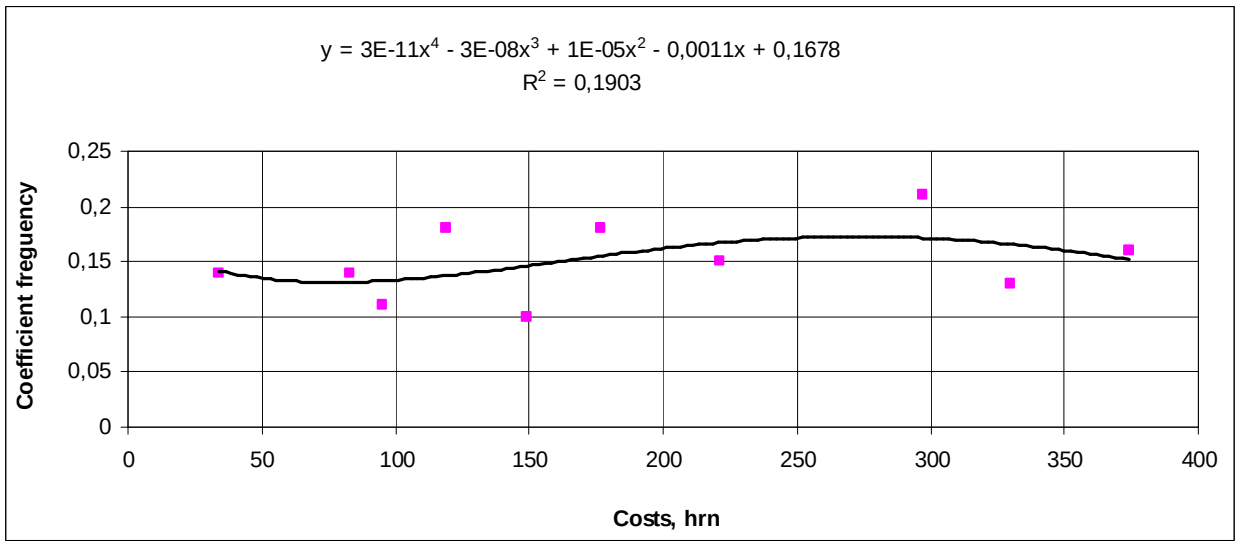

Fig. 2. Dependence of the frequency coefficient of injuries with the lethal outcome on the costs spent per worker

The dependence of the frequency coefficient of injuries on the amount of the harvested wood and the number of inspections, surveys (prescriptions) per specialist in labour protection were also investigated.

It is obvious that in real production environment the level of injuries rarely depends on one cause. In this case it is recommended to use the methods of multifactor correlation and regression analysis, which allow us to estimate the degree of influence on the studied resultant figure of each entered into the model factors with the fixed position of other factors at the average level.

Suppose that the most dangerous types of works in the forest industry are logging (X_1), transporting (X_2), low-stocking (X_3), wood-working (X_4), repairing (X5) and all other types of works (X_6), and as the resulting factor $\hat{Y}$ select the number of injuries during the corresponding year, then using the standard procedure of multifactor correlation and regression analysis, in the result of solving a system of linear algebraic equations (8) we obtain:

$$\hat{Y}=3,39195+1,38970X_1-2,5822X_2+7,3267X_3+ +0,4474X_4+1,6863X_5+0,0022X_6. \quad (16)$$

Confidence intervals for the coefficients of the regression equation for the reliability level of 50% in the considered case are the following:

$$-33,0553<a_0<39,8392,\ 1,2824<a_1<1,4970,$$
$$-4,0536<a_2<-1,1108,\ 3,8679<a_3<10,7855,$$
$$0,4181<a_4<0.4766,\ 1,4337<a_5<1,9389,\ 0,0017<a_6<0,0028.$$

Multiple correlation coefficient R=0,99835 is close to one, indicating the density of the relationship between the studied variables. Notice that the proposed model is generally adequate, as calculated statistics of Fisher F=150,8636, and the nearest value of Fisher's statistics with a level of reliability of 95% and degrees of freedom 6 and 3:

$$F_{0\,95}\,(6,3) = 8,94. \quad (17)$$

In the paper [27] a detailed statistical analysis of the proposed model has been conducted:

– the matrix of paired correlation coefficients allowing to determine the density of the link between the

two studied factors (excluding their interaction with other factors) is provided;

– it is shown, that all coefficients of multiple regression equation with the reliability level of 0,5 are significant and with the reliability level of 0,95 significant are only the coefficients a_1 , a_3;

– partial elasticity coefficients ε have been calculated, and on this basis according to the model (8) the greatest number of injuries (Y) at the enterprises of forestry causes such types of works as: low-stocking (X_3), transporting (X_2) and logging (X_1);

– standardized regression coefficients β have been defined, and on this basis it was found out that the greatest amount of scope for improving the resulting rate have the following types of works: low-stocking (X_3), transporting (X_2) and logging (X_1);

– Δ – coefficients also confirm that the greatest influence on the resultant variable have the factors X_3, X_2, X_1.

If in the role of the independent variables we choose the working occupations: logger (X_{11}), driver (X_{12}) , machine(-tool) operator (X_{13}), hooker (X_{14}), master (X_{15}) and others (X_{16}), then the multiple regression equation (Y – number of injuries) assumes the form:

$$Y=-77,7392+2,0578X_{11}+2,9519\ X_{12}-0,5517\ X_{13}+ + 0,7870X_{14}+3,0449X_{15}+0,5112X_{16}. \quad (18)$$

CONCLUSIONS

The main results obtained in the paper:

1. Occupational injuries at the enterprises of the State Forestry Committee of Ukraine over a period of 10 years (2000-2009) have been analyzed and the main causes, consequences and factors of the injuries have been found out.

2. Using correlation and regression analysis and multifactor analysis the models for the study of functional connection between individual pairs of factors affecting the rate of occupational injuries and the influence of individual factors on injuries frequency coefficients have been developed. The level of significance of each parameter has been defined.

3. On the basis of the constructed mathematical models the state of occupational injuries in the field of forestry has been analyzed. Quantitative estimates of its main causes and factors have been obtained.

4. The developed methods will form the basis for the development of the system of administering labour protection [28, 29] in the field of forestry with the aim to reduce the occupational risks to the minimum.

All developed methods and calculation models are of general nature and can be used to determine the rate of occupational injuries not only at the enterprises of forestry.

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Experimental research on the influence of the production quality of tooth operation surfaces of cylindrical gearwheels and torque on a gear oscillation amplitude

O. Vasyljeva[1], I. Kuzio[2]

[1] Department of exploitation of transport vehicles and fire-rescue technique,
Lviv state University of Life Safety
[2] Department of Mechanics and Mechanical Engineering Automation,
Lviv Polytechnic National University,
79007 Lviv, Kleparivska str., 35, e-mail: Vassabi13@ukr.net

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Abstract. For carrying out experimental research a proving stand with closed power flow was designed. For the determination of oscillation process parameters (amplitude and frequency) the devices with input signals from strain sensors were used. Planning the experimental research and mathematical treatment of the results obtained was performed with the use of a full factorial experiment. The results of the experiment allowed for obtaining a nonlinear mathematical model for determining the oscillation amplitude and the amplitude-frequency characteristic of gear box oscillations (first harmonic). It then is used for determining the harmonic of the oscillating process caused by the inaccuracy of a tooth operating profile, which influences the smoothness of gear operation. The dependences taking into account internal and external dynamic loads from oscillating processes during the calculations of teeth gear hardness were obtained.
Key words: proving stand, oscillating processes, measuring equipment, full factorial experiment, amplitude-frequency characteristic.

SETTING THE TASK

During the operation process of the tooth gear, dynamic phenomena appear in its mechanical system, that considerably influence the operational characteristics of driving and other constituent elements of a tooth gear transferring relevant torque. Appearing at the process of rotary axis motion, dynamic phenomena cause oscillating processes in a mechanical system. These processes influence the operational characteristics of the structure. The main factor causing oscillations in the tooth gears is the inaccuracy of production of tooth gears, shafts, bearings, boxes, assembly imprecision etc.

The force oscillating frequency in the process of transferring tooth gear torque at some operation speed can coincide with the natural frequency of a whole system. In this case resonant phenomena emerge that quite often lead to the failure of mechanical system units. But in scientific and technical literature the sufficient analysis of these phenomena hasn't been provided, particularly concerning their effect on the smoothness of tooth gear operation. Therefore, there occurs a need to carry out experimental research on these phenomena using a proving stand and to reveal the amplitude-frequency characteristic of the oscillating the tooth gear greatly depending on the inaccuracy of the tooth operating profile of tooth gearwheels. In addition, while solving this problem, it is necessary to compare the results obtained in practice with the results of theoretical research and to choose optimal parameters for using them in the computations of contact fatigue of tooth gears (namely, of tooth active faces and their bending fatigue).

ANALYSIS OF RECENT ACHIEVEMENTS AND PUBLICATIONS

The examples of the first research in the field of dynamics of reductor tooth gears were shown in the works of such scientists, as A.I. Petrusevych [1, 2] and such foreign authors, as Niman H. and Rettig H. [3].

Existing techniques of investigating the dynamical processes of reductor tooth gears in most cases concern involute gear systems. In [4] the tooth gear oscillations are considered, including high-speed gear pairs, parallel shaft gear units, planetary gearboxes. For each of these groups, dynamical mathematical models in the form of differential equations are given, with instructions on how to investigate them with the help of a computer and with examples of calculating tooth gear external and internal oscillation frequencies. The parameters of the dynamic models and damping forces are shown. In addition, the methods of reducing tooth gear vibration activity at the expense of lowering excitation forces, vibration isolation and avoiding resonant modes are considered. The theoretical part of this work is well elaborated, but such issues of engineering methodology, as determining the influence of dynamical processes on the change of forces and torques, are not considered here.

In [5-8] research on tooth kinematics and dynamics is considered, showing the beat pattern of wheel advance angle in the case of shaft misalignment or shaft obliquity. The analysis of drive operation enabled to draw a conclusion that when the advance angle is positive, it causes radial runout, and when the advance angle is negative, it causes axial runout. A.I. Petrusevych suggested a technique for determining an impact force for the involute gears. The development of tooth gears considering the influence of dynamical forces, including impact ones, is a quite difficult task, because the values and patterns of the change of the dynamic load are influenced by numerous factors. So, the investigation of oscillating processes in the teeth gears of reductors is the important task of the machine-building industry.

The aim of the work is to develop the method of the determining the amplitude-frequency characteristic of tooth gearwheel oscillations, conditioned by the inaccuracy of tooth operating profile, its surface roughness and the torque value on the basis of the result of the research done. Another method is to be determined for taking into consideration the dynamical phenomena of the oscillating process during the calculation of the contact fatigue of tooth gears (namely, of tooth active faces) and their bending fatigue.

SOLVING THE SET TASK

For investigating the oscillating processes the proving stand with closed power flow was designed and constructed [6]. The kinematic diagram of the stand is shown in the Fig.1, and its general view is shown in Fig.2.

The main units of this stand (Fig.1) are reductors 1 and 2, which contain testing tooth gearwheels z_1 and z_2, which form a testing reductor, and gearwheels z_3 and z_4 form a closing reductor. Tooth gearwheels z_1 and z_3 are connected together by a shaft 6 with the help of rigid flange couplings 5, and gearwheels z_2 and z_4 are connected together by the shaft 7 with cardan joints. The reductors are operated by a drive from an electric motor *D* with the help of a pin flexible coupling.

