MOTROL

AN INTERNATIONAL JOURNAL
ON OPERATION OF FARM
AND AGRI-FOOD INDUSTRY MACHINERY

Polish Academy of Sciences
University of Engineering and Economics in Rzeszów
University of Life Sciences in Lublin

MOTROL

COMMISSION OF MOTORIZATION AND ENERGETICS IN AGRICULTURE

AN INTERNATIONAL JOURNAL
ON OPERATION OF FARM
AND AGRI-FOOD INDUSTRY MACHINERY

Vol. 19, No 4

LUBLIN – RZESZÓW 2017

Linguistic consultant: Orest Hrekh

Typeset: Viktor Shevchuk, Adam Niezbecki

Cover design: Hanna Krasowska-Kołodziej

Photo on the cover: Janusz Laskowski

All the articles are available on the webpage:
http://www.pan-ol.lublin.pl/wydawnictwa/Teka-Motrol.html

All the scientific articles received positive evaluations by independent reviewers

ISSN 1730-8658

Editorial Office address
Polish Academy of Sciences Branch in Lublin
Pałac Czartoryskich, Plac Litewski 2, 20-080 Lublin, Poland
e-mail: eugeniusz.krasowski@up.lublin.pl

Publishing Office address
Lviv National Agrarian University
St. Vladimir the Great, 1, Dubliany, Ukraine, 80381
e-mail: motrol@ukr.net

Printing
Lviv National Agrarian University
St. Vladimir the Great, 1, Dubliany, Ukraine, 80381
phone: +38 032 22 42 954

Edition 150+16 vol.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 5-8

EXPERIMENTAL EVALUATION OF CAPACITY GAS REDUCER OF FOREIGN PRODUCTION, ADAPTED TO THE ENGINE POWER SUPPLY SYSTEM

Manoylo Vladimir, Shevchenko Igor, Kolesnik Ivan
Kharkiv Petro Vasylenko National Technical University of Agriculture
Moskovskyi prospect, 45, Kharkov, Ukraine. E-mail: ivankolesnik89@gmail.com

Summary. At the present time in our country have received wide spread of the gas-supply system of the 4th generation, mainly foreign production. Using the foreign power systems at the initial stage of development, it is possible to obtain high technical, economic and environmental indicators of the ICE workflow, which will later enable the production of domestic power systems. Constant tightening of the Euro requirements, forcing experts in this industry to continuously improve gas systems. Experimental studies were performed to assess the capacity of natural gas from a foreign gas reducer adapted to a domestic medium-power engine. From the analysis of the review of foreign gas reducers, the most preferable options have been chosen, which are supposed to be adapted to the domestic gas engine of medium power. Of particular interest is the series of unified gas reducers of the Italian firm BRC and Tomazetto. These modifications of gas reducers satisfy Euro 4-5 exhaust gas emission standards, they are distinguished by high reliability, small dimensions, maintainability, simple installation and easy start of the engine on gas fuel at low temperatures, and also the possibility of mounting to engines of different capacities. Nevertheless, during the experimental studies it was established:

- the capacity of this type of gas reducer allows them to be used on engines with liter volumes from 1.0 to 5.0 liters;

- technological intervention, associated with an increase in the diameter of the nozzles of the inlet openings by more than 2 mm, did not allow the use of this type of reducer on an ICE of average power with a liter capacity of up to 15 liters.

Key words: experimental estimation, gas reducer, power supply system, vehicle engine.

INTRODUCTION

Recently, a problem has arisen in the world engine development, related to the deficit of liquid motor fuels, which are produced from oil. As a result, there is a general trend associated with the use of liquefied or compressed natural gas on motor vehicles. Natural gas is widely used as a motor fuel for automotive tractor engines of various purposes.

Therefore, with the growth of gas fuel consumption, specialists need to develop more advanced power systems for automotive tractor engines, and the state should stimulate the development of domestic electronic gas control and dosing systems.

Currently widespread gas supply system of the 4th generation in our country [1, 2-8], mostly foreign-made. Using foreign power systems at the initial stage of development, it is possible to obtain high technical and economic and ecological indicators of the working process of automotive tractor engines, which will later enable the production of domestic power systems.

Constant tightening of the Euro requirements, forcing experts in this industry to continuously improve gas systems. The main constructive unit in gas-fired power supply systems with electronic control is a set of electromagnetic gas metering devices (EDG). However, its operation is not possible without simultaneous and coordinated work with the gas reducer [3, 4].

Therefore, this work is aimed, first, to study the particularities of the design of gas reducers (foreign production) for power systems for automotive tractor engines. Gas reducers are an integral part of power systems and work in combination (in pairs) with electromagnetic gas dispensers and, on them, the effective, reliable and coordinated operation of the electromagnetic gas dosimeter itself, as well as the power unit of the vehicle as a whole, depends.

Secondly, the work is aimed at choosing the most suitable (rational) to adapt the type of reducer, the consumption characteristics of which will be coordinated with the consumption needs of the gas engine in a wide range of changes in the speed and load conditions of the vehicle.

The main purpose of the gas reducer, in the scheme of the power supply system of the transport engine, is to provide a specified flow rate (productivity) of the working fluid supplied to the gas train of the metering unit in a wide range of changes in the speed and load modes of operation of the internal combustion engine.

At the same time, the gas pressure drop at the outlet from the reducer and the entrance to the gas ramp when the engine is running should be as small as possible. Since the non-linear drop (change) of the gas pressure in the gas train in different modes of operation of the transport engine complicates the algorithm of the working process of the microprocessor control unit for gas supply, power units of vehicles [11-13].

Therefore, the work aimed at adapting one of several most-preferred types of gas reducer of foreign production to the variant of the engine, which is being studied by the authors, is relevant.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Considerable attention among the European countries, the development and improvement of LPG equipment is on the Italian and Polish companies.

Firm «ELPIGAZ» [1], offers new technical solutions in the field of adaptation of automatic telephone exchanges for work on compressed gas (CNG), which are presented in the form of a new series of reducers of the C300 series manufactured by the Polish company «EMER». These reducers have found application in passenger cars and buses.

The authors reviewed the gas reducers of Italian companies for compressed [2-5] and liquefied gas [6-10]. On the basis of the survey, the most preferable in terms of consumption characteristics were the gas reducers of the Italian companies BRC and Tomazetto.

OBJECTIVES

The purpose of this work is to provide additional overview information to a wide range of readers, as well as specialists in the installation, repair, diagnostics and development of gas power systems for automotive tractor combustion engines.

From the analyzed technical information, the authors selected the most rational designs of gas reducers, which can be adapted to domestic designs of ICE for medium-sized mobile vehicles.

Technical interest reducers BRC company [2, 10, 14, 15] (Italy) where the following modifications designed gas reducers: Tecno, AT90ESO, AT90EP and others are also quite attractive reducers Tomazetto company [5, 16-18].

Over one of these modifications of the reducers of the firm Tomazetto, conducted an experimental study. The studies were carried out in conjunction with a series of metering devices, connected in series by the company Waltek (Italy).

A very brief description of the design features of the most preferred type of gearbox and the results of its investigation will be given below.

THE MAIN RESULTS OF THE RESEARCH

The Italian company M.T.M. S.r.l. BRC Gas Equipment produces various power systems for the operation of ICE, both on liquefied petroleum gas and on compressed natural gas. The company develops and modernizes gas equipment: it offers simple gas supply systems that can work in combination with carburetor vehicles; and developed the most sophisticated electronic power supply systems for Euro IV vehicles equipped with OBD diagnostics.

Gas reducers are used in power systems to reduce the propane gas or methane gas pressure that comes from the balloon, and to maintain a constant working gas pressure at the output of the LPG / CNG reducer (LPG-liquefied petroleum gas, CNG-compressed natural gas). Reducer (for compressed natural gas) provides a reduction in the pressure of the mixture from 200 to 10-15 MPa In the 1 st stage, and in the 2 nd stage of the node lowers the pressure of the working fluid to 0,1 – 0,2 MPa.

Gas reducers differ both in the adjustment method and in the device of the starting and idling system. Reducers are made of two types: electronic and vacuum.

Electronic reducers have some advantage over vacuum ones. When the ignition is switched on, when the switch is in the "gas" position, the starting gas portion is supplied to the intake manifold of the ATS engine, which is necessary for the best start of the engine. In vacuum reducers such a portion of gas is supplied only after a short time the starter works.

A system of controlled sequential injection of "Sequent" by M.T.M. is widely used. S.r.l.

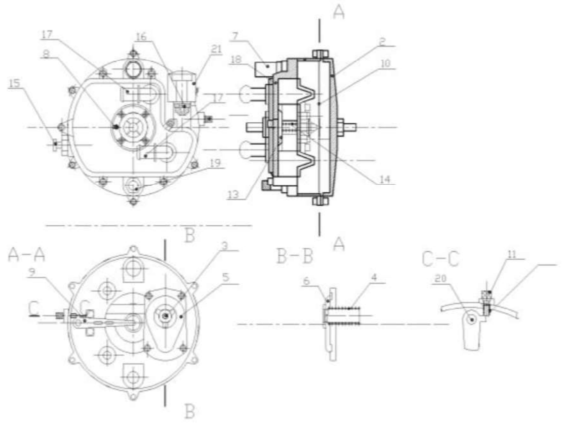


Fig. 1. Gas reducer-evaporator BRC AT90EP: 1 – reducer housing, 2 – cover, 3 – first reduction valve, 4 – conical spring of the first stage of the reducer, 5 – diaphragm, 6 – cover, 7 – outlet, 8 – pressure connection, 9 – second stage lever, 10 – second stage membrane, 11 – the adjusting screw of the second stage, 12 — the spring of the second stage, 13 – the discharge diaphragm, 14 – the spring of the discharge diaphragm, 15 – the gas inlet, 16 – the solenoid valve, 17 – the cooling pipe, 18 – the front cover, 19 – the condensate drain plug, 20 – the second valve, 21 – the solenoid

Technical characteristics of the reducer are given in table. 1.

Table 1. Technical characteristics of the gas reducer of BRC AT90EP

Housing material	Molded (under pressure) aluminum body
Node Weight	More than 1,6 kg
Overall dimensions of the reducer	100x150x160 mm
Max. outlet pressure	3 MPa
Power ICE	From 120 to 180 kW
Type of gas reducer	vacuum
Internal gas inlet inlet	6 mm
Internal outlet of the gas outlet	20 mm
The unit is suitable for operation at low gas quality	
The unit is equipped with a convenient condensate drain system; Emergency relief valve	

The electronic reducer of compressed gas BRC "Tecno" is shown in fig. 2.

This small size reducer makes it easy to install on any type of vehicle. It combines efficient operation and stable consumption characteristics for engines up to 150 kW. Technical characteristics of the reducer are given in table. 2.

At present, the automotive market in Ukraine is filled with various modifications of gas reducers for power systems of automotive and foreign combustion engines.

From the review of the gas reducers [19], which the authors made for a gas engine 6ГЧ 13/14 with spark ignition (medium power), a series of unified gas reducers of Italian firms BRC and Tomazetto are of particular interest.

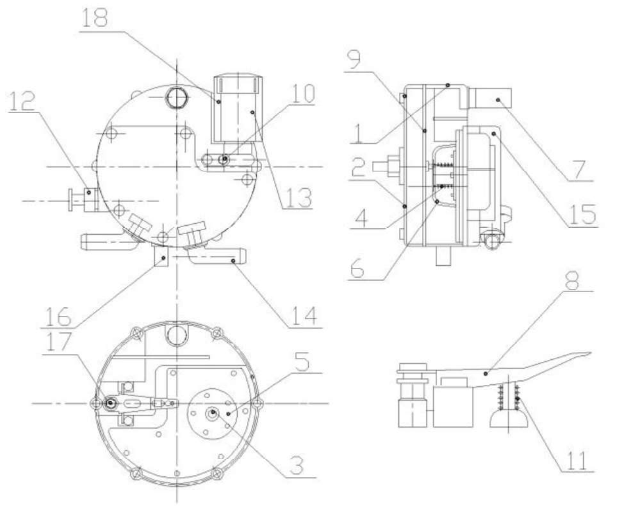


Fig. 2. Assembly drawings of the gas reducer-evaporator BRC Tecno: 1 – housing, 2 – the rear gearbox cover, 3 – the first stage valve, 4 – the first stage spring, 5 – the first stage membrane, 6 – the first stage cover, 7 – the outlet pipe, 8 – the lever of the second stage, 9 – the membrane of the second stage, 10–the adjusting screw, 11 – the spring of the second stage, 12 – the gas inlet, 13 – the solenoid valve, 14 – a branch pipe of a supply of cooling, 15 – a forward cover, 16 – drain of a condensate, 17 – the valve of the second stage, 18 – the solenoid

Table 2. Technical characteristics of the gas reducer of BRC Tecno

Housing material	Molded (under pressure) aluminum body
Node Weight	More than 1,2 kg
Overall dimensions of the reducer	100x120x125 mm
Max. outlet pressure	3 MPa
Power ICE	140 kW
Type of gas reducer	electronic
Rated voltage applied to the ends of the solenoid valve of the coil	12 V
Rated power of the shut-off solenoid valve	11 W
Internal gas inlet inlet	6 mm
Internal outlet of the gas outlet	10 mm
The unit is suitable for operation at low gas quality	

Nevertheless, in order to finally make sure the correctness of the chosen technical solution, it is necessary to carry out tests to determine the throughput (productivity) of gas reducers in a wide range of speed and load modes of operation of autotractor ICEs.

In the laboratory of ICE KhNTUA, on a non-motorized bench for testing gas-fuel equipment, joint experimental studies of a set (consisting of four units) of electromagnetic gas metering devices of the Italian company Waltex (Italy) and a two-stage gas reducer Tomazetto (Italy) were carried out.

The purpose of the experiment is to determine the throughput and stability of the parameters of the working fluid in a gas reducer, working together with a set of gas metering devices installed to adapt to a domestic medium-range gas engine.

The results of the experimental studies were carried out at five speed regimes n = 1000, 2000, 3000, 4000 and 5000 min^{-1}, respectively, and five load operation modes represented in the form of different time intervals (τ = 8, 10, 12, 14 and 16 ms) Opening by the valve-core of the bypass holes of gas supply in the internal combustion engine.

The standard diameter of the set of nozzles of the dispenser is 1.6 mm. Constructive features of the node allow to increase the diameter of the nozzles to the maximum possible permissible value, respectively, equal to 3.5 mm.

Results of joint studies of low-pressure gas reducer.

Italian company Tomazetto and a set of gas metering devices from Waltex are shown in Fig.3

It has been experimentally established that the efficiency of the dispensers depends directly on the stable and efficient operation of the low pressure reducer.

It can be seen from the graphs that reliable and efficient operation of the low pressure gas reducer is carried out only in the range of pressures from 200500 Pa to 349000 Pa (from 0,08 to 0,25 MPa).

Further, with an increase in n and τ to the maximum values, a sharp drop in the values of the pressure of the working fluid in the gas train is observed with respect to the static pressure on which the reducer is regulated.

The drop in pressure after the reducer in the gas train (at τ = 16 ms and n = 5000 min^{-1}) was about 12.6%.

Then experiments were carried out for maximum performance and limit of maximum static pressure, which is possible to adjust this type of reducer. At the limit of maximum pressure of the gas medium P = 550900 Pa (0,42 MPa), the pressure value at which the serial reducer is not operated), the gas pressure drop after the reducer, respectively, reached 37.4%.

It became obvious that it is not advisable to adapt this reducer to the power system of the gas engine 6ГЧ 13/14, due to the low capacity of this reducer for such a liter engine volume. Small through-hole sections made by the manufacturer in the body and other parts of the GRND do not allow using it on medium-capacity transport engines.

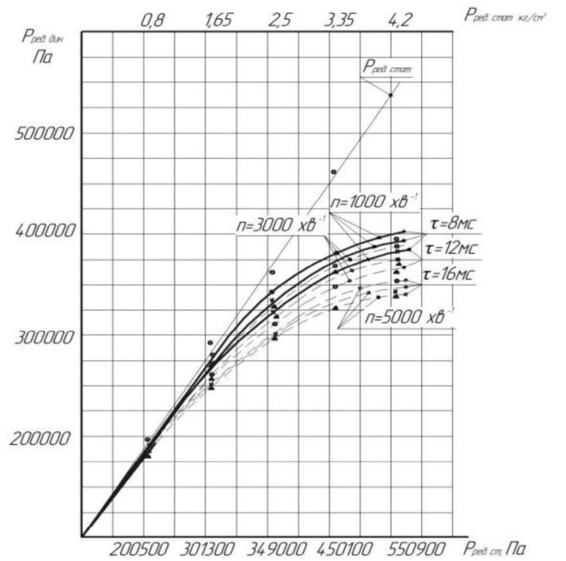


Fig.3. Experimental estimation of the gas capacity of the low pressure gas reducer of the Italian company Tomazetto using the kit of gas dispensers of Waltex

The performance of a single dispenser with a calibrated nozzle diameter of 3.5 mm with a gas pressure in the reducer of 349000 Pa does not exceed 4.1 m^3 / h, and naturally does not correspond to the required (passport) performance of the vehicle engine, which should be equal 8.1 m^3 / h.

CONCLUSIONS

From the analysis of the review of foreign gas reducers [1-10], the most preferable options have been chosen, which are supposed to be adapted to the domestic gas engine of medium power [19, 20]. Of particular interest is the series of unified gas reducers of the Italian firm BRC and Tomazetto. These modifications of gas reducers meet Euro 4-5 standards, they are distinguished by high reliability, small dimensions, maintainability, simple installation and easy start of the engine on gas fuel at low temperatures, and also the possibility of mounting to engines of different capacities. Nevertheless, during the experimental studies it was established:

1. The capacity of this type of gas reducer allows them to be used on engines with liter volumes from 1.0 to 5.0 liters.

2. Technological intervention, associated with an increase in the diameter of the nozzles of the inlet holes by more than 2 mm, did not allow the use of this type of reducer on an ICE of average power with a liter capacity of up to 15 liters.

REFERENCES

1. **Based on the materials of the company «ELPIGAZ» (Poland) 2008.** A new series of reducers for compressed gas / Based on the materials of the company «ELPIGAZ» (Poland) // International scientific and technical journal. «Transport on alternative fuel» № 6 (6). 30-31. (Russian).
2. **Tymchenko I.I. 1995.** Automobile engines / I.I. Tymchenko, Y.F. Gutarevicn, K.E. Dolganov, M.R. Muzhdabaev; edited by. I.I. Tymchenko. – Kharkiv.: Osnova, 464. (Ukraine).
3. Injector gas equipment [Electronic resource] / Resource access mode: http://www.motor-gas.com.ua /injection gas equipment.
4. **Panov Y.V. 2003.** Installation and operation of gas vehicle equipment. – M.: Publishing center "Academy", 160. (Russian).
5. **Trushin V.M. 1990.** Gas equipment and fittings for cars working on gas. – Leningrad, 250. (Russian).
6. **Grigor'ev E.G. 1989.** Gas balloon cars / E.G Grigor'ev, B.D. Korubaev, V.I. Eroxov and others. – M.: Mechanical engineering, 216. (Russian).
7. **Morev A.I. 1992.** Gas balloon cars: Directory / A.I. Morev, V.I. Eroxov, B.A. Beketov and others. - M.: Transport, 250. (Russian).
8. **Zolotnitsky V.C. 2001.** Power system for gasoline vehicles. - M.: "Third Rome" Publishing House, 125. (Russian).
9. **Klennikov E.V. 1986.** Gas balloon cars: Technical operation / E.V. Klennikov, O. A. Martyrov, M.F. Krylov // - M.: Transport, 77. (Russian).
10. **L'otko V. 2000.** The use of alternative fuels in internal combustion engines / V. L'otko, V.N. Lykanin, A.S. Xachiyan // - M.: MADI (TC), 325. (Russian).
11. **Morev A.I. 1988.** Operation and maintenance of vehicles working on gas / A.I. Morev, V.I. Eroxov // M.: Transport, 187. (Russian).
12. **Grigor'ev E.G. 2001.** Automotive gas supply systems / E.G Grigor'ev, B.D. Korubaev, V.I. Eroxov and others. – M.: Mechanical engineering, 175. (Russian).
13. **Zolotnitsky V.C. 1997.** Domestic and foreign gas equipment on passenger cars // Publishing house: «LIVR», 46. (Russian).
14. **Zolotnitsky V.C. 2005.** New gas fuel systems of cars // ed: "Publishing House Third Rome", 64. (Russian).
15. **Afonin S. 2001.** Gas equipment of cars. Cars, trucks. Device, installation, maintenance. A Practical Guide // Publishing house: «PONchIK», 53. (Russian).
16. **Lixanov V.A. 2006.** Application and operation of gas cylinder equipment / V.A **Lixanov**, R.R Devetiarov. Ed: "Kirov: Vyatka State Agricultural Academy", 183. (Russian).
17. **Zolotnitsky V.C. 2007.** Automotive gas fuel systems / V.C Zolotnitsky // Publishing house: "AST", 128. (Russian).
18. **Chernov A. 2005.** Principle of operation and design features of gas engine control systems / A. Chernov, D. Alekseevskij // Auto gas filling complex. Alternative fuel. International scientific and technical journal. – №5 (23). 40-45. (Russian).
19. **Gavrilov A.K. 1991.** Car gas equipment / A.K. Gavrilov N.G. Pevnev L.N. Buxarov // M.: Nedra, 144. (Russian).
20. **Vasil'ev Y.N. 1992**. Transport on gas / Y.N. Vasil'ev, A.I. Gritsenko L.S. Zolotarevskij // M.: Nedra, 342. (Russian).

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 9-12

CALCULATION SCHEME OF THE OSCILLATORY SYSTEM "MANUAL VIBRO-SHOCK SHAKER – THE FRUIT SPUR"

Shevchuk Roman, Krupych Roman
Lviv National Agrarian University
V. Velykogo Str. 1, Dubljany, Ukraine. E-mail: rshevchook@i.ua

Summary. Modernization of the scheme of the Italian vibration shaker of fruits SC105 created a basic scheme of manual vibration shock shaker, generating a wide range of shaking frequencies, which covers the range of required shaking frequencies of all branches and increases the completeness of the fruit removal. On the basis of the principal scheme, the calculation scheme of the oscillating system "manual vibro-shock shaker - fruit spur" is developed, which allows to obtain differential equations of motion of all masses of the indicated oscillatory system.

Key words: scheme, oscillatory system, manual vibration shock shaker, branch, fruit, frequency of shaking, spectrum, range, completeness of removal.

INTRODUCTION

Vibrating fruit harvesting tools [1, 2] do not always provide a high, agro technically regulated fullness of the fruits removal. The branches have different diameters and lengths and from these sizes the range of required shaking frequencies depends, by which a high completeness of removal is achieved. To achieve this, a wide spectrum of shaking frequencies, covering the required range of frequencies, must be generated.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The research of fruit-harvesting tools of the shaking type [3-16] indicates that the work is directed at the improvement of vibration means and creation of vibration shock shakers based on tractors, chassis or special self-propelled power vehicles. The results of the researches are significant, however, they require an expansion in the direction of creating and substantiating the parameters of manual vibro-shock shakers of fruits intended for work in thickened plantations and on the slopes.

The theoretical analysis of the parameters of oscillatory systems is based on their calculation schemes. The high results of such an analysis can be achieved if the calculation scheme broadly takes into account the features of the developed oscillatory system. That is, each developed scheme of the fruit shaker must meet its design scheme, in particular - and the calculation scheme of the oscillating system "manual vibration shaker - fruit spur".

OBJECTIVES

By modernization of the scheme of the Italian vibration shaker of the fruit SC105 to create a schematic diagram of the manual vibration shaker, generating a wide spectrum of shaking frequencies, which covers the range of required shaking frequencies of all branches, which increases the completeness of the fruit removal. In addition, on the basis of the established schematic diagram of the shaker to develop a calculation scheme of the oscillating system "manual vibration shock shaker - the fruit spur", which is the basis for further theoretical analysis of the indicated oscillatory system and obtaining differential equations of motion of all concentrated masses of constituent parts of the shaker and the consolidated mass of the fruit branch.

THE MAIN RESULTS OF THE RESEARCH

Manual vibration shaker [17-22] contains (Fig. 1) an oscillator 1of crank-sliding type, executed in the form of a body 2, whose bearings are rotor mounted on the shaft 3 and driven 4 conical gears. On the driven conical gear 4 a crank 5 is mounted hingedly connected to a piston rod 6, which is hingedly connected to a slider 7 mounted in the guide of the body 2 of the oscillator 1. To the body 2 it is attached the body 8 of the centrifugal coupling 9 in the form of a driving 10 and a driven 11 parts. The driving part 10, made as a hub with hinge mounted on it, is connected to the internal combustion engine 12 attached to the body 8 of the centrifugal coupling 9. The driven part 11 of the centrifugal coupling 9 is mounted on the shaft of the driving conical gear 3.