The reductor 1 is fixed on a mattress, and the reductor 2 is mounted on the bearings and two supports 8. Supports 8 are also fixed on the mattress. Loading gearwheels is realized by the principle of closed power flow when the redactor 2 is loaded by the moment *M=FL* (*L* = 650 mm), which is created by a lever 4 with a weight 3.

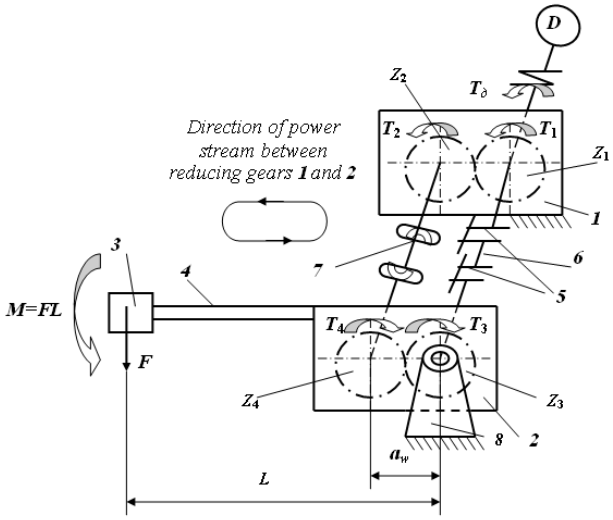

Fig. 1.Kinematic diagram of the testing stand with closed power flow

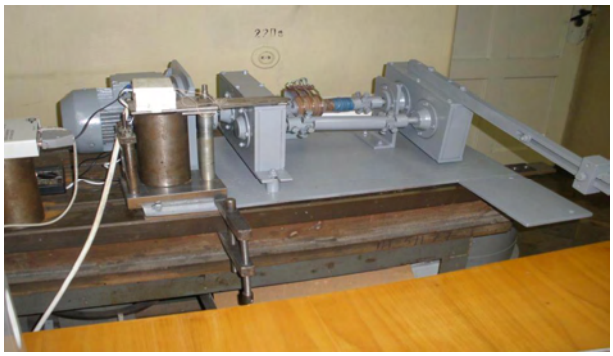

Fig. 2. Testing stand

Tooth gearwheels are loaded by the moment *M=FL*, namely:

$$T_3 = \frac{M}{\left(1+\frac{z_4}{z_3}\frac{1}{h_{34}}\right)h_{12}h_{34}},$$

$$T_4 = \frac{M}{1+\frac{z_3}{z_4}h_{34}},$$

$$T_1 = T_3 h_5; \quad T_2 = T_4 h_7,$$

$$T_д = \frac{M(1-h_{12}h_{34})}{\left(1+\frac{z_4}{z_3}\frac{1}{h_{34}}\right)h_{12}h_{34}},$$

where: $h_{12.}, h_{34}$ – are efficiency factors between the tooth gearwheels of relevant gears; η_5 is the efficiency factor of the rigid flange couplings 5; η_7 – is the efficiency factor of the cardan drive 7.

Rotary motion of the tooth gearwheels is realized by the asynchronous generator A32-4 (*D*) with nominal power P_o =1 kW and rotational speed n_o = 1410 min^{-1}. Its power is used only for overcoming frictional forces at toothing and in couplings.

While developing the research techniques for carrying out the research on the testing stand, the main attention was paid on following questions.

Firstly it is necessary to determine the influence of the ridge tip height Δ on the tooth operating surface of the driving wheel z_1 (profile error), conditioned by the gear milling technology with the use of hob cutters with a certain tooth number z_ϕ according to its additional angular motion, by a value $\Delta\varphi = f(\Delta)$ in the range 0,00005…0,0004 rad.

Such angular error corresponds to the error of the tooth profile f_{fr} of the wheel in accordance with the state standard GOST 1643-81 from 21,7% to 86,9% of the tolerance band, that is, from wheel accuracy level 6 to 8 at different meanings of the torques T_1 and T_2, which are determined by the moment $M = FL$. In addition, the surface roughness of the tooth operating profile R_a also influences the oscillation processes in the tooth gearwheel.

For determining T_1 on the shaft 6 (Fig.1) four tension sensors were glued on between tooth gearwheels z_1 and z_3 of the right and left redactor. They were stuck at the angle of 45^0. Two of them (R_1 and R_3) were directed right-hand, and another pair (R_2 and R_4) – left-hand, all being connected into a half-bridge circuit. The half-bridge circuit, then, was connected to a strain gauge installation "УТ-4" with the help of a current-collector. The signal from the strain gauge installation was input to microammeters, used for fine balancing of the bridge circuit together with the strain gauge installation. The microammeters were connected directly to the analog-to-digital converter USB300.

For obtaining, processing and storing the results of measurements in a PC, software «PowerGraph» was used.

For determining a value T_1 the calibration of values T_1 was made by the deflection of a cursor, caused by the loading force *F*, that is, by the moment *M*. Loading was performed using mass 3, fixed on the lever 4 (Fig.1). Then a force $F = mg$, N (where *m* is the loading mass, kg; *g* is free fall acceleration, m/s^2). For creating the loading moment M = 150 Nm, the mass m = 23,5 kg ($M = FL$ = 23,5·9,81·0,65 = 150 Nm) was used. At this load the cursor deflected by 40 mm.

For determining the parameters of the oscillating process (amplitude and frequency), the beam of uniform strength was used, with tension sensors being glued on the beam and connected into a bridge circuit. A signal from the bridge circuit was input to an amplifier and then to a recorder, to the ADC USB300 and the computer. A computer active window is shown in Fig.3.

The beam of uniform strength is fixed on the support, which is connected with the mattress. For determining the parameters of the oscillating process (the amplitude-frequency characteristic) the beam of uniform strength, fixed on the support, was connected to a gear box mounted rigidly on the mattress.

The full factorial experiment (FFE) was used for planning the experimental research and mathematical processing of the results obtained [11-13]. The task is set to determine the influence of the error of the tooth operating profile $\Delta\varphi$, the roughness of the tooth operating surface R_a and torque T_1, which is spent for overcoming the useful load, on the oscillation amplitude value *a*. The tests were performed with the use of spurs $b = 0^0$, produced of steel 40X and a module m_n = 4 mm with a number of teeth $z_1 = z_3 = 30$ i $z_2 = z_4 = 30$ ($a_t = 20^0$) and a gear face b = 20 mm. Tooth gearwheels after thermal treatment (improvement) had hardness values as follows: for a driving wheel HB_1 = 245…280; for a driven one HB_2 = 215…235. The gearwheel teeth were toothed using hobbing cutters m_n = 4 mm made of quick-cutting steel P6M5 with a grade of accuracy AA and a number of teeth z_ϕ = 6…10.

The axle spacing of the reductors of the testing stand is a_w = 120 mm, and gear ratio u = 1. During the period of investigations the lubrication of the reductor tooth gearwheels on the testing stand was done using a lubricant CT – 20, being considered the most effective one [14, 15].

The relationship between the amplitude *a* and the factors influencing its value can be shown in such a way:

$$a = C_a \Delta j^{\,n} R_a^m T_1^p , \qquad (1)$$

where: C_a – is a proportionality constant; *n, m, p* are unknown power exponents.

The dependence (1) is non-linear according to the factors included. For passing to a linear dependence the logarithm of it should be found, and it gets a form:

$$\ln a = \ln C_a + n \ln \Delta f + m \ln R_a + p \ln T_1 .$$

Let us introduce a following notation:

$\ln a = y$; $\ln C_a = b_0$; $n = b_1$; $\Delta\varphi = x_1$; $m = b_2$; $R_a = x_2$; $p = b_3$; $T_1 = x_3$.

Then we obtain:

$$y = b_0 + b_1 \ln x_1 + b_2 \ln x_2 + b_3 \ln x_3 . \qquad (2)$$

The equation (2) is a postulated empirical model of the amplitude dependence on factors influencing its value. For determining the proportionality constant and power exponents let us use the FFE of a 2^3 type.

The levels of the change of the factors influencing the value of the oscillation amplitude are given in the Table 1.

For the reproducibility of measurements, let us set the number of repeated tests r = 2. The conditions of the experimental research and the results obtained are given in the Table 2.

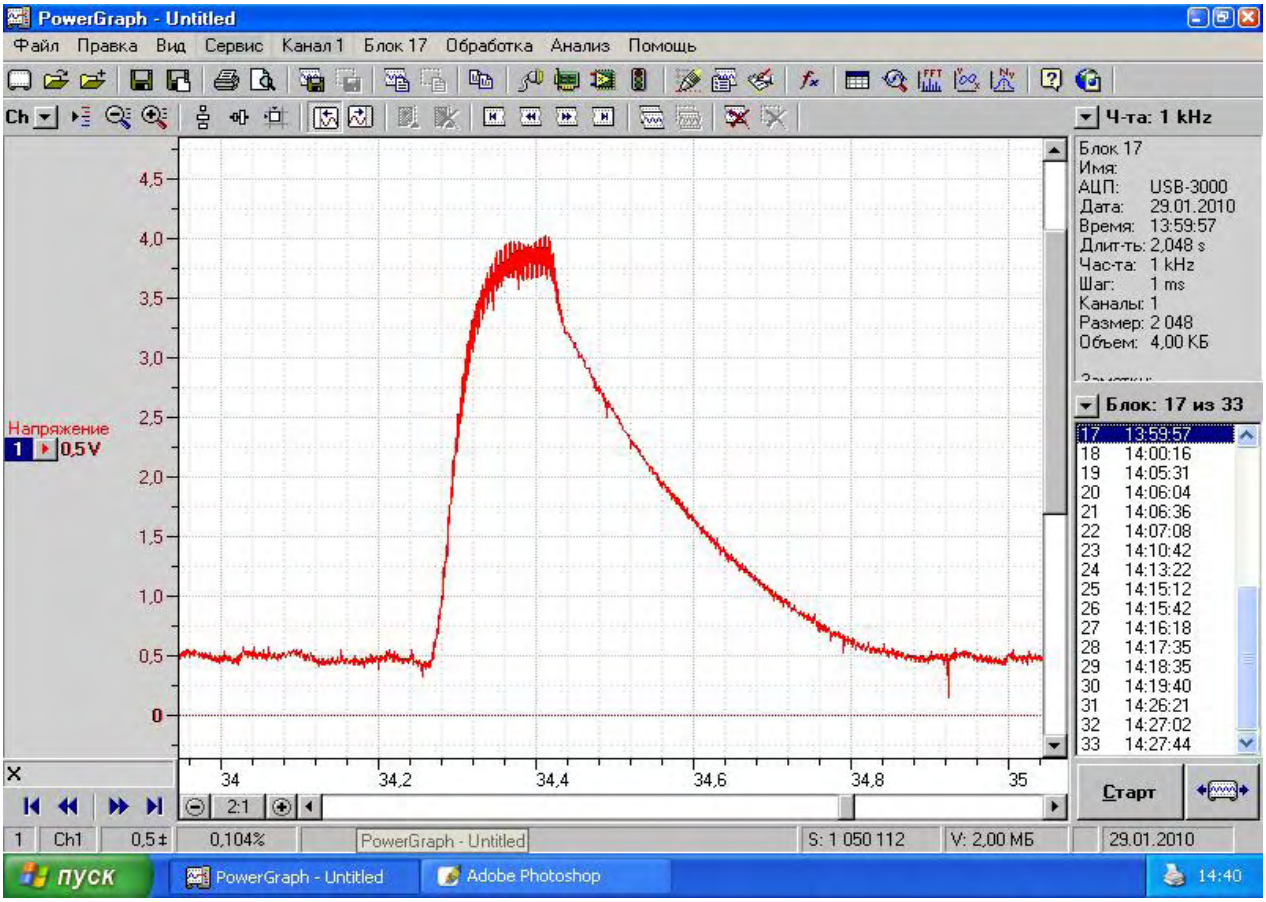

Fig. 3. Computer active window of the calibration process

Table 1. Factor changing levels

Factor levels	$\Delta\varphi$, rad		R_a, μm		T_1, N·m	
	χ_1	$\ln \chi_1$	χ_2	$\ln \chi_2$	χ_3	$\ln \chi_3$
Upper level (+)	0,0004	-7,82	3,2	1,16	150	5,01
Zero (0)	0,000225	–	1,9	–	100	–
Lower level (–)	0,00005	-9,9	0,63	-0,46	50	3,91