The shaker is equipped with a shock mechanism 13 with an adjustable shock impulse. A shock mechanism 13 is executed in the form of a cylinder 14 and attached to its ends of lids 15 and 16. The one lid15 is connected to the slider 7 of the oscillator inverter 1, and in the cylinder 14 there are sliding cups 17 and 18, between which a spring 19 is located and the washer 20 adjusts its previous tension. In sliding cups 17 and 18, a slide rod 21 with stops 22 and 23 and washers 24 adjusting the gap between these cups is installed. To a slide rod 21 a bar 25 is attached, with its rotation lever 26, and on the bar 25 a fork 27 is mounted, equipped with elastic cushions 28 and 29. These cushions are located at a certain angle to each other, forming a wedge slope, through which the bark of branches of various diameters is tightly covered.

To the body 2 of the oscillator 1, brackets 30 and 31 are attached, in the holes of which a guide rod 32 is mounted on the mechanism of retention, maneuvering and control of the shaker. On the guide rod 32 damping springs 33 and 34 and stops 35 and 36 adjusting the pretension of these springs are installed. In the front of the guide rod 32 there is a handle 37 with damper springs 38 and 39, and a transversal lever 40 is mounted on the rear of the guide rod 32. One end of the lever 40 is a retaining strap 41, connected to the other end with a guide rod 32.

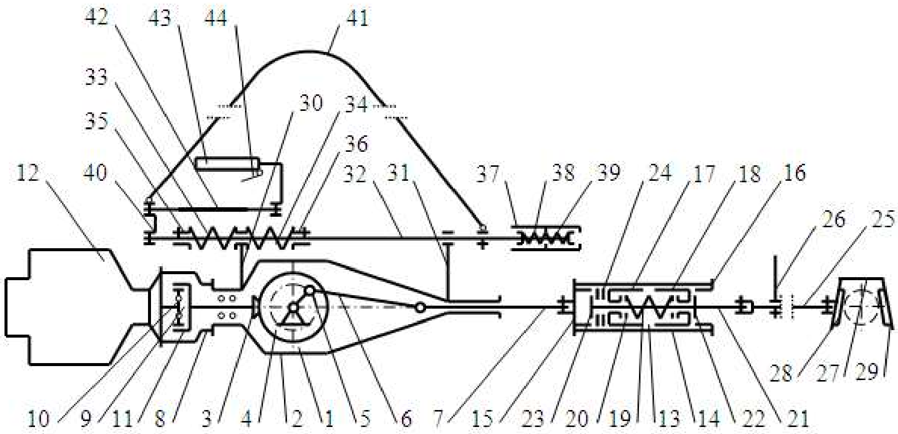


Fig.1. The principal scheme of the manual vibration shaker

To the transverse lever 40 an elastic insert 42 is also attached to which the handle 43 is fixed with the lever 44 for controlling the fuel supply system of the internal combustion engine 12 of the shaker.

After capturing the branches, the worker-collector of the fruits increases the fuel supply and, accordingly, - the rotational speed of the engine 12. The centrifugal coupling 9 is used, the crank 5 of the oscillator starts to rotate. Simultaneously with the translational motion of the slider 7, the perturbing force is harmoniously changed through the shock mechanism 13, the bar 25 and the grip 27 and transmitted to the fruit branch. Shaking of the branch with frequency of change of perturbing force is provided. Such a vibration mode of shaking continues until there is a gap between the sliding cups 17 and 18.

At the moment when the named cups are struck one after the other, the harmoniously changing perturbing force is supplemented by the force of impact, and vibration shaking mode of the fruit branch shaking is ensured.

The law of the change in the force of impact is the sum of harmonically varying perturbing forces with a wide spectrum of frequencies. That is, in the vibro-shock mode, a broad spectrum of shaking frequencies is generated that covers the range of required shaking frequencies for all branches, and therefore the completeness of the removal of the fruits that fall to the intermediate row surface increases.

The calculation scheme of the oscillating system of the "manual vibro-shock shaker – fruit spur" (Fig. 2) consists of a branch, the mass of which is m, and a manual vibrating shaker, having four links with lumped masses m_1, m_2, m_3, and m_4. In particular, m_1 is the weight of the bar 25 (fig. 1) together with the grip 27, the elastic cushions 28 and 29, and also with the part of the shock mechanism 13, the sliding rod 21, the adjusting washers 24, one of the sliding cups 17 or 18, and the clamp of connection of the specified rod and bar. Mass m_2 is the sum of the masses of the conducting part of the oscillator of the shaker 1 and the driving part of the shock mechanism 13, namely: parts of the piston rod 6, washers 20. Mass of m_3 of the main part of the shaker form an internal combustion engine 12, a centrifugal coupling 9, a part of an oscillator inverted 1, excluding the parts of the connecting rod 6 and the slider 7, but taking into account the brackets 30 and 31 of the mechanism of holding and controlling the shaker. This mechanism has a mass m_4 consisting of masses of the guide rod 32, damper springs 33 and 34, stops 35 and 36, handles 37 with damping springs 38 and 39, a transverse lever 40, an elastic insert 42, and a handle 43 with a lever 44.

Links weighing m_2 and m_3 (Fig. 2) are connected with each other by means of the curve- toothed-slide mechanism, the crank of which r rotates at a constant angular velocity ω_c, and the piston rod 6 has a length of l_0. We assume that link 4 with mass m_4 is connected to a link of 3 mass m_3 at points A and B with the help of ideal cylindrical hinges. All other internal and external joints, imposed on the oscillating system "manual vibration shaker - fruit spur," will be considered elastic or visco-elastic with certain coefficients of stiffness or stiffness and viscous resistance. We choose the origin of the fixed coordinate system xOy at the point O, which coincides with the center of mass m_4 when there is no action of any forces on the specified oscillatory system. Since the outer bands, imposed on a link of mass m_4, are elastic, this link can perform a plane-parallel motion - to move in the direction of coordinate axes and to return to a certain angle φ around the center of mass m_4. Links of mass m_1, m_2, and m_3 are in a complex motion, the portable component of which is determined by the movement of the link 4, and the relative movement of the indicated links can be made relative to the link 4 in the direction of the axis Oy. The motion of a branch of mass m in the direction of the Oy axis is independent, and the movement in the direction of the axis Ox is determined by the links of the shaker mechanism.

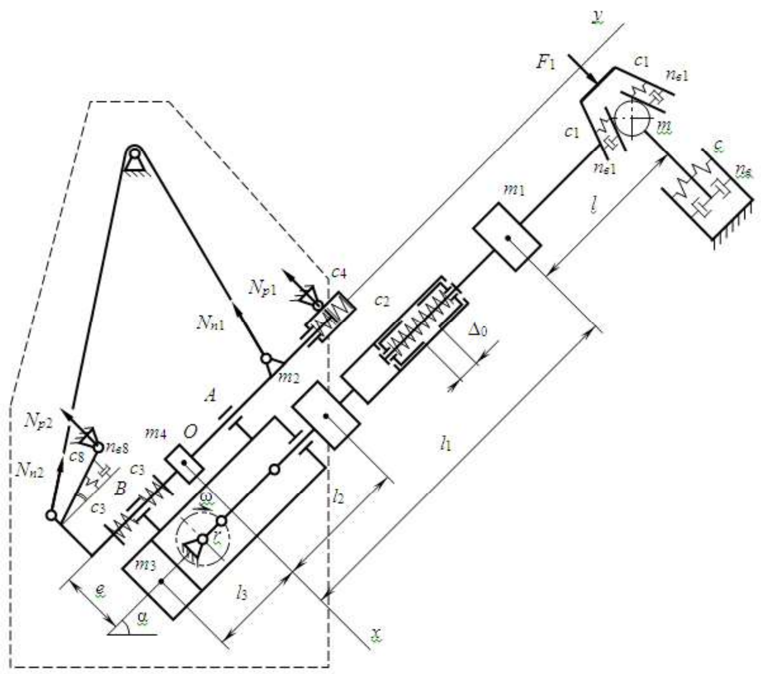


Fig.2. A calculation scheme of the oscillating system "manual vibration shock shaker - the fruit spur"

In addition, in Fig. 2 we noted: c, c_1, c_2, c_3, c_4, c_8 – coefficients of stiffness of a branch and components of a shaker; n, $n_{в1}$, $n_{в8}$ – coefficients of viscous resistance of a branch, cushions of capture and elastic insert; l, l_1, l_2, l_3 – the distance to the coordinate axis Ox from the centers of the mass of the branch and the corresponding parts of the shaker; Δ_0 is the initial gap between the sliding cups of the shock mechanism; e is the distance between the longitudinal axes of the guide rod of the holding and control mechanism and the all shaker; α is the angle of the oscillation direction, that is, the angle of the bar to the horizontal; N_{p1}, N_{p2} – normal reactions of the hands of the worker-collector of fruits on the handles; N_{n1}, N_{n2} – the reaction of the holding strap; F is the force of pressing the capture.

The oscillating system, the "manual vibration shaker – the fruit spur" has six degrees of freedom, namely: the mass m_4 has three degrees of freedom, and the masses m_3, m_1 and m are one degree of freedom. In order to find the regularity of the motion of all masses of the oscillatory system and the reaction of the joints to four differential equations of longitudinal motion of masses m_4, $m_2 + m_3$, m_1 and m, we must combine two differential equations of the transverse and rotational movements of the entire oscillatory system.

CONCLUSIONS

The design scheme of the oscillating system "manual vibro-shock shaker - fruit spur" is developed taking into account the peculiarities of the established principle scheme of the manual vibro-shock shaker of the fruit. This calculation scheme is the basis of the theoretical analysis of the oscillatory system and the obtaining differential equations of motion of all concentrated masses of the components of the shaker and the consolidated mass of the fruit branch.

REFERENCES

1. Engineering. Encyclopedia 1998. Ed. council: K.V. Frolov and others. T. IV-16. Agricultural machinery and equipment. / I.P. Ksenevich, G.P. Varlamov, N.N. Kolchin and others – M.: Engineering. 45–53. (Russia).
2. **Varlamov G.P. 1978.** Machines for fruit harvesting / G.P. Varlamov – M.: Engineering, 216. (Russia).
3. **Shevchuk R.S. 2001.** Processes and means of mechanization of removal of fruits. / R.S. Shevchuk P.C. Dis ... doc. Agricultural Sciences: 05.20.01. – M, 532. (Russia).
4. **Shevchuk R.S. 2001.** Prospects for the development of fruit and vegetables harvesters / R.S. Shevchuk // Agricultural machines: Zb. sciences Ave. Lutsk State Technical University, Ed. 8. – Lutsk. 363–367. (Ukraine).
5. **Shevchuk R.S. 2002.** Operational indicators of means for mechanized removal / R.S. Shevchuk // Visnyk of Lviv State Agrarian University: Agro engineering researches. – №6. 107–112. (Ukraine).
6. **Krupych O.M. 2003.** Substantiation of the hydraulic circuit of the drive of the cable shaker of fruits / O.M. Krupych, R.S. Shevchuk, J.V. Semen, R.I. Paslavskyi // Mechanization of agricultural production: Coll. Science works of National Agricultural University. T. XII. – K. 261–269. (Ukraine).
7. **Shevchuk R.S. 2003.** Vibro-shock shakers for fruits / R.S. Shevchuk, O.V. Dranyi, V.I. Kotysko // Tractors and agricultural machines. – №7. 37–39. (Russia).

8. **Shevchuk R.S. 2005.** Hydraulic actuator of fruit shakers with alternate inclusion of pneumatic and hydraulic accumulators / R.S. Shevchuk, I.J. Pidstrygach, J.V. Semen, O.F. Pryshlyak // Engineering of agro-industrial complex. – №10–11. 36–37. (Ukraine).
9. **Shevchuk R.S. 2006**. Hydraulic actuator for fruit with alternate inclusion / R.S. Shevchuk, I.J. Pidstrygach, O.V. Dranyi // Tractors and agricultural machines. – №4. 15–16. (Russia).
10. **Myronyuk O.S. 2008.** The substantiation of the functional structure of the vibration shock shaker / O.S. Myronyuk, R.I. Paslavskyi, R.S. Shevchuk // Engineering of agro-industrial production: Scientists of the Faculty of Mechanics and Energy - for production. – Ed. 2. – Lviv. 10–12. (Ukraine).
11. **Shevchuk R.S. 1998.** Elements of the theory of research of vibro-impact removal of fruits by a shaft shaker / R.S. Shevchuk // Visnyk of Lviv State Agrarian University: Agro engineering researches (№2). – Lviv. 65–68. (Ukraine).
12. **Shevchuk R.S. 1999.** Interaction of a cable vibro-impact shaker of fruit with a tree / R.S. Shevchuk // Coll. Science works. All-Russian Institute of Agricultural Mechanization. – M. 25–33. (Russia).
13. **Shevchuk R.S. 1999.** Interaction of the standard vibro-impact shaker of the fruit with the tree / R.S. Shevchuk // Agricultural machines: Zb. sciences Ave. Lutsk State Technical University, Ed. 5. – Lutsk. 322–326. (Ukraine).
14. **Shevchuk R.S. 2004.** Model of pneumo-hydraulic accumulators in drives of linear vibro-shock shakers of fruits / R.S. Shevchuk // Engineering of agro-industrial complex. – №10–11. 34–35. (Ukraine).
15. **Semen J.V. 2006.** Energy efficiency of using pneumatic and hydraulic accumulators in hydraulic drives of harvesting machines / J.V. Semen, O.M. Krupych, R.S. Shevchuk // Motorization and Energetics in Agriculture. Motoryzacja I energetyka rolnictwa. – Vol. 8A. – Lublin, – 251–257. (Poland).
16. **Semen J.V. 2002.** Economic studies of the process of assembling apples with a cable vibration shock shaker with an accumulator ї / J.V. Semen, O.M. Krupych, R.S. Shevchuk // Proceedings of the Tavria State Agrotechnical Academy. – Ed. 7. – Melitopol: TDADA. 110–115. (Ukraine).
17. **Shevchuk R.S. 2011.** Manual vibro-shock shaker of fruits / R.S. Shevchuk, R.O. Кrupych // Agricultural machines: Zb. sciences Ave. Lutsk State Technical University. – Ed. 21, tome II. – Lutsk: Ed. Department of Lutsk National Technical University. 238–243. (Ukraine).
18. **Shevchuk R.S. 2013.** Manual vibro-shock shakers of fruits / R.S. Shevchuk, R.O. Кrupych // Scientists of the Lviv National Agrarian University - for production: Catalog of innovational developments / Under the constituents. Ed. V.V. Snitinsky. – Ed. 13. – Lviv: Lviv National Agrarian University, 53. (Ukraine).
19. Patent 95453 Ukraine, МПК A01D 46/26. Manual vibro-shock shakers of fruits / The applicant R.S. Shevchuk, R.O. Кrupych. –№ 201407346; Declared 01.07.2014; Published 25.12.2014, Bul. №24. (Ukraine).
20. **Shevchuk R.S. 2015.** Modernized hand fruit shaker / R.S. Shevchuk, R.O. Кrupych. // Engineering and technology of agro-industrial complex. – № 3(66). 24–26. (Ukraine).
21. **Shevchuk R.S. 2016.** Manual vibro-shock shakers of fruit / R.S. Shevchuk, R.O. Кrupych // and agricultural machines. – № 1. – 21–25. (Russia).

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 13-18

MODELING AND ANALYSIS OF EFFICIENT ELECTROMAGNETIC PARAMETERS OF CAPILLARY SYSTEM OF ELECTRICAL CONDUCTIVITY OF AGRICULTURAL SOILS I: METHOD OF ANALYSIS OF NON-STATIONARY ELECTROMAGNETIC FIELDS IN DISPERSIVE AND CONTROLLED ENVIRONMENTS

Brovarets Olexander[1], Chovniuk Yuri[2]
[1]Kyiv Cooperative Institute of Business and Law
Lomonosova Str., 18, Kiev, Ukraine. E-mail: brovaretsnau@ukr.net
[2]National University of Life and Environmental Sciences of Ukraine
Heroes of Defense Str., 15, Kiev, Ukraine. E-mail: brovaretsnau@ukr.net

Summary. We have developed exact models of impulsive optics of dispersive media such as agricultural soils (AS), in the time dimension such models describe the interaction of ultra-short video impulses, which consist of only one or several field fluctuations, with some classes of dielectrics and conductors of (AS). Fields that are excited by video impulses in these environments can be submitted analytically due to precise non-periodic and non-stationary solutions of the Maxwell equations. Such solutions are obtained directly in the time dimension, outside the Fourier - plans and without the traditional separation of fields into parts / components which depend on time or coordinates (i.e., inseparable solutions). These inseparable solutions form the mathematical basis for the analysis of non-sinusoidal waves. Flexible simulation of the form of video impulses with the help of Lager's functions allows to explicitly representing the processes of reflection and refraction of the video impulses of electromagnetic fields from their forms and duration when interacting with the AS.

Key words: modeling, analysis, electromagnetic parameters, capillary system, electrical conductivity, agricultural soils, non - stationary electronics, dispersion, conductivity, non – Fourier analysis.

INTRODUCTION

Non-stationary electromagnetic fields in dispersive and conducting environments (such as AS) can be formed under the influence of short-wave impulses on these environments. Nowadays the effects of shock excitation and the propagation of such waves attract researchers of the AS electrical conductivity by means of non-stationary electrodynamics. This attention is due to a number of reasons.

Recent successes in generating video impulses using broadband radars have stimulated interest in the prospects of using video impulses for the transmission of energy and information through solid media [1]. The structure of such impulses is significantly different from the traditionally studied models with rectangular or Gaussian curvature:

a) the envelope of the video impulse consists of only one or several oscillations, the forms of which are usually far from sinusoidal;

b) the front and rear fronts are asymmetrical;

c) the distances between the points of the zero intersection are uneven.

Dispersion and diffraction of finite-duration video impulses on finite-size targets lead to a number of new effects. In contrast to the usual representations of the stationary dispersion indicatives and diffraction patterns characteristic of long stretched strings of sinusoidal waves, the field of the dispersive video impulse changes rapidly over time. Classical formulas for dispersion monochromatic waves on a cylinder or diffraction on a slit and circular aperture are only partial instances of expressions describing the non-stationary interaction of short video impulses with such objects [2].

Traditional solutions of the Maxwell equations in continuous media are connected with the representation of solutions in the form of product of functions dependent, either on coordinates or on time (i.e., separate solutions); at the same time, the time dependence is usually investigated using the Fourier transformation. For many years, such an approach shaped the language of describing quasi-monochromatic waves in optics, acoustics and radio physics; however, attempts to apply this same approach in the dynamics of the interaction of short video impulses with dispersive media and, in particular, conductors of (AS) encountered unexpected difficulties, both conceptual and computational:

a) due to Fourier transformation of the enveloping signal of finite duration averaged over an infinite interval of time (from $-\infty$ to $+\infty$). The areas of rapid change of envelope are hidden at this time; however, these areas are important for signal registration in the information machines for (AS). On the other hand, to restore the time bending localized signal with the help of a careful Fourier transformation, the fields of harmonics outside the localization area should be excluded, however, to clarify the region of localization should take into account the increasing density of harmonic components;

b) the deformation of the impulse in the dispersive medium is described, as it is known, in the frequency region by the method of decomposition of the phase in a series of degrees of the ratio of the spectral width of the impulse $\Delta\omega$ to the carrier frequency ω [2] However, for short impulses of a broad band consisting of one or more field fluctuations, the ratio $\Delta\omega/\omega$ is not a small parameter; with the amount of spectral components needed to synthesize the field of the impulse in the depth of the environment, it becomes quite large. This situation gives rise to a number of computational difficulties [3];

c) in the expansion of the phase of the wave due to degrees of ratio $\Delta\omega/\omega$, all components have a refractive index in the denominator $n(\omega)$. If in the impulse spectrum there is a cutoff frequency of a dispersive transparent medium ω_0, then $n(\omega_0)=0$, and the row which represents the phase layout, becomes discrepancy.

It should be emphasized that these difficulties are not related to the Maxwell equations, but with the traditional method of their solution by separating the Fourier transforms and transformations. However, the representation of fields using this method is not a consequence of the Maxwell equations, but only one of the ways of their solution; this method is convenient for describing quasi-monochromatic waves with slowly varying amplitude and phase, but is ineffective for the analysis of non-stationary and non-harmonic fields.

You can obtain information about such fields using new Maxwell equations, built directly in the time domain, without using the standard separation of variables and beyond the limits of Fourier-plans. Such inseparable, precise analytical solutions that are not bound by traditional assumptions about the small value and slowness of the time-varying fields form a mathematical basis for the description of fast-changing non-periodic fields and short impulses in dispersing media. This medium is considered to be stationary in the state of rest and not the stationary space-time structure of the propagating field due to significant changes in its bending characteristic time, which is determined by the microscopic processes of determining the field in the environment, in particular, in AS (for example, the time duration of the bulk charge relaxation in the conductor). Such unsteady electrodynamics of stationary media is the subject of this study.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

The authors [2, 4-9] investigate various aspects of the propagation of electromagnetic waves with a wide frequency band (so-called short impulses) in conducting media. However, the AS has not yet been investigated in this regard, although this task is relevant, especially for the analysis on the basis of the electrical conductivity of AS, the possibilities of their replenishment in future crop yields grown on these soils (usually under constant monitoring). It should be noted that the results of the above works will be partly used in this study.

OBJECTIVES

The purpose of this work is to substantiate the physical - mechanical model and the method of analysis of the distribution of short electromagnetic impulses in dispersing and conducting environments such as AS, the methods developed in the works [5-8].

THE MAIN RESULTS OF THE RESEARCH

Non-standard electromagnetic fields in the AS are described in this paper in a time dimension by means of exact solutions of the Maxwell equations [7]:

$$\begin{cases} rot\vec{E} = -\dfrac{1}{c}\cdot\dfrac{\partial\vec{B}}{\partial t}, \\ div\vec{H} = 0 \end{cases} \qquad \begin{cases} rot\vec{H} = \dfrac{1}{c}\cdot\dfrac{\partial\vec{D}}{\partial t}. \\ div\vec{D} = 0 \end{cases} \tag{1}$$

The induction $\vec{D}$ is connected with the electric field $\vec{E}$ and with the current $\vec{j}$ given by this field in the AS, known by the formula:

$$\vec{D} = E\infty\cdot\vec{E} + 4\pi\cdot\int_{-\infty}^{t}\vec{j}dt. \tag{2}$$

In the formulas (1), (2) the following notations are introduced:

where: t – time, $\vec{E}$ – electric field strength, $\vec{B}$ – magnetic induction of this field, $\vec{H}$ – magnetic field strength, c – speed of light in vacuum, D – vector of electric polarization of the medium (so-called electrical induction), $E\infty$ – dielectric permeability of the medium (AS) for high frequencies (for the boundary of these frequencies, which goes to infinity).

Below we will assume (at the first stage of the AS study) that the medium is nonmagnetic and isotropic. (In the further sense of the study of the properties of AS, the property of isotropy will be removed).

For further research and analysis it is expedient to express the components of the field $\vec{E}$ and $\vec{H}$ through the vector – potential $\vec{A}$ according to the known formulas:

$$\vec{E} = -\frac{1}{c}\cdot\frac{\partial\vec{A}}{\partial t},\quad \vec{H} = rot\vec{A}. \tag{3}$$

The support (3) in (1) reduces the first equation of the system (1) to the identity. For cross-polarized fields, which are considered in the following, the spatial-temporal evolution of the vector-potential $\vec{A}$ is described by the equation (second) of the system (1) and the material equation $\vec{j} = j(\vec{E})$.

This system of equations is traditionally used to construct optics of sinusoidal waves in the frequency area. However, this approach is not a universal system for constructing wave optics based on Maxwell's equations. Part of the information contained in these equations clearly manifests itself when using solutions obtained directly in the time dimension. It is this alternative approach, suitable for the analysis of impulsive electromagnetic fields in dispersive conducting and non-conducting media of (AS), is developed in this paper. This approach is based on inseparable solutions of the Klein-Gordon equation and the telegraph equation. It should be noted that the possibilities of flexible modeling of video impulses that excite such fields, using the Lager and Hermite functions, in conjunction with the inseparable solutions of the Maxwell equations for fields inside dispersive media form a model of optics of video impulses in an AS that can be precisely solved.

Let us consider below the inseparable solutions of the Klein-Gordon equation in the optics of dispersive media of the AS type.

The physical foundations and mathematical apparatus of the theory of non-stationary wave processes in dispersive media of (AS type) are clearly illustrated by the problem of the propagation of an electromagnetic field in a conducting isotope medium. Let us consider for simplicity the one-dimensional problem of the propagation of a plane linearly polarized wave.