Table 2. Conditions and results of the tests

Test	x_1		x_2		x_3		First test a_1, μm	Second test a_2, μm	Average value $\bar{a}$, μm	$\ln \bar{a}$
	Код	$\Delta\varphi$, rad	Код	R_a, μm	Код	T_1, N·m				
1	+	0,0004	+	3,2	+	150	10	9	9,5	2,25
2	–	0,00005	+	3,2	+	150	8	9	8,5	2,14
3	+	0,0004	–	0,63	+	150	9	8	8,5	2,14
4	–	0,00005	–	0,63	+	150	7	8	7,5	2,01
5	+	0,0004	+	3,2	–	50	13	14	13,5	2,60
6	–	0,00005	+	3,2	–	50	12	11	11,5	2,44
7	+	0,0004	–	0,63	–	50	12	13	12,5	2,53
8	–	0,00005	–	0,63	–	50	11	10	10,5	2,35

During the process of testing the oscillation processes of the system related to the error of the tooth operating profile $\Delta\varphi$, the roughness of the tooth operating surface R_a and torque T_1 were recorded. They were recorded as oscillograms, which are shown in Fig.4 and Fig.5. The amplitude of the system oscillation a is related to the value of voltage changing in Volts (V) and the periodicity of the oscillation is given in microseconds (μs).

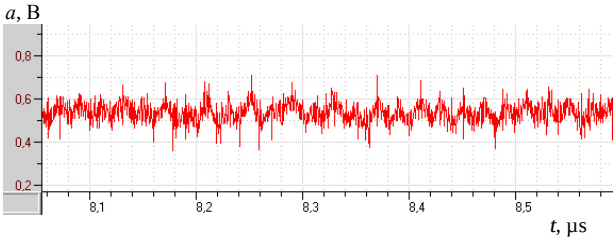

Fig. 4. Results of test 1 (Table 2)

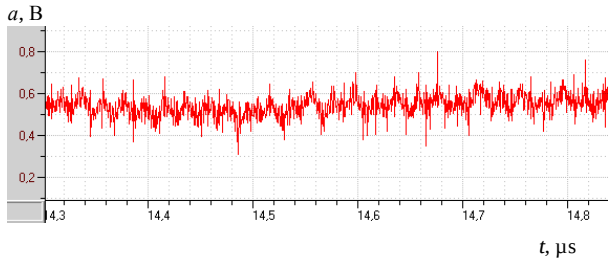

Fig. 5. Results of test 5 (Table 2)

After processing the results of FFE with the use of PC, we can obtain the average value of the amplitude $\overline{a}$ of the gear box oscillation in μm (the 1st harmonic component):

$$\overline{a} = \frac{67{,}16\Delta j^{\,0{,}07} R_a^{0{,}06}}{T_1^{0{,}31}}, \qquad (3)$$

where: $\Delta\varphi$ – is the error of the tooth operating profile, rad; R_a – is the roughness of the tooth operating surface, mm; T_1 – is the torque on the driving wheel, N·m.

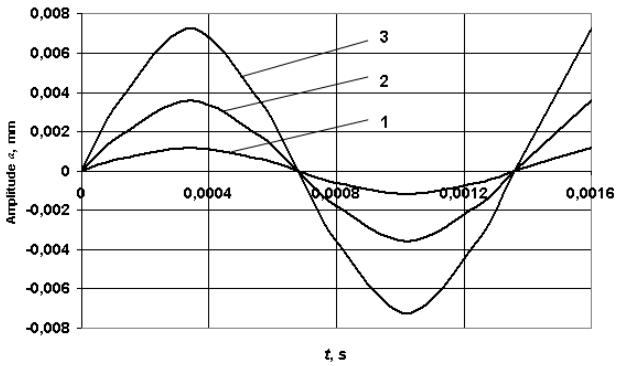

Fig. 6. Dependence of the oscillation amplitude on the error of the tooth profiles of driving and driven wheels:
1 – $\Delta\varphi$ = 0,0001 rad; *2* – $\Delta\varphi$ = 0,0004 rad; *3* – $\Delta\varphi$ = 0,0006 rad

For checking the correspondence of the results obtained during the experimental research they were compared with the results of theoretical research. The latter were obtained by the computing the common nonlinear differential equation system of motion with the help of the Runge-Kutta method, the software being developed in programming language Fortran-6. The results of the theoretical investigations are shown in Fig.6.

For obtaining the amplitude-frequency characteristics, which can take into account the results of the experimental research, let us follow guidelines from [16]. In this work (while considering trigonometric function-series) it is shown that the sums of the trigonometric functions make the possibility for simulations the great variety of excitations and the reactions of dynamical systems. It is determined, that a function $a = a(\varphi)$, where a is the oscillation amplitude and φ is the rotational angle of the tooth gearwheel, can be shown as:

$$a_{(k)} = c_k \sin \Omega_k t_i, \qquad (4)$$

with the satisfactory accuracy level, where:
$a_{(k)}$ – is an amplitude of the *k-th* harmonic component; c_k – is the proportionality constant; $\Omega_k = k\omega$; ω – is the angular velocity of the considered tooth gearwheel, s^{-1}; t_i – is time, s;

$$w = \frac{p\,n}{30}, \text{ s}^{-1}, \; t = \frac{2p}{z}, \text{ rad}, \; t_t = \frac{t}{w}, \text{ s},$$

n – is a shaft speed, min^{-1}; τ – is the period of changing the amplitude; z – is a number of gearwheel teeth; t_τ – is the duration of one period.

For the analysis of the results of theoretical and experimental research the harmonics of the frequencies were considered. They are allocated as follows:

– the first harmonic is related to the gear box,

– the second harmonic refers to a bearing bushing, fixed to the gear box together with an external racer, pressed in the bushing,

– the third harmonic is related to the rolling elements of the bearing,

– the forth harmonic concerns an inner racer of the bearing,

– the fifth harmonic is related to the shaft, on which the tooth gearwheel is fixed,

– the sixth harmonic concerns the tooth gearwheel, whose amplitude-frequency characteristic is being determined,

– the seventh harmonic is related to the tooth operating profile of the gearwheel.

In our case it is necessary to consider the first, the sixth and the seventh harmonic. The first harmonic is analyzed with the use of dependences (3) and (4) at the nominal value T_1 = 150 N·m of the testing stand torque and the roughness of the tooth operating surfaces of the tooth gearwheels R_a = 0,63 μm (according to the requirements of the working drawings considering the tooth gearwheels of the general-purpose reductors) at two values of the tooth profile error: 1) $\Delta\varphi$ = 0,0001 rad

(gear milling was performed by means of the hobbing cutter z_ϕ = 10); 2) $\Delta\varphi$ = 0,0004 rad (gear milling was performed by means of the hobbing cutter z_ϕ = 6).

For determining the amplitude-frequency characteristic of the first harmonic on the basis of the dependences (3) and (4) we obtain:

$$a_{(k)} = \frac{67{,}16\Delta j^{\,0{,}07} R_a^{0{,}06}}{T_1^{0{,}31}} \sin(kwt_i),$$
$$a_{(1)} = \frac{67{,}16\Delta j^{\,0{,}07} R_a^{0{,}06}}{T_1^{0{,}31}} \sin(1wt_i), \quad (5)$$

where: $\omega = \pi n_o/30 = 3{,}14\cdot 1410/30 = 147{,}58$ s^{-1}; t_i – is time, s; let us consider this time as the period from $t_i = 0$ till $t_i = t_\tau = \tau/\omega = 2\pi/(z\omega) = 2\cdot 3{,}14/(30\cdot 147{,}58) = 0{,}0014$ s.

In Fig.7 the amplitude-frequency characteristic of the first harmonic is given at the relevant values of the error of the tooth gearwheel profile.

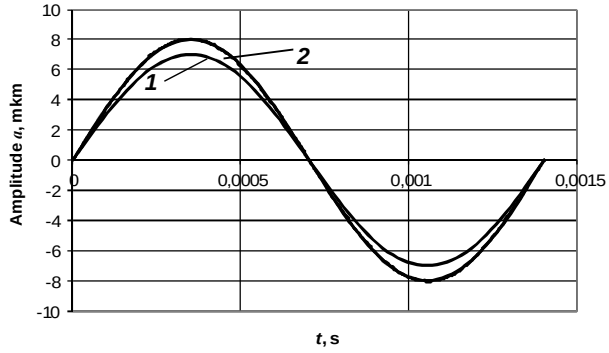

Fig. 7. Amplitude-frequency characteristic of the first harmonic (oscillations of the gear box) at the error of the tooth gearwheel profile: 1 – $\Delta\varphi$ = 0,0001 rad; 2 – $\Delta\varphi$ = 0,0004 rad

Using the curves (Fig. 7) and trend models, let us present the amplitude-frequency characteristic of the first harmonic as a 3rd degree polynomial:

$$a_{(1)} = c_1 t_i^3 + c_2 t_i^2 + c_3 t_i + c_4,$$

where: for $\Delta\varphi$ = 0,0001 rad: $c_1 = 5\cdot 10^{10}$; $c_2 = -10^8$; $c_3 = 5469$; $c_4 = -0{,}5826$,

for $\Delta\varphi$ = 0,0004 rad: $c_1 = 6\cdot 10^{10}$; $c_2 = -10^8$; $c_3 = 62303$; $c_4 = -0{,}6614$.

For determining the amplitude of the certain oscillation harmonic $a_{(k)}$ depending on the duration of the oscillation period on the basis of the polynomial obtained we use the Fourier series at the time interval $[-t_\tau, +t_\tau]$ [16]. Then:

$$a_{(k)} = \sqrt{a_k^2 + b_k^2},$$

where: a_k – is the cosine index of the k-th harmonic / (k = 1; 2; 3; …); b_k – is the sine index of the k-th harmonic.

For the sixth harmonic (k = 6) the indexes a_6 and b_6 can be determined by the dependences [16]:

$$a_6 = \frac{1}{t_t}\int_{-t_t}^{t_t} (c_1 t_i^3 + c_2 t_i^2 + c_3 t_i + c_4)\cos\frac{6p}{t_t} t_i dt, \quad (6)$$

$$b_6 = \frac{1}{t_t}\int_{-t_t}^{t_t} (c_1 t_i^3 + c_2 t_i^2 + c_3 t_i + c_4)\sin\frac{6p}{t_t} t_i dt. \quad (7)$$

After the integration of the dependences (6) and (7) we obtain:

for $\Delta\varphi$ = 0,0001 rad

$$a_6 = \frac{c_2 t_t^2}{9p^2} = \frac{-10^8\cdot 0{,}0014^2}{9\cdot 3{,}14^2} = -2{,}21,$$

$$b_6 = -\frac{c_1 t_t^3}{3p} + \frac{c_1 t_t^3}{18p^3} - \frac{c_3 t_t^3}{3p} =$$

$$= -\frac{5\cdot 10^{10}\cdot 0{,}0014^3}{3\cdot 3{,}14} + \frac{5\cdot 10^{10}\cdot 0{,}0014^3}{18\cdot 3{,}14^3} -$$

$$-\frac{54691\cdot 0{,}0014^3}{3\cdot 3{,}14} =$$

$$= -14{,}56 + 0{,}25 - 0{,}000016 = -14{,}31.$$

In this case the oscillation amplitude in μm will be:

$$a_{(6)} = \sqrt{a_6^2 + b_6^2} = \sqrt{(-2{,}21)^2 + (-14{,}31)^2} = 14{,}5.$$

A phase angle φ_k can be determined by the dependence:

$$j_6 = arctg\frac{a_6}{b_6} = arctg\frac{-2{,}21}{-14{,}5} = arctg(0{,}1526) = 8^0 40',$$

and frequency in Hz is proportional to the rotation frequency of the tooth gearwheel and to the number of the teeth:

$$w_6 = \frac{nz}{60} = \frac{1410\cdot 30}{60} = 705.$$

Accordingly, for $\Delta\varphi$ = 0,0004 rad we obtain: $a_6 = -2{,}21$; $b_6 = -17{,}16$; $a_{(6)} = 17{,}3$ μm; $\varphi_6 = 7^0 20'$.

Similar calculations are done for the seventh harmonic, that is, for oscillations conditioned directly by the error of the tooth operating profile. For performing them, let us determine the periods of the oscillations, caused directly by the ridges on the tooth operating surface. Then it should be mentioned, that the number of the ridges on the operating surface of each tooth depends on the tooth number of the hob cutter z_ϕ. In this case the time of the period of oscillation will be:

1) for $\Delta\varphi$ = 0,0001 rad (z_ϕ = 10)

$$t = \frac{2p}{zz_\phi} = \frac{2\cdot 3{,}14}{30\cdot 10} = 0{,}021, \text{ rad},$$

$$t_t = \frac{t}{w} = \frac{0{,}021}{147{,}58} = 0{,}00014, \text{ s},$$

2) for $\Delta\varphi$ = 0,0004 rad (z_ϕ = 6): τ = 0,035 rad; t_τ = 0,00024 s.

For the seventh harmonic (k = 7) the indexes a_7 and b_7 can be determined by the dependences:

$$a_7 = \frac{1}{t_t}\int_{-t_t}^{t_t} (c_1 t_i^3 + c_2 t_i^2 + c_3 t_i + c_4)\cos\frac{7p}{t_t} t_i dt,$$

$$b_7 = \frac{1}{t_t}\int_{-t_t}^{t_t} (c_1 t_i^3 + c_2 t_i^2 + c_3 t_i + c_4)\sin\frac{7p}{t_t} t_i dt.$$

After the integration for $\Delta\varphi$ = 0,0001 rad:
a_7 = –0,016; b_7 = –1,16; $a_{(7)}$= 1,16 μm; $\varphi_7 = 0^0 47'$.
For $\Delta\varphi$ = 0,0004 rad: a_7 = –0,016; b_7 = –4,01;
$a_{(7)}$= 4,01 μm; $\varphi_7 = 0^0 13'$

Let us compare the results of the experimental research with the results of the theoretical research (Fig. 6) determining the relative error (relative to the experimental results). At the tooth profile error $\Delta\varphi$ = 0,0001 rad the theoretical result is $a_т$ = 0,0012 mm =1,2 μm, and the experimental result is a = 1,16 μm. Then the relative error is:

$$d = \frac{a - a_T}{a} 100\% = \frac{1{,}16 - 1{,}2}{1{,}16} 100 = -3{,}45\%.$$

At the tooth profile error $\Delta\varphi$ = 0,0004 rad: $a_т$ = 3,6 μm; a = 4,01 μm:

$$d = \frac{4{,}01 - 3{,}6}{4{,}01} 100 = 10{,}2\%.$$

Numerous calculations of the relative error have shown, tha it doesn't exceed 11,3%. This value is acceptable, and the results obtained can be used for the calculations of the of contact fatigue of tooth gears (namely, of tooth active faces and their bending fatigue) [17-19].

While doing the calculations of tooth gearwheel strength, internal dynamic loads are taken into consideration with the use of indexes K_{Hv} (contact strength of tooth active faces) and K_{Fv} (tooth folding strength), which are determined in the state standard ГОСТ 21354-87 [20] depending on the degree of accuracy and the smoothness standard of the gear operation, the hardness of the gearwheel teeth and tooth angle velocity. In addition, during the determining the indexes K_{Hv}, K_{Fv}, external dynamic loads are taken into account by introducing the index K_A, whose value depends on the loading mode of an engine.

On the basis of the results of the theoretical and experimental research the dependences have been obtained, taking into consideration internal and external dynamic loads during the calculations of the tooth gearwheel strength.

In this case:

$$K_{Hv} = 1{,}1 \exp\left[\frac{77{,}7\, l \cos b}{m_n z_1}\right] \cdot \exp\left[3 \cdot 10^{-6} \frac{w_1}{u} d_2\right],$$

$$K_{Fv} = 1{,}4 \exp\left[\frac{77{,}7\, l \cos b}{m_n z_1}\right] \cdot \exp\left[3 \cdot 10^{-6} \frac{w_1}{u} d_2\right],$$

where: $\lambda = \Delta + f_{pbr}$ – the error, conditioned by the profile error depending on the ridge tip height Δ on the tooth operating surface, and a tooth pitch error which also causes the dynamical loads, mm.

The ridge tip heights Δ (mm) are determined by the dependence:

$$\Delta = \frac{p^2 r_1 k^2}{2 z_\phi^2 z_1^2} + \frac{p^2 r_2 k^2}{2 z_\phi^2 z_2^2},$$

where: ρ_1, ρ_2 – are the radii of the involute curves of driving and driven wheels in the point under consideration, mm; z_1, z_2 – are tooth numbers of driving and driven wheels correspondingly; k – is a number of hob cutter passes; z_ϕ – is a number of the hob cutter teeth; β – is the gradient angle of the gearwheel teeth; m_n – is a normal module of the tooth gearwheel, mm; ω_1 – is the angular velocity of the driving tooth gearwheel with the number of the teeth z_1, s^{-1}; u – is the gear ratio of the tooth gearwheel; d_2 – is the reference diameter of the driven tooth gearwheel with the number of the teeth z_2 ($d_2 = m_n z_2/\cos\beta$), mm.

The tooth pitch error f_{pbr} is taken into consideration during the calculations of the value λ replacing it by the acceptable value f_{pb} in accordance with the necessary accuracy level of the tooth gear and the index of operating smoothness.

.CONCLUSIONS

1. The results of the research with the help of the full factorial experiment on the testing stand enabled us to obtain non-linear mathematical model for determining the oscillation amplitude depending on the operating profile error of the gearwheel teeth, their roughness and the torque value.

2. On the basis of the non-linear mathematical model for determining the oscillation amplitude the amplitude-frequency characteristic of the gear box oscillations (the first harmonic) has been obtained.

3. With the use of the amplitude-frequency characteristic of the first harmonic the harmonics of tooth gear oscillations have been determined, including the harmonic of the oscillations caused by the tooth gearwheel errors, influencing on the gear operation smoothness.

4. The research results made it possible to obtain the dependences for determining the influence of the treatment of the tooth operating surfaces of the gearwheels on the internal and external dynamic loads of the tooth gearwheel while calculating its fatigue strength.

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The innovative approach to the study of decision-making in the context of the specific character of a product of managerial work

M. Vysochina

Department of Management,
National Academy of Environmental Protection and Resort Development,
181 Kyivska street, Simferopol, Ukraine, 95013
e-mail: vysochina.marina@yandex.ua

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Abstract. The article is devoted to the review of the administrative decision from the point of view of a product of managerial work. The nature and content of managerial work is studied. The research of parameters of managerial work is conducted, its features are identified. The specific characteristics of the administrative decision as a product of managerial work are identified.
Key words: managerial work, administrative decision, decision-making.

INTRODUCTION

Effective decision-making by executives of any rank is an important condition for the successful development of the organization, its survival in a competitive fight, successful adaptation to changes in the environment, the formation of rational organizational structures, carrying out the correct personnel policy and work, regulation of the social and psychological relations at the company, etc. Administrative decision has many definitions, this concept is multifaceted and ambiguous. In the scientific literature, it is seen as an alternative, a process, a product, a function, a result, a plan of action, an influence, means of influence. Such variety of definitions is explained, first of all, by complexity and diversity of the administrative decision, and also the direction of its research.

Administrative decisions are the subject of research of management, cybernetics, psychology, psycho-physiology, praxeology and other sciences. Various researchers are trying to analyze the situation in the field of decision-making to identify the objective laws of decision-making, regularities of human intellectual activity, the factors influencing the process of decision-making and realizing, etc. In this case the various points of view of scientists on the nature of administrative decisions become a source of contention and often contradict each other.

In recent years, both in theory and in practice, more attention is paid to problems of quality control. Particular interest is represented by works of G. Azgaldov [1], J. Gharajedaghi [6], V. Vinokurov [23], A. Kostin [12], R. Lepa [14]. In the scientific literature dealing with issues of quality control in organizations, the problems of studying the quality of administrative decision are given too little space, though it is widely consideration of the administrative decision as "the central link in the management cycle", "management process bases". The quality of the administrative decision is mentioned without any explanation and specificity, very vague, without the consideration of the aspects of administrative decision. At the same time, the development of effective mechanisms for ensuring the quality of management should be based on a review of the administrative decision as a product of managerial work – a specific product. Therefore, research of specific features of the administrative decision requires further exploration, and is part of the research of the Department of Management of the National Academy of Environmental Protection and Resort Development.

The aim of the study is to identify the specific characteristics of the administrative decision as a

product of managerial work that will form the basis of evaluation techniques of the quality of decision-making.

MATERIALS AND METHODS

In the article we used the materials of researches of scientists in the field of management, decision-making theory, philosophy, psychology, sociology, valeology. The methods of logical and comparative analysis, synthesis method, a graphical method were used.

RESULTS AND DISCUSSION

1. Managerial work, its parameters

In order to formulate the specific features of administrative decision as a product, it should be, first of all, given characteristics of managerial work. In explanatory dictionaries, there are following definitions of "work": it is purposeful activity of the person, it requires mental and physical effort [18]; purposeful activities of the person aimed at creating of material and spiritual values by means of production; a task to be undertaken; the result of an action [15]. In this case, the concept "work" will be considered from the point of activity. A variety of types of work assumes existence of their specific characteristics. The same applies to the manage**r**ial work.