The current density $\vec{j}$ induced in such an AS, for example, by a field $\vec{E}$, is determined in the linear approximated equation:

$$\frac{\partial \vec{j}}{\partial t} = \frac{\Omega^2}{4\pi} \cdot \vec{E}. \quad (4)$$

Here Ω is the so-called "plasma" frequency of AS, which is related to the density N, the charge ℓ and the mass m of ions:

$$\Omega^2 = 4\pi \cdot \ell^2 \cdot N/m. \quad (5)$$

By defining the components of the wave field E_x and H_y through the component of the vector potential $\vec{A}$ (3) and combining with the second equation (1), (2) and (4), we have an equation for the function $\vec{A}$ ($A_x \neq 0; A_y = A_z = 0$) in the form:

$$\frac{\partial^2 A_X}{\partial Z^2} - \frac{1}{c^2} \cdot \frac{\partial^2 A_X}{\partial t^2} = \frac{\Omega^2}{c^2} \cdot A_X, \; A_x = A_x(z, t). \quad (6)$$

Equation (6) is the Klein-Gordon equation. Traditional solutions of this equation describe, as it is known, harmonic waves with frequency ω and wave vector k:

$$A_X = A_O \cdot \exp[i \cdot (kz - \omega t)], \; i^2 = -1,$$

$$k \cdot c = \sqrt{\omega^2 - \Omega^2}. \quad (7)$$

Along with the (7) the Klein-Gordon equation has a large number of classes of precise analytical non-harmonic solutions in the time dimension. To construct such solutions, it is expedient to introduce a normalized vector potential f and dimensionless variables η and τ by the formulas:

$$A_X = A_O \cdot f(\eta, \tau), \; \eta = z \cdot \Omega \cdot c^{-1}, \; \tau = \Omega \cdot t. \quad (8)$$

Equation (6) will be rewritten by this in dimensionless form:

$$\frac{\partial^2 f}{\partial \eta^2} - \frac{\partial^2 f}{\partial \tau^2} = f. \quad (9)$$

The Klein-Gordon equation in (9) plays a key role in the further analysis of the properties of the AS, in which the electromagnetic fields propagate. Exact non-periodic solutions of equation (9) describing non-stationary fields that propagate in the "plasma" of the AS from the limit $n = 0$ to the depths of the indicated "plasma" ($n \rhd 0$) can be presented in $\tau^2 \geq \eta^2$ in the form [7]:

$$f = \sum_q a_q \cdot f_q(\eta, \tau), \quad (10)$$

$$f_q(\eta, \tau) = \frac{1}{2} \cdot [\Psi_{q-1}(\eta, \tau) - \Psi_{q+1}(\eta, \tau)], \quad (11)$$

$$\Psi_q(\eta, \tau) = \left(\frac{\tau - \eta}{\tau + \eta}\right)^{q/2} \cdot I_q \cdot \sqrt{\tau^2 - \eta^2}). \quad (12)$$

Here is the Bessel function of order q, the constant coefficients a_q and q are determined from the boundary conditions on the surface of the AS $\eta = 0$.

Time and spatial derivatives of functions are calculated by the formulas:

$$\frac{\partial \Psi_q}{\partial \tau} = \frac{1}{2} \cdot (\Psi_{q-1} - \Psi_{q+1}), \quad (13)$$

$$\frac{\partial \Psi_q}{\partial \eta} = -\frac{1}{2} \cdot (\Psi_{q-1} - \Psi_{q+1}). \quad (14)$$

Substituting (10) into (3), one can find the electric and magnetic components of the field:

$$E_X = -\frac{A_O \cdot \Omega}{c} \cdot \sum_q a_q \cdot e_q, H_y = -\frac{A_O \cdot \Omega}{c} \cdot \sum_q a_q \cdot h_q, \quad (15)$$

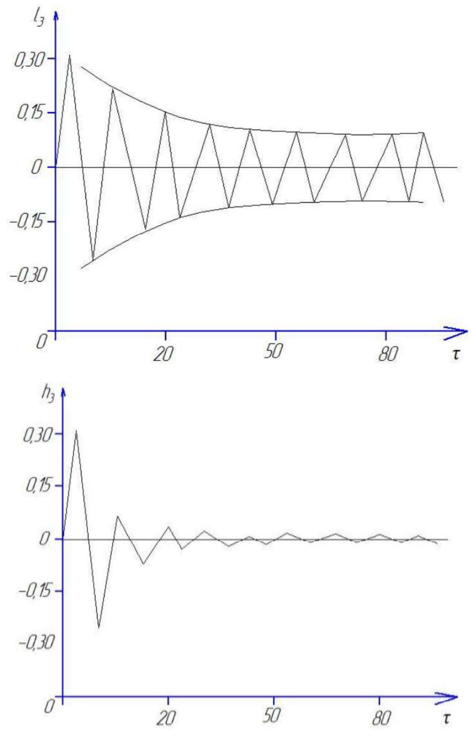
$$e_q = \frac{1}{4} \cdot \{\Psi_{q-2} - 2 \cdot \Psi_q + \Psi_{q+2}\}, \quad (16)$$

$$h_q = \frac{1}{4} \cdot \{\Psi_{q-2} - \Psi_{q+2}\} \quad (17)$$

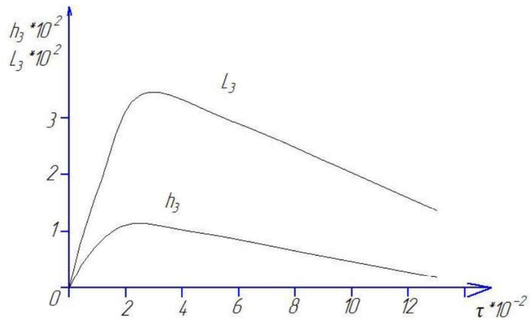
The current density $\vec{j}$ is also expressed in terms of functions Ψ_q:

$$j = \sum_q a_q \cdot j_q, \; j_q = \frac{1}{2} \cdot (\Psi_{q-1} - \Psi_{q+1}) \quad (18)$$

The obtained solutions of the Klein-Gordon equation represent the field and current in the "plasma" of the AS as the sum of non-periodic harmonics, which are expressed in inseparable functions Ψ_q. In contrast to (7), these harmonics can not be presented as a product of the functions of time and coordinates. The envelope harmonics of the field e_q, h_q (16), (17) are rapidly deformed in the process of propagation in the AS (without losses and that which is transparent to the waves of the electromagnetic field) and are shown in Fig.1.



a)



b)

Fig. 1. The enveloping of inseparable harmonics of electric (e_3) and magnetic (h_3) composites of the field in the "plasma" of AS in the sections $\eta = 0(a)$ and $\eta = 3(\delta)$; $\tau = \Omega \cdot t$.

Under the influence of the dispersion, the deformation indicated above occurs, and the spatial temporal structure of such fields is significantly different from the structure of the field of monochromatic waves in the same medium (AS):

a) intervals between the points of the intersection of zero with the bending harmonics of both the electric and magnetic fields are unequal, that is, the components of the alternating field E_x and H_y (15) are non-periodic;

b) the extremums of the enveloping harmonics e_q and h_q vary in time, and the relation | h_{max} | / | e_{max} | is non-permanent;

c) the rates of dispersion deformation of the harmonics e_q and h_q when diffused into the depth of the "plasma" of the AS are significantly different.

It is also worthwhile to mention some mathematical features of the representation of fields (15):

At all points where $\tau = \eta$ (for $z = ct$), the values of the function Ψ_q (12) are:

$$\Psi_{q/\tau=\eta} = 0\,(q > 0),\ \Psi_{0/\tau=\eta} = 1. \qquad (19)$$

Using (19), we can find the enveloping of harmonics e_q and h_q for $\tau = \eta$:

$$e_{q/\tau=\eta} = h_{q/\tau=\eta} = 0\,(q > 2)$$

$$e_{2/\tau=\eta} = h_{2/\tau=\eta} = \frac{1}{4}. \qquad (20)$$

Thus, the fronts of all the harmonics e_q and h_q are moving at the speed of light c.

The enveloping oscillations Ψ_q (12) at any point η decrease indefinitely for $\tau \to \infty$:

$$\lim_{\tau\to\infty} \Psi_{q/\eta=const} = 0. \qquad (21)$$

The values of the function Ψ_q under $\tau = \eta$ (19) and $\tau \to \infty$ (21) allow us to establish an important integral property of the fields E_x, H_y, f represented by non-stationary harmonics (15) and (18). We will write the expressions for harmonics of field and current, using the recurrent formulas (13), (14), in the form of derivatives:

$$j_q = \frac{\partial \Psi_q}{\partial \tau},\ e_q = \frac{\partial^2 \Psi_q}{\partial \tau^2},\ h_q = \frac{\partial^2 \Psi_q}{\partial \tau \partial \eta}. \qquad (22)$$

Substituting (22) into the representation of the fields (15) and (18) and taking into account the boundaries (19) and (21), we obtain for an arbitrary point *η:*

$$\int_\eta^\infty \mathrm{E_X}\,dt = \int_\eta^\infty \mathrm{H}_y\,dt = \int_\eta^\infty j_\mathrm{X}\,dt = 0. \qquad (23)$$

Asymptotic expressions for the harmonics of the field e_q and h_q corresponding to the "peripheral" parts of the envelopes at $\tau \gg \eta(\tau \gg 1)$, are formed from (16), (17) by the corresponding asymptotic behavior of the Bessel functions:

$$Jq(\tau)/\tau \gg 1 = \sqrt{\frac{2}{\pi\cdot\tau}}\cdot\left\{\cos(\alpha_q) - \frac{4q^2-1}{8\pi}\cdot\sin(\alpha_q) + \mathrm{O}(\tau^{-2})\right\}, \qquad (24)$$

$$\alpha_q = \tau - \frac{\pi}{4} - \frac{\pi\cdot q}{2}.$$

Using the plan $Jq(\tau)/\tau \gg 1$ in (24), we can apply the "tail" of the harmonic e_q (as h_q) at each point η in the form:

$$e_q/\tau \gg 1 = -\sqrt{\frac{2}{\pi\cdot\tau}}\cdot\cos\left\{\Omega\cdot t - \frac{\pi}{4} - \frac{\pi q}{2}\right\}, \qquad (25)$$

$$hq/\tau \gg 1 = -\frac{1}{\tau}\cdot\sqrt{\frac{2}{\pi\cdot\tau}}\cdot\{\eta\cdot\cos(\alpha_q) + q\cdot\sin(\alpha_q)\}. \qquad (26)$$

Thus, the evolution of the harmonic of the field leads to the formation of sinusoidal oscillations in the depth of the "plasma" of the AS, the amplitude of which decrease over time, and the time equals the cutoff frequency of the harmonic waves. Electric harmonics in each section decrease over time as $\tau^{-1/2}$; magnetic harmonics fall faster – as $\tau^{-3/2}$. It should be noted that the excitement of the oscillations (25), (26) with the help of sinusoidal waves with a frequency $\omega = \Omega$ which are falling on the boundary of the AS (its "plasma") from the outside, is rather difficult due to the reflection of these waves at the boundary.

An interesting result of the formulas (25), (26) is the appearance of their cutoff frequency as the natural time scale of the dispersive medium.