According to [8] there are two approaches to the concept of managerial work – cybernetic and synergistic. In the classic sense managerial work is a cybernetic concept, which is associated with the formulation of a certain purpose and stage-by-stage movement to this purpose. Managerial work is considered as a process of the organization, i.e. a definite organizational and administrative work. The current understanding of managerial work is synergistic in nature. This kind of managerial work is understood as the management, "the linking of all" for a specific goal-setting. Moreover, this goal-setting can be characterized as achieving a particular result, and optimize a particular process.

The literature presents different interpretations of the concept of managerial work: "managerial work is purposeful activity of the person which is carried out in management process" [2]; "type of work, operations and work on the implementation of management functions by administrative and management personnel in the organization" [20]; "sort of social labor, the main objective is to provide a focused, coordinated activities of individual members of joint labor process and labor groups in general; ... it is systematic activities of administrative and management personnel, aimed at the organization, regulation, motivation and control over work of staff of the organization" [7]. One of the most acceptable, according to the author, the modern points of view on the problem of allocating labor aspects of management activity supports the definition of Professor A. Kibanov [21]: "a managerial work is understood as the type of work for the implementation of management functions in the organization, the purpose of which is to provide a focused and coordinated activity of the personnel according to the solution of tasks facing it."

Like any kind of work, managerial work has its own parameters: aim, object, subject, means, and the result (product) (Fig. 1).

2. The specific characteristics of managerial work

According to Professor G. Popov [17], "the specificity of work of the head is that he solves the production, economic, technical and social problems for the most part in the organizational aspect, influencing people who have to solve directly these problems." The final product of managerial work is a set of administrative decisions and the impact they have on the object of management. Specificity of managerial work is that it results, as a rule, distant in space and time from the time and place of its costs. They only ultimately are inseparable from the results of functioning of the organization [19].

In the process of managerial work material values directly are not created, but it has a productive character as without management no social production nor normal life activity are possible, its costs are socially necessary and constantly increase. Managerial work in relation to the final results of production is mediated, i.e. this type of work does not create directly consumer cost, but is intended to manage workers engaged in creation of material benefits or provision of services, and through them – the material elements of production.

Managerial work is a work largely mediated and it is not always possible to determine at what stage or in what link created (or not created) prerequisites for achieving the extended target, the end result [24]. An important property of a productive form of managerial work is that its effectiveness should be measured not by the number of documents prepared and issued orders, and on the effectiveness and progressiveness of made technical, organizational, economic decisions – by their effect on results of activity of employees directly engaged in the production of products or services. This specificity determines the following requirements for the organization of managerial work, as the need for a thorough analysis of the content and forms of information, methods and means of performing work processes to identify and eliminate the excesses of documentation.

Managerial work belongs to category of brainwork, mental work carried out by a person in the form of nervous and mental effort. Brainwork is in the processing and analysis of large amounts of diverse information, and as a consequence - the mobilization of memory and attention. The main indicator of brainwork is the tension that reflects the load on the central nervous system [5].

The features mostly mental work are the high proportion of nervous and mental effort; diversity and frequent removability of working dynamic stereotypes; higher in comparison with the physical labor share of creativity and responsibility, the absence of material result of work. Physiological characteristics of mental

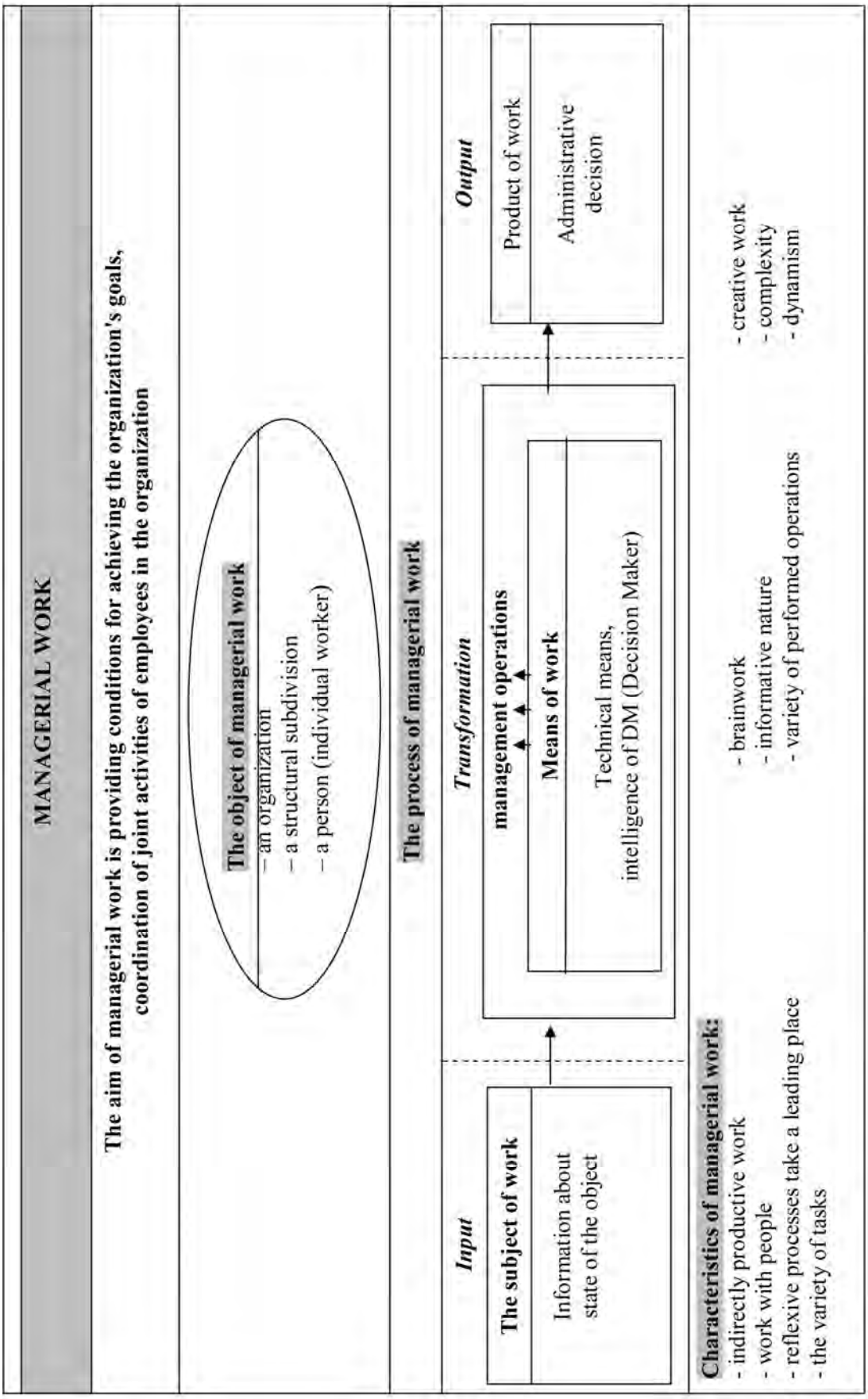

Fig. 1. Parameters and characteristics of managerial work

work are related to the fact that the content of this work has an important place of creativity – the most complicated psycho-physiological process that occurs in the cortex of the human brain during labor activity. In addition, the characteristics of mental work are: a high level of attention (i.e. concentration of mental activity in one or more interconnected objects) and, above all, an active volitional attention, good memory (i.e. psycho-physiological point of view, the process of formation, storage and play at a certain time the necessary information). Mental work of the manager differs unevenness of loading and the need to make operational non-standard decisions. Features of mental work require from managers the high professionalism and good theoretical training [9].

Managerial work is mental by nature. The content of managerial work, its essence is the way of thinking, and this means that many of the processes are hidden from the observer (pass 'in the manager's head') and the results of this work can not be predicted in advance, and they are often vague, hard momentary [4]. Reflexive processes occupy leading position in this case. They provide, first, forecasting and anticipating the response of subordinates by setting themselves in the position of others, and secondly, the ability to understand what other people think, and the knowledge of how the head himself is perceived by the communication partners.

Managerial work of senior executives is intellectual. Intellectual work is defined in general terms as a thinking (mental) process carried out by such efforts (abilities) of a person that directed the production of goods and services [3]. According to K. Kirsanov, V. Buyanov, L. Mikhailov [10], intellectual work is defined as work that generates knowledge, work requiring a recombination of old elements into new configurations depending on what is needed now "by right of such actions could be called innovative, creative".

The specifics of intellectual work is that even after the termination of the work the thought of it does not leave the person and the work remains dominant in the central nervous system long enough [22].

Intellectual work of senior executives has the creative nature with a predominance of mental energy costs associated with the processing of information and the creation of new knowledge, with a high efficiency and high-tech manufacturing from both a social and an economic points of view. The creative nature of work of the manager is reflected in the emergence of new ideas, advanced technologies, more advanced and high-performance tools, new types of products, materials, energy, which lead to the development of needs [13].

One of the features of managerial work is informative nature of the subject and the product of work. Managerial work is characterized by the necessity of perception and processing of large amounts of information, lack of time to process it, increasing both the public concern and a personal responsibility for decisions [15]. The amount of information in the world doubles every 10-12 years, leading to a significant compaction of the information that people must learn at a time – it requires him high mental stability, long-term nerve stress, long-term maintenance of attention, etc. [22].

Managerial work is extremely varied. Managerial work of senior executives responds poorly to mechanization and automation, especially creative work. The nature of managerial work is quite changeable in time, in tasks and uncertainties due to the presence of different types. The content of managerial work remains unchanged. As a result of managers' and specialists' application of technical equipment, transfer of stereotypes, incoherent or irrelevant functions of machines, new methods and means of work, improving the organization of management the content of their work changes significantly, the share of creative operations of the work is increasing. In addition, managerial work combines elements of management with elements of trades and professions. Thus, the complexity of managerial work caused magnitude, number and composition of the problems being addressed, the connections between them, the variety of methods used, organizational principles, the need to make new, innovative decisions, often in the face of uncertainty or risk that requires deep professional knowledge, experience and broad erudition, degree of efficiency, independence, responsibility, risky decisions that need to be made.

3. Features of the administrative decision as a product of managerial work

Product of work of the managers, realizing the interconnected functions of management and containing setting goals (tasks), justification of means, methods and timetables, is an administrative decision. Administrative decision is a product of the analysis, forecasting, justification, optimization and the choice of an alternative, made on the basis of information processing by the person, making the decision.