Consider the reflection of the video impulses from the surface of the AS as a conductor. The e_q and h_q harmonics can be applied on the boundary η =0 through the modified Bessel functions $I_q(r)$:

$$e_q = \frac{\exp(-\tau)}{4}\cdot\{\mathrm{I}_{q-2} - 4\mathrm{I}_{q-1} + 6\cdot\mathrm{I}_q - 4\mathrm{I}_{q+1} + \mathrm{I}_{q+2}\}, \qquad (27)$$

$$h_q = \frac{\exp(-\tau)}{4}\cdot\{\mathrm{I}_{q-2} - 2\mathrm{I}_{q-1} + 2\cdot\mathrm{I}_{q+1} - \mathrm{I}_{q+2}\}. \qquad (28)$$

Using the formula from [10]:

$$\int_\mathrm{O}^\infty \exp(-px)\cdot\mathrm{I}_{q+1}(\beta x)dx = \beta\cdot Д\cdot\int_\mathrm{O}^\infty \exp(-px)\mathrm{I}q(\beta x)dx \qquad (29)$$

$$Д = \left(\rho + \sqrt{\rho^2 - \beta^2}\right)^{-1},\ \rho = \beta + \frac{1}{2},\ \beta = \frac{t_\mathrm{O}}{T},$$

where: t_o – is the time scale of the signal, T – is the duration of the signal of the electromagnetic field (at the input to the AS), one can obtain the component of the AS-refracted wave (at the interface Z-0):

$$\mathrm{E_X} = -\frac{\mathrm{A_O}\cdot\Omega}{c}\cdot\sum_{q=3}^{\infty} a_q\cdot\frac{1}{4}\cdot\left[J_{q-2}(\tau) - 2J_q(\tau) + J_{q+2}(\tau)\right]. \qquad (30)$$

$$H_y = -\frac{A_O \cdot \Omega}{c} \cdot \sum_{q=3}^{\infty} a_q \cdot \frac{1}{4} \cdot \left[J_{q-2}(\tau) - J_{q+2}(\tau)\right] \quad (31)$$

We can record these components through the Laguerre functions $L_m(x)$:

$$L_m(x) = \frac{\exp(x/2)}{m!} \cdot \frac{d^m}{dx^m}\left[\exp(-x)\cdot x^m\right],$$

$$x = \frac{t - z * c^{-1}}{t_0}. \quad (32)$$

We will have:

$$E_X = -\frac{A_O \cdot \Omega}{c} \cdot \sum_{m=0}^{\infty} T_{1m} \cdot L_m(x), \ x = t * t0\text{-}1. \quad (33)$$

$$H_y = -\frac{A_O \cdot \Omega}{c} \cdot \sum_{m=0}^{\infty} T_{2m} \cdot L_m(x). \quad (34)$$

$$T_{1m} = \sum_{q=3}^{\infty} a_q \cdot P_{mq}(\alpha), \ T_{2m} = \sum_{q=3}^{\infty} a_q \cdot Q_{mq}(\alpha),$$

$$\alpha = t_0 \cdot \Omega. \quad (35)$$

The matrix elements of P_{mq} and Q_{mq} are related to the excitation of the m-Laguerre impulse of the q-th harmonic of the non-sinusoidal field:

$$P_{mq}(\alpha) = \int_0^{\infty} L_m(x) \cdot e_q(x\alpha) dx. \quad (36)$$

$$Q_{mq}(\alpha) = \int_0^{\infty} L_m(x) \cdot h_q(x\alpha) dx. \quad (37)$$

If we consider the incident video impulse of an electromagnetic field in the form:

$$F_0(x) = B \cdot \left[L_0(x) - L_2(x)\right]. \quad (38)$$

Then the reflection coefficient R_m can be applied as follows:

$$R_m(\alpha) = \frac{1 - T_{2m}/T_{1m}}{1 + T_{2m}/T_{1m}}. \quad (39)$$

For sums T_{10} and T_{20} (35) you can obtain:

$$T_{10} = (1 - \beta \cdot Д)^4 \cdot \sum_{q=3}^{\infty} a_q \cdot M_q, \quad (40)$$

$$T_{20} = (1 - \beta \cdot Д)^3 \cdot (1 + \beta \cdot Д) \cdot \sum_{q=3}^{\infty} a_q \cdot M_q, \quad (41)$$

$$M_q = \frac{1}{4} \cdot \int_O^{\infty} \exp(-px) \cdot I_{q-1}(\beta x) dx. \quad (42)$$

Then for the reflection coefficient R_m (39) we have:

$$R = -\frac{2\beta}{1 + 2\beta + \sqrt{1 + 4\beta}}. \quad (43)$$

The dependence of the reflection coefficient of the AS of the video of the impulses of the electromagnetic field as the ratio of the characteristic times (durations t_0, T) is shown in Fig. 2. As it is seen, impulse reflection increases with increasing $t_0 * T^{-1}$ ratio, with: $-1 < R < 0$.

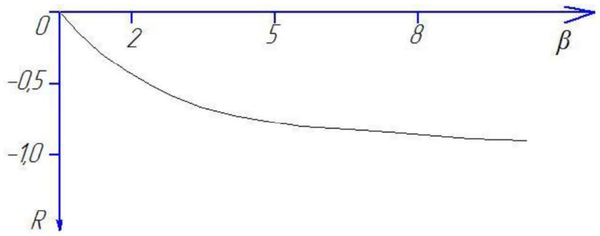


Fig. 2. Dependence of the reflection coefficient R of the video impulse F_0 (38) on the AS (as a conductor) in the normal drop from the ratio of the characteristic times and medium impulse $\beta = t_o \cdot T^{-1}$

CONCLUSIONS

1. Solutions of the Maxwell equations for short (video) impulses of electromagnetic fields that interact with the AS as a conductor reveal significant differences in the dynamics of the electric and magnetic components of non-periodic waves (15) in the AS model in the form of a transparent dispersive medium (Fig. 1).

2. In contrast to the slow dispersion fission of a quasi-monochromatic impulse with a narrow band (oscillation frequencies), which is usually described within the perturbation theory by means of a plan of the degrees of a small parameter $\Delta\omega/\omega$, the exact solutions (16), (17) are not related to the concepts the frequency and phase of the wave and not limited by variations of the envelope. These solutions, which describe the fields in the "plasma" of the AS, are: a) non-sinusoidal; b) non-stationary; c) inseparable.

3. The use of the known in literature Laguerre's polynomials allow us to determine the dependence of the reflection coefficients of electromagnetic impulses on the surface of the AS q k conductor, and the use of the modified Bessel functions is an analytical expression for an AS-refracted wave.

4. The results obtained in this study may, in the future, serve to clarify and improve existing electromagnetic fields and devices intended for diagnostics and monitoring of AS both at the stages of design (construction) and in the framework of real exploitation.

REFERENCES

1. **Bakhrakh L.D., Bliskavitsky A.A. 1993.** The successes of physical sciences. – V. 162, No. 2, 160.
2. **Landau L.D**. **1982.** Electrodynamics of continuous media / L.D. Landau, E.M. Lifits. - Moscow: Nauka, 624.
3. **Brovarets O.O. 2011.** Analysis of the structure of perturbing roughnesses of agrofones / Brovarets O.O. // MOTROL. Commission of Motorization and Energetics in Agriculture – No. 13B. 161-166. (Poland).
4. **Sun E., Rusch W**. **1994.** IEEE Transactions. Antennas & Propagation. V. 42, №1, 9.
5. **Kaizer G.A**. **1994.** Friendly Gnide to Wavelets / G.A. Kaizer. – N.Y.: Birkhanser, 480.
6. **Shvartsburg A.B**. **1996.** Time - Domain Optics of Ultrashort Waveforms / A. Shvartsburg. - Oxford Univercity Press, 510.

7. **Shvartsburg A.B**. **1993.** Non-Sinear Pulses in Integrated and Waveguide Optics / A.B. Shvartsburg. – Oxford: Oxford Univercity Press, 360.
8. **Schwarzburg A.B**. **1998.** Video pulses and non-periodic waves of dispersive media (exactly solvable models) / A.B. Schwarzburg // Progress in Physical Sciences. – V. 168, №1. 85 - 103.
9. **Danilov V.A**. **1995.** Nonharmonic Electromagnetic Pulses in a Conductive Medium. Danilov, A.B. Schwarzburg // Reports of the Academy of Sciences. – V. 341, № 3. 330-333.
10. **Harmuth H.F**. **1994.** Propagation of Electromagnetic Signals / H.F. Harmuth, G.M. Hussain. – Singapore: World Scientific, 400.
11. **Diktin V.A. 1961.** Integral transforms and operational calculus. Diktin, A.P. Prudnikov. – Moscow: Fizmatgiz, 360.
12. **Sheets, K.R., Hendrickx, J.M.H.**, **1995.** Noninvasive soil water content measurement using electromagnetic induction. Water resources research. Vol. 31 No. 10. 2401-2409.
13. **Corwin D.L. and Lesch S.M**. **2005.** Characterizing soil spatial variability with apparent soil electrical conductivity I. soil survey. Computers and Electronics in Agriculture. Vol. 46. 32-45.
14. **Alexander Brovarets. 2014.** Identification of the agrobiological state of agricultural lands by measuring the electrical conductivity properties of the ground environment / Brovarets Alexander // Motrol. Commission of Motorization and Energetics in Agriculture. Vol. 16, No. 3. 187-194.
15. **Olteanu, C., Zamfira, S., Oltean, Gh., Olteanu, F., Turcu,.C**. **2004.** Mechatronics in Agriculture - One of the Research Directions within the Precision Mechanics and Mechatronics Department with Transilvania University of Brasov.(Ed. MondoR), Revista Mecatronica nr. 2, Bucuresti. 72-76.
16. **Campbell, J.E., 1990**. Dielectric properties and influence of conductivity in soils at one to fifty megahertz. Soil Science Society of America Journal 54. 332-341
17. **Malicki, M.A.. Walczak, R.T.. 1999**. Evaluating soil salinity status from bulk electrical conductivity and permittivity. European Journal of Soil Science 50. 505-514
18. **Seyfried. M.S., Grant, L.E., Du, E., Humes, K., 2005**. Dielectric loss and calibration of the hydra probe water sensor. Vadose Zone Journal 4.1070-1079.
19. **Won and Haoping Huang I. J. 2004.** Magnetometers and electro-magnetometers. THE LEADING EDGE. May. 26-29.
20. **Kraus, J.D.. 1992. Electromagnetics. McGraw Hill, Inc.. Leao, T.P., 2009; Raju, G.G.. 2003.** Dielectrics in Electric Fields. Dekker. 578. 847.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 19-22

NOISE LOAD OF A CAR ON THE ENVIRONMENT

Mironyuk Oleg, Shevchuk Viktor
Lviv National Agrarian University
Str. V. Vylokoho, 1, Dublyany, Ukraine. E-mail: muronjuk@ukr.net

Summary. The questions of influence of transport noise on the environment are considered. A comparison of the noise field of passenger cars of Renault brand is made. Rational noise field and the direction index of a car, which increases the safety of road users is proposed.

Key words: noise field, car, noise level, safety of road users, direction index.

INTRODUCTION

Automobile transport is of great importance for the national economy of Ukraine. It is quite competitive compared to other modes of transport, and in some sectors it is dominant. In addition to the positive characteristics, cars have negative ones, one of which is the noise pollution of the environment [3, 7].

Car noise has a negative impact on the health of people, especially in cities [15]. Reducing noise in the city is the most appropriate, first of all, by reducing the noise level of urban transport. In recent years, there has been an increase in the power of motor vehicles, increasing their speed and growth in the number [4, 12, 18, 19]. Along with the introduction of constructive measures to reduce vehicle noise, the problem of controlling noise that is spreading by these means to the external environment is still urgent. World trends are also characteristic of the Ukrainian cities due to the unceasing growth of the passenger car fleet, which according to the forecast of the Ministry of Infrastructure of Ukraine by 2020 will be 2 times higher than in 2000. The trend of noise growth is typical for the streets of the big cities of Ukraine. For example, the level of noise at the intersection of Gorodotska Street and Chornovil Avenue in the center of Lviv during the rush from the place of cars was 90 dB, which significantly exceeds the permissible (65 dB) level according to the national regulatory framework [14, 16]. Therefore, the noise load of vehicles in the environment is becoming more and more relevant.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

In the opinion of a number of scientists [1, 4, 9, 11, 13, 19] in the process of movement of the car, it emits noise generated by the engine, units of transmission of the car, the body (under the influence of the engine, the road and air flow), the reduction of which is possible, for example, by replacement of concrete pavement with asphalt, installation along highways of noise isolating screens or forced reduction of cars speed. At the same time, noise remains a problem along highways and in populated areas. Some scholars [12, 17] are convinced that reducing traffic noise in cities through traditional methods is difficult enough and requires substantial investment. More accessible is the control and noise reduction from the direct sources of its occurrence - cars.

OBJECTIVES

The main task of the research is to study the impact of noise of cars on the environment. In the fight against noise, the most appropriate way is to reduce its level directly in its source, in our case, the level of noise generated from cars. Therefore, the purpose of the research was to construct the noise field of the car and to determine the rationale of the direction.

THE MAIN RESULTS OF THE RESEARCH

For the object of study of external noise we adopted a car of Renault firm, model Symbol, key characteristics of which is reliability, low price and low operating costs [8]. The studies were conducted in accordance with generally accepted [2, 5, 6, 10, 20] and developed techniques [13] using the WSHW-003-M2 noise meter with a measurement error of ± 0,7 dB. To measure the speed of the crankshaft of the engine, the tachometer of the Renault Symbol instrument panel with a range of measurements (0-7000 rpm), with a marginal error (-50 - +300 rpm), was used. To measure the wind speed, the ANEMO device made in Germany was used, with a range of 0-35 m / s, with a margin of error of ± 0.5 m / s and the finest reading of 1 m / s.

The space in which the waves propagate is called the field [12]. The noise field of a car is considered to be the distribution of the intensity of noise around it during parking and engine operation in a certain mode. The noise field of the car (fig. 1) was determined on the basis of the results of noise measurements at 12 points around the car at a distance of 1 m from its outer surface at a height of 1.2 m from the surface, with the engine running without the load on the speed of the crankshaft 4,500 rpm.

Analyzing the nature of the noise field obtained, it can be argued that the distribution of the noise level around the Renault Symbol has the greatest impact on the engine. The noise level at points 12, 1, 2, is 7-11 dB higher than at points 6, 7, 8. The noise from the exhaust gases on the noise field has a lower effect than the noise of the actual engine.

The noise field for other Renault models (under the same conditions) was also studied, with a different engine volume - the Dacia Logan 1.6 model with a K7M710 engine with a working volume of 1600 cm^3, Laguna with an engine F4P770 with a working volume of 1800 cm^3 (Fig. 2). These measurements confirm the hypothesis that an increase in engine working volume causes an increase in the sound level of the car at all points of the noise field.

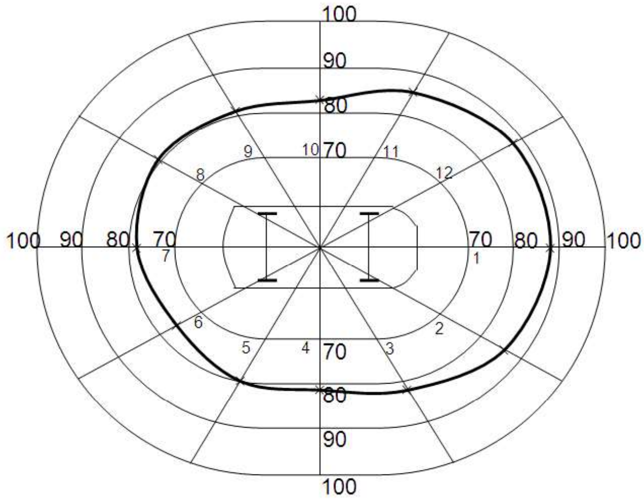


Fig. 1. Noise field of the car Renault Symbol

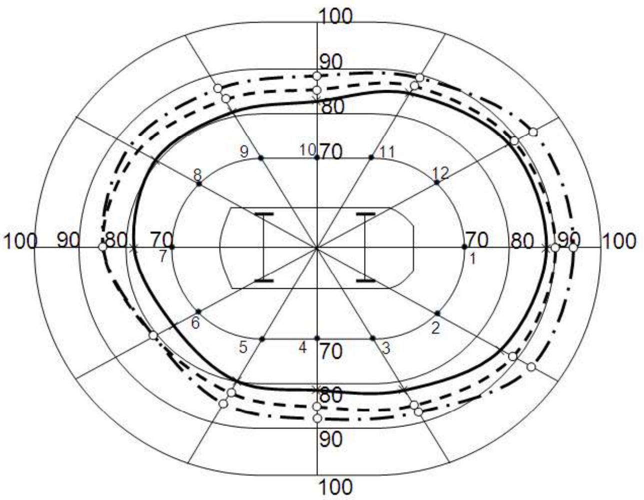


Fig. 2. Noise field of models of Renault cars with working volume: _____ Symbol (1400 cm^3); - - - - Dacia Logan (1600 cm^3); -.-.-. Laguna (1800 cm^3).

After analyzing the noise fields and noise spectra obtained during the car's motion, it can be argued that the noise of the car, which is to the left axis, is practically the same from the axis of motion to the right. Undeniably, for the right-hand traffic pedestrians the residential buildings are located on the right side of the car too. This circumstance, having in mind that the noise field has a symmetrical character, increases the sound load on them. A similar pattern is inherent in the radiation of the noise forward and backward. Therefore, it is important to solve the issue of rational noise field of the car, which would take into account not only the permissible noise level, but also the organization of traffic and information about the approach of the car to the crossroads. It is possible to form such a field by redistributing the radiated sound energy by acoustic screens, without resorting to noise suppression, which is too expensive. The proposed rational noise field requires the distribution of the noise level around the car, formed on the basis of three prerequisites: adhering to the permissible noise level at a distance of 7.5 m from the longitudinal axis of the car; increased direction of sound in the direction of movement, as additional information about the approach of a car that protects pedestrians and drivers; different indicator of direction from the left or right side of the car depending on the organization of traffic (left or right-hand traffic).

In the case of a redistribution of the sound energy of the Renault Symbol from right to left and in the direction of movement (back and forth), we get a noise level at a distance of 7.5 m from the car's longitudinal axis on the left side of 73 dB A (point 10), and on the right side - 69 dB A (point 4), ahead - 97.2 dB A (point 1), and behind - 97.2 dB A (point 7) (fig. 3). In this way, a rational noise field is built empirically.

Under the indicator of the direction (ID) we understand the difference between the average sound level in dB (A) and the value of the level in the given direction and the given point, located at a distance of the reference radius. The reference radius is the distance from the point under study to the center of the source of noise.

In Figure 4 the noise diagram of the Renault Symbol is shown. From the figure it is clear that the direction of the noise ahead of the car (points 1, 2, 11, 12) is greater than the other, due to the location of the engine in front, which noise is directed through the front and bottom open radiator grilles, that is why the direction is less behind.

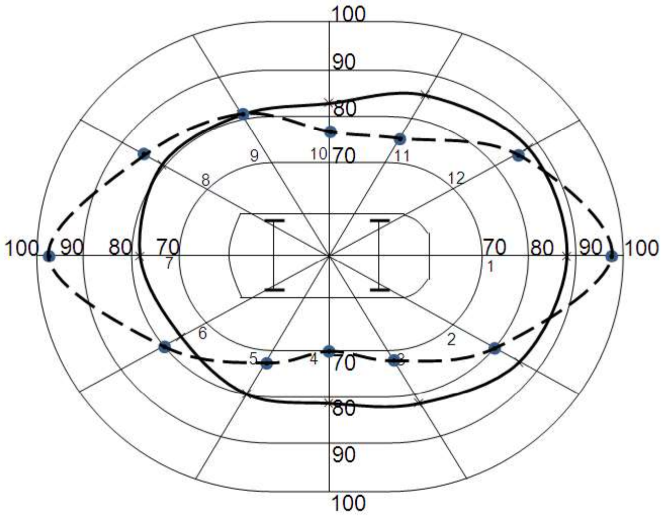


Fig. 3. Measured (——) noise field of the car Renault Symbol and proposed rational (- - - -)

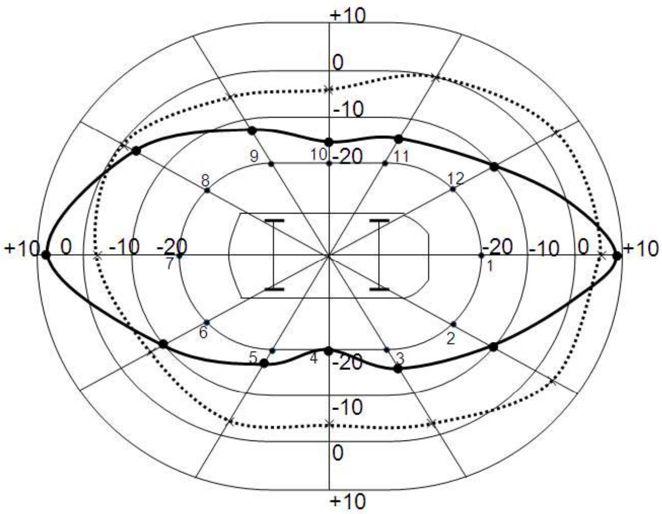


Fig. 4. The direction indicator of the noise level of the Renault Symbol vehicle at a distance of 7.5 m:
-x- experimental data;
- • - indicator of rational direction

After redistributing the sound energy of the Renault Symbol, you can get an indicator of rational direction (Fig. 4).

The following should be noted:

1. A greater direction of sound in the direction of the car (points 1, 7) helps to further inform pedestrians and drivers about the approach of the car, ensuring their safety.

2. Different values of the direction indicators from the right (p.4) and left (p.10) side of the car are due to the right-hand traffic in Ukraine and the attempt to reduce the direction of sound for pedestrians.

CONCLUSIONS

We indicated the noise field of the Renault Symbol car and proposed a rational noise field, for which formation is required: adherence to the permissible noise level at a distance of 7.5 m from the longitudinal axis of the car; providing increased direction of noise along the direction of motion as a factor in additional informing pedestrians and drivers about the approach of the car to ensure their safety; providing different indicator of the direction of the right or left side of the car depending on the organization of traffic (right or left-hand traffic).

Thus, reducing the overall noise level of a car without losing its source level can be achieved by redistributing noise energy from right to left and in the direction of motion (back and forth).

REFERENCES

1. **Barrelet S. 2005**. Development and refinement for the sound package of the new Renault Clio 3 / S Barrelet, T Laurent, K Trdak - Rieter Automotive Conference.
2. **Balabin I.V. 1988.** Testing of cars: Textbook. I.V. Balabin, B.A. Kurov, S.A. Laptev – M.: Mechanical Engineering, 192.
3. **Vasilyeva V.V. 2010.** Road noise in cities and its impact on the environment / V.V. Vasilyeva // The world of transport and technological machines. – № 3 (30). 101-107.

4. Questions of noise in the interaction of the tyre with the road / [V.A. Karpenko, V.A. Peregon, A.N. Levchenko, A.A. Koryak] // Bulletin of Kharkov National Automobile and Highway University. 2015. No. 71. 109-111.
5. **GOST 27436-87. 1987.** External noise of vehicles. Permissible levels and methods of measurement. - Moscow: Standardizdat, 13.
6. **DSTU 3649: 2010. 2010.**"Wheeled vehicles. Safety requirements to the technical condition and methods of control" – K.: Ministry of Economic Development of Ukraine, 11.
7. **Kachmar R.Ya. 2013.** Estimation of environmental and economic losses from traffic noise in the city of Lviv / R.Ya.Kachmar // Automobile transport: research. – Lviv №1 (231). 10-13.
8. **Kisulenko B.V**. **2004.** Brief automobile directory. Volume 3. Cars. Part 2. / Kisulenko B.V. – M.: NSTT "Transeconculting", 560.
9. **Kunovskiy E.B**. **2005.** Identification of car noise sources / EB. Kunovsky – Minsk: Technoprint, 324.
10. **Kushvid R.P. 2011.** Tests of the car: the textbook / R.P. Kushvid. – Moscow: MGIU, 351.
11. **Leasure W.A**. **1975.** Tire-road interaction noise / W.A. Leasure, E.K. Bender – America: 39-50.
12. **Lukanin V.N**. **1981.** Reducing the noise of the car / VN. Lukanin, V.N. Gudtsov, N.F. Bocharov – M.: Mechanical Engineering, 243.
13. **Mironyuk O.S. 2005.** Investigation of the noise characteristics of the fruit-extractor / O.S. Mironyuk // Visnyk of Lviv State Agrarian University: Agroengineering research. – No. 9. 154-158.
14. **Petrenko O**. **2013.** Analysis of the requirements of the current normative legal acts on permissible levels of noise and vibration of the car / O. Petrenko // Bulletin of the National University "Lviv Polytechnic". – № 753: Automation of measurement and control. 152-158.
15. **Petrenko O.K**. **2010.** Influence of noise of motor transport on the human body \ O.K. Petrenko // Ukraine in the European Space. Problems of business, politics, law: mat. VI International science-practice conference, Lviv University of Business and Law. – Lviv, 46-48.
16. **Petrenko O.K. 2011.** Control over noise in the central streets of Lviv / O.K. Petrenko // Quality of technology and education. – Kharkiv, 45-51.
17. **Samoylyuk E.P. 1981.** Fighting noise in populated areas / Е.П. Samoylyuk, V.I. Denisenko, A.P. Pilipenko. – K.: Budivelnik, 144.
18. **Faktorovich A.A**. **1982.** Protection of cities from traffic noise / A.A. Faktorovich, G.I. Postnikov. – K.: Budivelnik, 144.
19. **Shatrov M.G**. **2014.** Noise of automobile internal combustion engines: training. tb / M.G. Shatrov, A.L. Yakovenko, T.Yu. Krichevskaya. – M.: MADI, 68.
20. **Ellison A. 1998.** Measurement of the noise of machines. A. Ellison. – Moscow: Energoatomizdat, 374.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 23-26

ELECTRIC DRIVES IN AGRICULTURAL TRACTORS

Janusz Zarajczyk[1], Jozef Kowalczuk[1], Stanisław Sosnowski[2], Marek Szmigielski[1], Karol Zarajczyk[3], Zbigniew Krzysiak[1],Waldemar Samociuk[1], Monika Kośko[3], Krzysztof Kowalik[3]

[1]University of Life Sciences in Lublin
Akademicka 13, 20-033 Lublin, Poland
[2]University of Rzeszow
aleja Tadeusza Rejtana 16C, 35-001 Rzeszów, Poland
[3]URSUS S.A.
Frezerów 7, 20-209 Lublin, Poland

Summary. Modern agriculture requires the use of more energy-efficient and environmentally friendly technology. Therefore, better technical solutions are still looked for. Progress in the field of electronics provides more and more opportunities to use electric drives in agricultural machinery. Currently, electric drives are used not only to power working parts of tractors and devices such as fans and wipers, but they also help to improve braking and steering systems. This article gives an overview of some possibilities of using electric drives in modern tractors.