The characteristics of managerial work stated above allow to mark out specific features of its product – the administrative decision, such as:

1) administrative decision is immaterial and does not meet the final needs of the people, society and the economy,

2) administrative decision has information character. Work with information accompanies and permeates the entire decision-making. The optimal amount and quality of information is a necessary prerequisite for making the correct decision. The method of analysis and synthesis of information, forming ideas of possible decisions become important. Each variant of the decision is a complex information about the possible answers to any question, collected into a single logical unit, and having a specific focus. Administrative

decision contains information about the way to resolve problem situations, the executors, terms, resources used, possible consequences. In addition, the administrative decision is made based on available information regarding internal and external environment of the organization**.** This information must satisfy the following requirements: accuracy, reliability, timeliness, accessibility, completeness,

3) administrative decisions are diverse and varied in nature. The variety of problems corresponds variety of solutions. There are such solutions: economic, social, political, ideological, strategic and tactical, global and specific, conceptual and program, scientifically based and empirical, intuitive, and innovative, routine,

4) administrative decision is creative. Development of scientific and technical progress, changes in technology and competition force managers to develop innovative approaches to solving traditional problems, look for innovative solutions. Creative abilities of a manager are the ability to detect and formulation of problems, the ability to generate a large number of ideas, the ability to produce a variety of ideas, the originality, the ability to improve the object adding details and the ability to analyze and synthesize. Manager's creativity should manifest in the creation of new technologies, products and services, in the development of effective schemes of functioning of the organization, in tying new partnerships, in working with customers, suppliers,

5) administrative decision contains a risk. Most administrative decisions are made in risk conditions, due to several factors: the lack of complete information, the presence of conflicting tendencies, the element of chance, etc. Manager should know about the possible occurrence of the risk, but this is not enough. It is important to determine the effect on performance of a specific type of risk, and what the consequences are. Moreover, he should first assess the chance that an event will actually happen, and then make a conclusion about how it will affect the economic situation of the enterprise,

6) there is subjectivity in the administrative decision. Individual thinking is subjective. Subjective perception of situations entails subjectivity of solutions. Subjective factors are connected with the decision maker, and influencing the perception of the adequacy of his objective position system. The most important of subjective factors are manager's innovative abilities, the ability to creatively take to resolve the problems, the ability to assess the situation and decide on a reasonable risk. An important subjective condition for the decision-making is the availability of logical thinking – ability to analyze information and synthesize obtained results,

7) the effectiveness of the administrative decision can be evaluated only after its realization. Any administrative decision must be assessed in terms of its effectiveness. We analyzed the situation after the administrative impact. This analysis should identify weaknesses and strengths of the decisions and plans for their realization; additional opportunities and prospects of opening as a result of those changes, additional risks that may be subject to achievement goals,

8) administrative decisions are made only in the presence of a problem situation,

9) administrative decision reflects the personality of its maker and the system of his/her values. Everyone has its own system of values that determines its actions and influences decisions. The value orientation affects the way in which decisions are made,

10) the administrative decision has a distinct time aspect. Untimely (precocious or delayed) decision-making, as well as the failure to make it at all, manager's inactivity may lead to irreparable results, for such a development of the situation in which a negative outcome will not be able to prevent. Timely development, adoption and realization – one of the main requirements for administrative decisions. Compliance with this requirement contributes to solving problems and prevent them from worsening or conversion activities staff useless. Administrative decision must be made and realized in time. The factor of time should be taken into account in economic calculations in determining the outcome and consequences of the adoption and implementation of administrative decisions in the future, due to inflation processes,

11) the outcome of the decision contains a significant degree of uncertainty associated with inaccurate information, limitations in time and cost, and also the cognitive limitations imposed on the manager who makes the decision.

CONCLUSIONS

1) A managerial work is understood as the type of work for the implementation of management functions in the organization. The aim of managerial work is providing conditions for achieving the organization's goals, coordination of joint activities of employees in the organization.

2) Characteristics of managerial work are indirectly productive work, brainwork, creative work, work with people, informative nature, complexity, reflexive processes take a leading place, variety of performed operations, dynamism, the variety of tasks.

3) The administrative decision is a product of managerial work. The administrative decision as a product of managerial work has specific characteristics: it is immaterial, creative, subjective, diverse and varied in nature, has information character, contains a risk, reflects the personality of its maker, has a distinct time aspect, its outcome contains a significant degree of uncertainty. The listed features distinguish the administrative decision from other types of decisions.

4) Identified specific characteristics of administrative decision as a product of managerial work should be taken into account in the development of evaluation techniques of administrative decision's quality and forming the mechanism of ensuring the quality administrative decision-making in organizations.

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Impact of the level of providing adaptability of an enterprice's on adaptation process of enterprise to innovation

V. Yachmeneva, Z. Osmanova

Managment department,
The National Academy of Environmental Protection and Resort Development,
Simferopol, Kievskaya street, 181, aud. 311
e-mail:k_men@napks.edu.ua

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Abstract. The article was dedicated to ensuring the adaptability of the enterprise. As a means of providing adaptability of an enterprice's activity there was suggested resources and their reserves: basic production assets of the enterprise, financial resources, material resources, carriers of knowledge, information and intangible resources of the enterprise. I-level barriers related to unawareness of need to involve the accumulation of resources and reserves resources for the providing adaptability of an enterprice's activity at the level of enterprise management. II-level barriers are associated with resource constraints — lack of resources, resources absence, lack of ability to attract resources and accumulate reserves resources for various reasons III-level barriers are associated with psychological resistance from employees. In the article problems hindering to providing adaptability of an enterprice's activity as barriers of I, II and III levels were presented and characterized. Influence of the level of barriers to providing adaptability of an enterprice's activity is characterized. Effect of the provision level of providing adaptability of an enterprice's activity on such characteristics of adaptation as rate of adaptation, the cost of adaptation, the scope and depth of adaptation is proved and the nature of such effects is investigated.

Key words: adaptation, adaptability, enterprice's activity, providing.

INTRODUCTION

In recent years the adaptation has become very popular in scientific literature. It is concerned not only adaptability of an enterprice's but also adaptation of individual workers of these enterprises. It is explained by the high level of competition on the market and high level of uncertainty of the environment, to the conditions of which the company should adapt systematically. Taking into account that fact that adaptability is a prerequisite for enterprise adaptation to environmental conditions, it is necessary to study adaptability of an enterprice's activity at first.

Adaptability of an enterprice's activity as an economic category is close with other characteristics of an enterprice's activity, namely competitiveness, sustainability, innovation, reliability and integrity. Like these characteristics, adaptability is a characteristic that can ensure survival, sustainable operation and development of the company. This, as well as direct adaptation of enterprises to environmental conditions is possible only when you reach the desired level provision of the enterprise adaptability.

Questions about adaptability were examined by domestic and foreign scholars in different periods of time and concerning on different researching objects. Among the researchers who were involved in the issues of adaptability and adaptation there are domestic and foreign scholars, namely I. A. Pitaikina [16], O. A. Pastuhova [15], V. M. Yachmenyova [25, 26, 27], A. V. Kozachenko, V. P. Ponomarov, O. M. Liashenko [6], G. I. Hanaliev [4, 5], A. P. Maksimovich [11], D. Z. Chuiko [2], E. V. Chigenkova [1], V. P. Stasiuk [20], T. T. Lastsev and A. A. Caygorodsev [10], V. N. Samochkin [18], V. N. Fomin [3], J. Shumpeter, R. Nelson, R. Akoff, T. Veblen and others. Most of their works are devoted to separate consideration of each of these categories within the different subjects of the study. Issues of direct influence the level of providing adaptability of an enterprice's activity to adapt to the

analyzed company works have not been studied. Therefore, we believe research topic relevant and timely.

THE MAIN MATERIAL

Authors who have studied the issues of adaptability [2, 6, 7, 11, 12, 13, 25], this concept is defined as follows:

– property required for the criteria changes;

– response needed to establish the causes of the change;

– ability required for determining the nature of current developments and to ensure the economic sustainability of the enterprise

In our research, we should say the adaptability as a feature of the enterprice's activity, which reflect the potential enterprice's opportunity, ability and responsiveness to change, which is the necessary condition for enterpice s adaptation to changes [28].

Survival, setting activity goals of enterprise, performing functions, preservation and expending market share and etc. Are depend on adaptability. Adaptability of the enterprise determines how quickly the enterprise is able to respond to conditions, which are changing, how safely and invisibly held the process of adapting of the enterprise. It is first necessary to provide adaptability of the enterprise accordingly if we want it will be able to maintain its position in the market and continued its development.

In previous publications on research, it was determined that the way to providing adaptability of an enterprice's activity is the resources of enterprise and cash reserves. Among these resources are basic production assets of the enterprise, financial resources, material resources, carriers of knowledge, information and intangible resources of the enterprise. Listed resources are a means of providing adaptability of an enterprice's activity only in the condition of an effective management on the level of the enterprice's management.

Providing adaptability of an enterprice's activity is a set of actions, measures and management decisions by management of the enterprice's activity to attract resources appropriate quantity and quality, the accumulation of reserves and resources of their intended use.

Like any other process, providing adaptability of an enterprice's activity associated with a number of problems [15, 21, 23, 25]. Such problems are presented in the form of barriers I, II and III levels, which interfere toproviding adaptability of an enterprice's activity.

I-level barriers — barriers related to unawareness of need to involve the accumulation of resources and reserves resources for the providing adaptability of an enterprice's activity at the level of enterprise management. Barriers of the first level are basic. It is not accidental, because without awareness of need to introduce measures to attract resources and the accumulation of reserves resources at the level of enterprise management, providing adaptability of an enterprice's activity is impossible. In addition overcoming of the Level I barriers is a prerequisite for overcoming the barriers these levels.

II-level barriers are associated with resource constraints — lack of resources, resources absence, lack of ability to attract resources and accumulate reserves resources for various reasons. Among these reasons are management incompetence, lack of financial resources and so on. For the adaptability of an enterprice's activity barriers overcoming related to resource constraints took the second place taking into account the importance. Without overcoming of II level barriers stable functioning and development of the enterprise is impossible, as it is a means of providing resources adaptability of the enterprise. That overcoming of II level barriers is the main objective to providing adaptability of an enterprice's activity.

III-level barriers are associated with psychological resistance from employees. Singling out psychological resistance from employees is a barrier because workers directly involved in ensuring the adaptability. First, the employees of the company serve as bearers of knowledge as a means of adaptive enterprise, and secondly, the whole process of adaptive enterprise happens by their direct participation.

Providing adaptability of an enterprice's activity should be a continuous process as the environmental conditions the company must adapt are constantly changing. This, in its turn, requires bringing new resources and the accumulation of reserves of resources. Changes in the environment which the company must adapt can be caused by various reasons. As for employees it may appear such a necessity to be involved with senior staff, with presently existing in the enterprise, skill level or improve the skills of their employees. Moreover, according to changes in the environment, it may be necessary to provide obligatory technological re-equipment of production and non-production activities of the enterprise. This can result in dismissal of workers from specific positions. In such conditions the psychological resistance from employees is related with fear of non-compliance with the new requirements for workers, the need to adapt to new working conditions and possible job loss and so on. Psychological resistance from employees may adversely affect the providing adaptability of an enterprice's activity. Therefore, to prevent such situations the company's management should systematically contact with their employees about need and importance of implementing measures to providing adaptability of an enterprice's activity. Taking into account the uncertainty of the environment, the situations different by nature and character, which forced the company to adapt are systematic.

Schematically barriers to providing adaptability of an enterprice's activity are presented in Fig. 1.

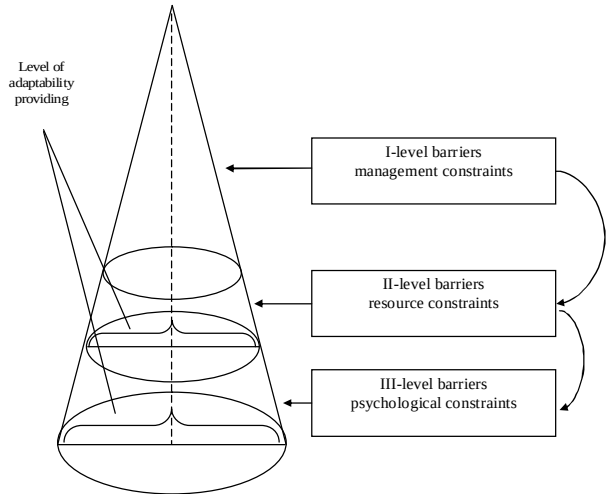

Fig. 1. Barriers that hinder providing adaptability of the enterprise

The scheme adopts the following notations:

I-level barriers — barriers related to unawareness of need to involve the accumulation of resources and reserves resources for the providing adaptability of an enterprice's activity management, they are marked as management constraints;

II-level barriers are associated with resource constraints — lack of resources, resources absence, lack of ability to attract resources and accumulate reserves resources, marked as resource constraints;

III-level barriers are associated with psychological resistance from employees of the company in measures to ensure the providing adaptability of an enterprice's activity, marked as psychological constraints.

The gap between the highest peak and the first base of the cone is the largest. Schematically, this reflects the importance and complexity comparable to overcome the I-level barriers. Applied schematic display of the I-level barriers as a larger gap between the barriers of other levels, confirms that without overcoming of the I-level barriers, overcoming of the following barriers is impossible. The intervals between II and III levels are practically identical, confirming their equivalence to providing adaptability of an enterprice's activity.

According to the scheme, the overcoming of the II and III levels barriers is the basis for achieving the appropriate level of providing adaptability of an enterprice's activity. After overcoming of I-level barriers the achieving of this or that level of providing adaptability of an enterprice's activity is not provided, as overcoming of I-level barriers is only the basis for overcoming these barriers of the following levels and condition for the implementation of measures to providing adaptability of an enterprice's activity (fundraising accumulation of reserves and resources).

Thus, it is clear that without awareness measures necessary to providing adaptability of an enterprice's activity on the level of enterprise management system, without attracting the necessary resources, the accumulation of reserves and resources, overcoming resistance from employees, i.e. overcoming of I, II and III levels barriers providing adaptability of an enterprice's activity.

Equally important is the level of barriers, because the higher the level of barriers, the more time, effort and financial costs is required to overcome them. For the company, given that adaptability is a condition of the adaptation of the enterprise to the environment that is constantly changing, overcoming operational barriers that hinder providing adaptability of an enterprice's activity is the primary condition for survival, sustainable operation and development. Therefore, to the extent of barriers that prevent the provision of adaptability of the company, for them not to be "unattainable" for overcoming, measures to ensure the adaptability of enterprises should be carried out systematically.

Among the measures that will predict the occurrence of barriers that prevent the providing adaptability of an enterprice's activity may be relevant courses, training for management and employees; gradual (as needed) attraction of resources and the accumulation of reserve resources. Systematic holding of such events provide absence / low level of barriers that hinder the providing adaptability of an enterprice's activity. As a result, in case of subsequent changes in the environment to which the company will be forced to adapt, spending time, effort and finances will be minimal.

Level of the providing adaptability of an enterprice's activity determines the efficiency of enterprise adaptation to environmental conditions. Such characteristics of adaptability depend on the level of provision of providing adaptability of an enterprice's activity:

the rate of adaptation,

the scope and depth of adaptation,

the cost of adaptation.

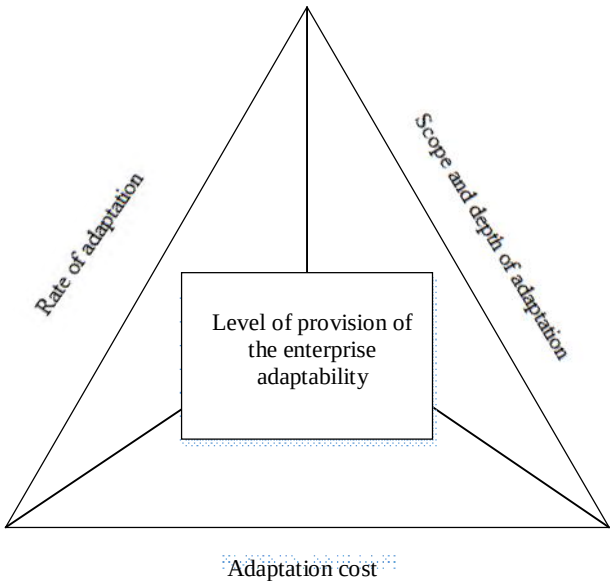

Fig. 2. The relationship of the level providing adaptability of an enterprice's activity and the characteristics of enterprise adaptation

Table 1. Impact of the provision level of the company adaptability on the characteristics of enterprise adaptation

Characteristics of adaptation process	Objects of impact	Direction of dependence	Note
Rate of adaptation	1) adaptation cost	Reverse dependence	This implies that rapid adaptation is possible with a high level of providing adaptability of an enterprice's activity. Therefore, the cost of adaptation by increasing its rate will decrease
	2) market share occupied by the company	Direct dependence	To save the market share occupied by the company or entering new markets, including international, some environmental conditions the company should react operatively
	3) company profit	Direct dependence	Rapid response and fast adaptation to specific changes in the external environment may cause an increase in profits and vice versa
Scope and depth of adaptation	1) market share occupied by the company	Direct dependence	The scope and depth of the adaptation process, including determining the stability of the position on the market and market share, which it occupies
	2) company profit	Direct dependence	Sustainability position on sales market, that the scope and depth of the adaptation process determine, has a positive impact on company profit
Cost of adaptation	1) financial condition of the company	Reverse dependence	The cost of adaptation increases with low level of providing adaptability of an enterprice's activity. The higher the value of the adaptation process, the more negatively it affects the financial position of the enterprise

If a company has a high level of adaptability provision, then:

firstly, the adaptation process will pass quickly so they do not need to engage in finding and attracting new resources;

secondly, the adaptation process will be characterized by the scale and depth of adaptation to new conditions;

thirdly, the cost of adaptation will be minimal, as the company will have the necessary resources for adaptation at its disposal.

The relationship of the level of providing adaptability of an enterprice's activity and the characteristics of enterprise adaptation is schematically shown in Fig. 2.

Analysis of the impact of providing adaptability of an enterprice's activity on the characteristics of enterprise adaptation is presented in Table 1.

Thus, the speed of adaptation affects the cost of adaptation; market share occupied by the company and the profits. It was determined that reverse dependence presents between the rate of adaptation and cost of adaptation, direct dependence — between the adaptation rate and the market share occupied by the company and the profit of the company. The scope and depth of adaptation affect the market share occupied by the company and the profits. It was determined that between them there is direct dependence. The cost of adaptation influences the financial position of the company with reverse dependence.

CONCLUSIONS

1. In our research, we should say the adaptability as a feature of the enterprice's activity, which reflect the potential enterprice's opportunity, ability and responsiveness to change, which is the necessary condition for enterpice s adaptation to changes.

2. Basis of adaptability of an enterprice's activity are its resources (basic production assets of the enterprise, financial resources, material resources, media knowledge, information and intangible resources companies) and their reserves provided effective management.

3. Problems that arise during process of providing adaptability of an enterprice's activity may be represented as the barriers of I, II and III levels. Barriers of I level are identified as administrative constraints and related unawareness of need to involve the accumulation of resources and reserves resources for the adaptive enterprise at the level of enterprise management. barriers of II-level are associated with resource constraints – lack of resources, resources absence, lack of ability to attract resources and accumulate reserves resources. Barriers of III-level are defined as psychological limitations and associated psychological resistance from employees regarding measures in order to providing adaptability of an enterprice's activity. The degree of these barriers overcoming determines the level of provision of the company adaptability.

4. Level of providing adaptability of an enterprice's activity determines the efficiency of enterprise adaptation to external changes, such as rate adaptation, the scope and depth of adaptation, the cost of adaptation.

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Optimization of marketing strategy's selection process in automobile company

O. Yurynets, O. Tomyuk

Department of organizations management,
Lviv Polytechnic National University
79013, Lviv, Bandery st. 12,
e-mail: olesya.tomyuk@gmail.com

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Abstract. The article analyzes existing classifications of marketing strategies of the company. The main criteria for marketing strategy's selection, used by management in its strategic activities, were defined. Based on research, a simplified classifier of marketing strategies, which will facilitate efficient strategic marketing activities, was developed.
Key words: marketing strategy, automobile companies, innovation potential.

INTRODUCTION

Management of automotive enterprises in practice requires clearly regulated guidelines on choosing a marketing strategy for the company. In most cases, theoretical research of scientists focused on improving the existing strategies or developing new classification, while automotive businesses need effective implementation strategies according to objective external conditions. It is difficult for management of the company to sort out the wide variety of branching classification schemes. Thus, the problem of systematization characteristic features of external and internal marketing environment under which management can orientate in the most effective strategy for the company become urgent. The choice of strategy depends on the direction of the company and the final financial result. Therefore, besides the matrix of marketing strategies the list of features, which should be decisive in the classification of marketing strategies according to the needs of the automobile enterprise, should be analyzed and determined.

It is necessary to conduct a detailed analysis of existing classifications marketing strategies in research, to identify the relevant market indices, which are crucial for the management of automobile enterprises in selecting marketing strategies. It is necessary to conduct a study whose results have demonstrated the effectiveness of separation of marketing strategies according to the levels of management. The possibility of different marketing strategies combining for automotive enterprises according to the latest market trends should be analyzed.

MATERIALS AND METHODS

Research in strategic marketing management carried out such scientists as D. Aaker and E. Korenyev, Ph. Kotler, N. Kudenko, J. Lambin, M. Porter, A. Starostina, R. Fathutdynov [1,3,4,6,8,10,20] and other foreign and Ukrainian scientists. Developments of aforementioned researchers related to strategic marketing and strategic management in general [1-8].

Most of the studies in strategic marketing administration consists in development of new and classification of existing strategies, while automotive businesses need efficient schemes, that would simplify the selection process of marketing strategy, as a management tool that is tested and effective under specific conditions, similar to that, where the object of research - the motor industry enterprises - consists.

Selecting, developing and implementing of marketing strategy involves analyzing the factors of micro-and microenvironment of enterprise, what is described in the researches of famous scientists and economists [1, 3, 8].

Table 1. Development of marketing approaches in entrepreneurial activity during the XV-XXI centuries. [15]

Marketing concept	Classical production	The concept of «exclusivity»	The concept of mass production	The concept of "blue oceans"	The concept of "socially responsible" marketing	Ecological marketing
Timeline	XVII century	XVIII-XIX centuries	1900s	2000s	2010-2012	Since 2012

Deepening into the process of strategic marketing analysis, it should be noted, that the major forms are PEST-analysis [9], SWOT analysis [10], the model of the five competitive forces by M. Porter [11] creation of strategic groups maps [6], SNW analysis [12], analysis using BCG matrix [13], McKinsey [14] and others. However, strategic marketing analysis in automotive industry, in addition to the aforementioned methods should be conducted in the form of determining of market trends for both the automotive industry and for related industries. Trends in related industries are essential in the creation of competitive products.

To determine of market trends managers often resort to alternative methods of projections called "trend watching", which is based on predicting the possible market trends relying on retrospective analysis according to the theory of cyclical economic system. The feasibility of this method is confirmed by the cyclical development of marketing as a science, what is shown below (Table1).

The cyclicity of development in the automotive industry is observed. For example, analyzing car design aspects there are some tendencies. As for the technological equipment of vehicles, the impact of related industries increases significantly. This dependence can be traced using the analysis method A. Slywotzky called "radar" of companies [16]. According to this methodology, the analysis of automobile enterprises represented on Fig.1, which schematically shows the "radar" of company, that is the object of analysis. At this radar, the sectors that have an impact on the enterprise are indicated. The distance between center, where is the object of analysis, and points of related industries inversely reflects their impact on the strength of the test motor industry enterprises.

Impact have electronics, software industry, art and field of alternative energy.

According to the conducted analysis, we can determine the potential competitive product of automobile company, which is based on the following main components:

- Cost and use of alternative energy sources (eco-trend);
- Innovative design (trend watching);

High level of technical equipment, security, usability, technical innovation (construction bereau (CB) activity or licenses purchasing).

- On the "radar" of the company, the most significant

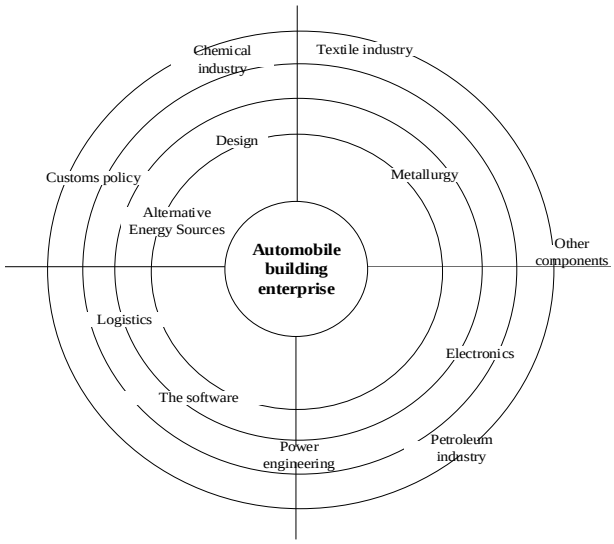

Fig. 1. "Radar" of domestic automobile company by A. Slywotzky

Determination of market trends involves the study of characteristics of more powerful market players, because it will lead to a permanent backlog of companies that can be explained by the duration of the transition process of designing a car to its mass production. After all, if the manufacturer sets today the goal to create car, which would correspond to the level of the strongest players in the market, than its competitor would be one step ahead, working on new better model.

RESULTS

Radical restructuring of strategic activity for improving the competitiveness of its products involves tangible and intangible investment attraction. In this regard, the company should be prepared for these changes.

None of the analyzed domestic automobile enterprises are not equipped for a quick transition to production of highly competitive them. This is preceded by a number of factors which include: - the willingness of staff to changes; - technological equipping of equipment; - the availability of financial resources for R&D; - effective marketing service of the enterprise; - accessibility of informal technical resources; - legal framework; - lobbying and others.

All these factors can be grouped by level of difficulty obtaining them: 1. Available; 2. Potential; 3. Perspective.

Management of Company has divide responsibilities for achieving the target resource support.

Level of readiness of enterprise for innovation is determined by the innovative potential of enterprises. The subject of evaluation and formation of innovative potential of enterprise engaged such scientists as I. Ansoff, N. Chukhray, V. Geets, A. Maslak., V. Shevtsova, [1,3,4,6,8,10,20] and others. Analysis of current developments provides the basis for the subject group and identifies the main categories of readiness of enterprises to innovate. Table 2 shows the main categories of enterprises according to their level of readiness to implement innovation, the most effective for each level marketing strategies and indicators that help identify the placement of the object of analysis in a particular category.

According to the each category of the innovation potential of enterprise, types of marketing strategies, that will be the most effective for the company, could be figured out. Importantly, the proposed matching categories and strategies is considered as a tool of strategic marketing management of company. Table 1 does not provide variants of strategies for functional level because of the inability to determine all financing conditions of companies, because each automobile producer is characterized by various conditions, organizational structure, management capabilities, etc.

It is important to note that scientists have identified various structural elements of the innovation potential of enterprise, but during the investigation the preparedness of automobile company to manufacture innovative products, we distinguished main components: financial, human, technological, industrial and technical, and marketing. No doubt, this classification can be expanded into smaller elements, but it requires a separate scale research, what is not envisaged by objectives of this study.

Among the Ukrainian automobile companies, only three automobile companies, that involved in cars assembling, are categorized as companies with middle and high innovative: plant "Eurocar" (cars Skoda), ZAZ (Zaporizhia Automobile Building Plant) and Cherkassy automobile factory "Bogdan". The statistics, which are based on a compulsory statements of the company to the State Statistics Committee of Ukraine, indicate the overall low level of expenditure on R&D in field of passenger cars production, that is certifying by number of innovative enterprises in Table3 [19].

Table 2. Categories of enterprises according to their level of innovation potential of enterprise *

The level of innovation potential of enterprise	The level of resources provision	Types of marketing strategies	Indicators of measurement of innovative potential
The low level of innovative potential	Financial: own funds, long-term loans and borrowings; Staff: own; Technological: outdated designs and models; Technical and production: outdated equipment; Marketing: absence of marketing subdivision or incorrect its using.	Corporate level: strategy of survival + stabilization strategy; Business level: a strategy on decline stage, the strategy of sequence, protection strategy, the strategy of price leadership	HR component: 1. The coefficient of personnel training (Personnel, that has been trained/all employees); 2. The coefficient of inventions (The number of inventions/All assortment); 3. Level education of the staff (Employees with a diploma of education/all employees); 4. The turnover coefficient (dismissed workers/all employees); 5. The coefficient of scientific support of employees (Employees CB/all employees) The financial component: 1. The volume of credit facilities; 2. The amount of own funds; 3. Capitalization coefficient; 4. Accounts Receivables 5. Value of fixed and current assets; 6. Coefficient of funds turnover, etc. Technological: 1. R & D expenditures/total cost; 2. The cost of borrowed innovation; 3. Technology transfer; Production and technology: 1. The coefficient of updating; 2. The coefficient of wear and tear of equipment; 3. Depreciation; 4. Costs relating to repairs; 5. Productivity; 6. Level of automation.
The average level of innovative potential	Financial: own + long-term loans; Staff: own + outsourcing; Technology: own + borrowed elaboration; Technical and production: coefficient of updating ≥ 0,5; Marketing: marketing researches + partial participation in the creation of products.	Corporate level: strategy of stabilization; Business level: strategy on the maturity stage, strategy of sequence, challenger strategy, strategy of protection strategy of price leadership, differentiation strategy.	
A high level of innovative potential	Financial: own funds + certain amount of long-term credit; Staff: Own + partner relations; Technology: own know-how and licenses involving related industries; Technical and production: coefficient of updating ≥ 0,9; Marketing: providing a full cycle of marketing services.	Corporate level: growth strategy; Business Level: strategy on implementation stage + strategy on growth stage, strategy of market leader, strategy of market niche coverage, strategy is an offensive strategy of differentiation	

* Source: Own elaboration based on [4; 17; 18]

Table 3. Expenditure on R & D by type of economic activity in Ukraine

N	Type of economic activity	Number of innovation active enterprises		
		2010	2011	2012
1	All industry	1462	1679	1758
2	Mechanical Engineering	417	443	426
3	Production of motor vehicles	81	84	90

Table 4. Classifier of marketing strategies according to the dynamics of the target market share figures

	Growing	**Sustentation**	**Reduction**
Corporative level	Growth Strategy: — Intense — Integration — Diversification	The strategy of stabilization; Strategy for survival	Survival Strategy
Business Level	The strategy of price leadership; Diversification strategy; Strategy on growth and implementation stage; The strategy of market leadership; Strategy of offensive	The strategy of differentiation; Strategy on the stage of maturity; Challenger strategy; The strategy of the follower; Strategy offensive or protection	Strategy on the stage of decline; Strategy of market niche coverage; Strategy of protection

Dynamics costs on release innovative products, as well as their scope in the domestic automobile enterprises is not conducive to the development of innovative potential of enterprise and their competitiveness in a sector, which is largely dependent on technological innovation.

In an analysis of the competitive environment of enterprise in automotive industry of Ukraine should take into account the specifics of the legislative component, which has recently become particularly relevant. However, the role of legislation in the automotive industry has two impacts: 1. Regulatory function on automobile enterprises and export-import policy, 2. Influence on the purchasing power of buyers in the market, due to the high cost of automotive products business, which brings the car to a category of previous long-term choice goods.

One of the most important elements of strategic analysis is to analyze the competition. Most scientists who have studied the issue of strategic marketing management agree on the necessity of this element in the analysis. [1, 4, 20].

The specificity of industry determines expediency of analyzing competitors through the provision of competitive groups [4, 21, 22]. However, this approach requires a number of corrections:

1. The object of the analysis should consider the specific car model line,

2. The analysis must focus on the customer profile of the object,

3. The choice of a competitive group of cars through the provision of "price range" of object of analysis,

4. Defining the set of priority characteristics of a "user profile", comparing them with those of market leader, or competitive reference point,

5. The definition of a competitive group and calculating the competitiveness of the object of analysis.

Conducting the strategic analysis of automobile enterprises preceded the final determination of the rate, which will be a criterion of success of achieving all target points in the component analysis: tracking market trends, improving of innovative potential, compliance with legal requirements, ensuring a high level of competitiveness of products in the market.

The main criterion for success should be measured and impact on financial results. Practice shows that companies involved in the automotive industry and the automotive market using market share as a landmark achievement. It should be a detailed plan and financial performance, taking into account the profitability of the automobile company, which is largely shaped margin products.

Considering the importance of market share for the automotive market participants in the research suggested a matrix of marketing strategies according to two criteria: the level of management and correlation growth rates and market share of analysis object, which is shown in Table 4.

Automobile Management of Company has permanently keep track the ratio of growth/ recession of the market (Rm.g.) to rate of the market share dynamics (Rm.sh.). If Rm.g.≤ Rm.sh., then the company may, pursuant to its mission and target segment of consumers, choose the strategy of all three levels if Rm.g.> Rm.sh., then the company should choose a strategy aimed at sustentation or growing market share.

It is important to note, that choosing the market share as indicator of enterprise's success, management, logically, can take action, that will lead either to its decrease/retain, or decrease the selected target narrowly focusing on a single niche. According to the direction of the selected target dynamics, certain types of marketing strategies can be used. An important element of this matrix is the lack of a functional level. Because the marketing policy of the company should include the

development of tightly controlled corporate requirements for preparation and implementation of marketing plans for resellers and distributors of cars on the market using the four elements of the basic elements of the marketing mix: product, distribution price and communication policy of the company. Target indicators of success so-called functional-level management components are transformed into the general corporate rate of market share the company's strategy and functional level turn to the implementation of operations management, that is regulated by corporation.

CONCLUSIONS

1. The study analyzed the main components of building a strategic plan for the company, offered by domestic and foreign scientists, allowed to formulate the main stages of the strategic marketing plan for enterprises of automobile industry, which are including: market trends, competition, performance, and legislative conditions.

2. Based on the strategic analysis suggested the use of indicators that are optimal in the automotive industry in strategic marketing planning.

3. This study allowed to form a classifier of marketing strategies according to the criteria of strategic analysis.

4. In further research is necessary to develop a mechanism of implementation the marketing strategy for particular automobile enterprises in Ukraine and suggest ways of improvement the competitiveness of its products in accordance with the objectives of the enterprise.

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Table of contents

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