Key words: farm tractors, electric drives.

THE MAIN RESULTS OF THE RESEARCH

The increase in the population forces the search for new, improved technologies in agricultural production. At the same time, it is preferable that the cost of agricultural production is lowest and the final product is the cheapest.

The drives of today's agricultural machinery are increasingly complex due to the need to adhere to strict environmental standards. That's why the newer, energy-efficient and eco-friendly drives of these machines are sought. Advances in electronics for the introduction of high power electronic and electronic systems for the processing of alternating currents make it very possible to use electric motors in agricultural machinery not only for environmental reasons [3,4,7].

There is a chance of constructing such an electric drive that will increase the traction capacity, safety, ergonomics and reliability of the agricultural machine. In the future, it may lead to the elimination of the internal combustion engine as the main source of energy in the mobile machine.

The electric advantages, including hybrid powertrains, combining the combustion and the electric car engine, has been recognized by the industry for a long time. At present, large automotive companies have hybrid vehicles in their offer. Solutions from the automotive industry are already used in agricultural tractors mainly intended for lighter work, including municipal [4,7].

In agricultural machines, the use of electric power is possible in two variants. In the first one - electricity is generated by the generator, mounted on the machine. It is made by an internal combustion engine and a generator, from where the electrical energy is delivered to the appropriate receivers in the machine. The second variant of electric propulsion is the use of batteries or other sources of electric power (supercapacitors, fuel cells). However, the prospect of its use on a wider scale is doubtful mainly for economic reasons [4,8].

An example of a tractor with a hybrid drive is the product of the German company Rigitrac (fig.1) [13].

Fig. 1. The agricultural tractor Rigitrac with electric drive. The drive is transmitted directly to the wheels by independent electric motors [13]

The tractor is equipped with a 91kW diesel engine, a 85 kW generator and 650 V DC, and four traction motors with a power output of 33 kW (total power 132 kW) (Figure 2).

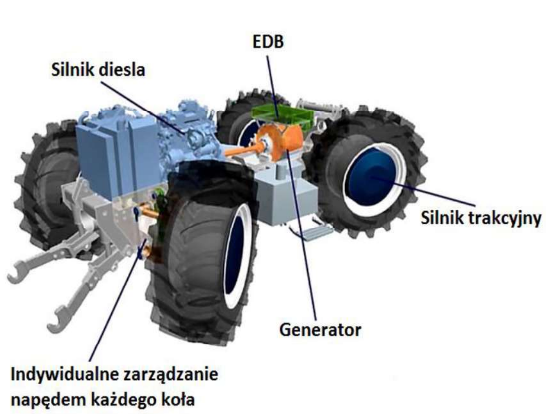


Fig. 2. Diagram of a hybrid tractor [13]

The Indian company Mahindra produces a small electric tractor (fig. 3). As the manufacturer declares, the tractor's electric drive can be charged from a variety of sources (including solar and wind). The tractor is equipped with a small internal combustion engine, which acts as an emergency power source, but does not have a PTO. The manufacturer clearly emphasizes the low level of complexity of the product (easy to produce) and directs it to agricultural applications and as a means of transportation in factories and for the movement of luggage at airports [14].

Fig. 3. Indian electric tractor Mahindra [14]

In 2009, the Institute of Technology and Life Sciences in Poznań and the Kujawska Agricultural Machinery Factory in Brześć Kujawski undertook activities that give the agricultural character of the machine shown in Fig. 4i. 5. The machine is a product of Italian engineers. The project was called Renewable Energy Agricultural Multipurpose System for Farmers (RAMseS) and was developed as a system to guarantee the energy independence of farms in the Mediterranean countries as a response to the potential increase in the price of liquid fuels and frequent breakdowns in the supply of electricity in these countries [15].

Fig. 4. Vehicle RAMseS on the Expo AGROTECH [15]

Fig. 5. Vehicle RAMseS during field spraying [15]

The presented vehicle has a three-point toolbar (TPT) and PTO. Unfortunately, due to the construction solutions used, its ability to move in difficult terrain is limited (lack of mobility of a typical tractor, tendency to sink due to high surface pressure).

Agritechnica 2007 presents the first integrated electric power system in the John Deere E-series tractors. This system was used in 7430 E and 7530 E Premium models, rated at 121 and 132 kW.

In these tractors, the electric generator enables the electric drive of the radiator fan, air conditioning compressor and pneumatic system compressor. As a result, their operation becomes independent of the tractor's internal combustion engine. For example, the main fan can work continuously even at low engine speeds [9].

For the first time, this solution enabled the use of electric power to increase the efficiency of the tractor. The power control system monitors the operation of individual teams at the set time and in a specific situation.

From May 2012, the John Deere 6210RE E-Premium tractor model is available, which enables the electric drive to work with the machine while driving, which contributes into greater accuracy and performance (Figure 6).

Fig. 6. New model of tractor John Deere 6210RE; PTO drives are replaced with two connectors for connection and drive

In addition to the use of electric power to drive fans, windshield wipers, etc., thanks to the development of electrical engineering, closed control systems are created which improve the braking and steering systems. However, electric motors have not yet been used to drive power units with high power requirements [http://www.farmer.pl/technika-rolnicza].

In modern tractors, there is a possibility to mount a high power generator so that the heavy rotor of this permanent magnet generator also functions as a flywheel.

The electric drive can also revolutionize the axle drives of the mounted and self-propelled machines. So far they have been driven mechanically from PTO or hydraulically. Electric drive compared to traditional solutions, can easily distribute power on the axles and individual wheels with high efficiency. In addition, electric motors are characterized by high overload. This means that they can work periodically with a load greater than the rated load. Electronic systems can also allow an easy control of the drive.

Large machines require a tractor with a large pull. Using heavy aggregates results in higher soil compaction and high fuel consumption. The electric drive used in the machine cooperating with the tractor will relieve it and thus affect the economical operation of the unit.

The new fuel technology is fuel cells. Currently, New Holland is developing this solution, which has created a Hydrogen-powered NH2 tractor (Figure 7) [11].

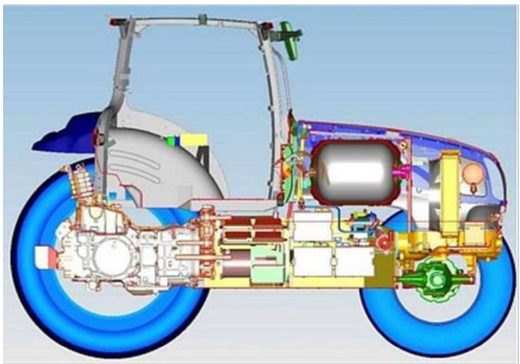


Fig. 7. The New Holland NH2 tractor powered by hydrogen [11]

The NH2 tractor is equipped with a hydrogen tank and fuel cells that produce electricity to power two electric motors that drive the machine, its systems and its equipment. One of them is used to support the drive system, while the other one - PTO and auxiliary power source. The undisputed advantage of this tractor is zero emissions. The fuel cell system releases only a small amount of water in the form of water vapor. A negative aspect of this technology is the small capacity of this tractor's hydrogen tank, which only lasts three hours. Storage of liquid hydrogen, possible only under high pressure or low temperature conditions, is troublesome.

The production of high performance of fuel cells is not economically justified, due to complex processing processes and the difficulty of obtaining of raw materials for their production in trace amounts in the earth's crust [2, 4, 5].

The most realistic in the near future seems to be the use of hybrid diesel engines in conventional agricultural diesel engines, generators and electric motors [4, 5].

The primary source of hybrid power is the chemical fuel from which the mechanical energy is generated in the standard piston engine. The electrical system in this case is essentially a transmission system, while in the mechanical systems it carries shafts and transmission belts and transmissions. In such a system, the main component is a generator, which is responsible for charging the batteries and lighting up the supply. The current generator is an alternator that converts mechanical energy into alternating current, which then converts the electronic rectifiers into DC 12 or 14 V. The generators used in the tractors have small power ranges (up to 5 kW), because the voltage 12 V is too low for high power transmission. Low voltage is the cause of energy loss in the transmission lines, as well as faster wear of the copper from which they are made [1, 4, 6].

PTO driven generators can be mounted on tractors and used to drive cooperating machines. The generator can be mounted on the front or rear three-point toolbar (TPT) between the tractor and the machine. Both have advantages and disadvantages. For example, attaching a generator on a rear TPT complicates connecting the machines to this tractor.

Currently, commercial vehicles based on electric propulsion technology are manufactured in Ursus S.A. from Lublin and Solaris from Bolechow as low emission vehicles, used for public transport. These companies have developed and offer electric buses, thus creating an innovative product on a European scale. In the area of agricultural applications, however, the activities are undertaken reluctantly. Agricultural machinery manufacturers are skeptical about this type of solution, fearing primarily the reaction of potential buyers who prefer proven solutions. However, it is necessary to undertake research and implementation work to make electrical machines also implemented on the Polish market by Polish producers. Such projects are important financial support for these activities.

CONCLUSIONS

The use of electric motors in agricultural machinery has many benefits. The development of control electronics and growing ecological requirements will enable the practical application of these solutions in agricultural machinery in the near future. It will be necessary to equip tractors with high power generators or other sources of electricity. Also, the demand for electrically driven machines to work with tractors will increase.

REFERENCES

1. **Breu W. 2013.** Design of a High Voltage System for Agricultural Machines, 4. Kolloquium Elektrische Antriebe in der Landtechnik 25-26 Juni 2013, Wieselburg.
2. **Götz M., Müller A. M., Abele M. 2011.** Electrification of a tractor and implement – The ZF project ElecTra. VDI-Bericht, 2124, Agricultural Engineering, 69. Int. Tagung.
3. **Karłowski J. 2009.** Wielozadaniowy ciągnik rolniczyz napędem elektrycznym. Renewable Energy Agricultural Multipurpose. System for Farmers, IBMER O/Poznań.
4. **Kęska W. 2012.** Electric Drive in Agricultural Machines-Prospects of the Application. Journal of Research and Applications in Agricultural Engineering, Vol. 57 (1), ISSN 1642-686X.
5. **Merkisz J. 2012.** Pojazdy hybrydowe i elektryczne, a sprawa Polska. Instytut Transportu Samochodowego, Warszawa.
6. **Onnen M. 2011.** Coming Soon: Tractor Electrification. Resource. 9-10.
7. **Thiel M. and all: 2011.** Development of a PTO driven generator for electrical drives in agricultural machinery. Concept and realization of an Add-on Power Generator. VDI-Bericht 2124, Agricultural Engineering, 69. Int. Tagung LAND.TECHNIK, 11.2011.
8. **Weymann S. 2016a.** Elektryczne napędy ciągników i maszyn rolniczych. Część 1. Technika Rolnicza Ogrodnicza Leśna, 4.

9. Weymann S. 2016b. Elektryczne napędy ciągników i maszyn rolniczych Część 2. Technika Rolnicza Ogrodnicza Leśna, 5.
10. www.fwi.co.uk/Articles/20/01/2012/130992/Electricity-generating-tractors-are-coming.htm.
11. http://agriculture.newholland.com.
12. http://www.deere.com.
13. www.rigitrac.ch/.
14. http://contest.techbriefs.com/component/content/article/2504.
http://www.kpk.gov.pl/pliki/9903/16.%20Jerzy%20Kar%B3owski.pdf.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 27-28

GEOPOLITICAL DETERMINANTS OF PRICES OF PETROLEUM FUELS

Marek Szmigielski[2], Józef Kowalczuk[2], Karol Zarajczyk[1], Janusz Zarajczyk[2], Agnieszka Starek[2], Andrzej Masłowski[2], Zbigniew Krzysiak[2], Anna Piecak[2], Krzysztof Kowalik[1]

[1]URSUS S.A.

Frezerów 7, 20-209 Lublin, Poland. E-mail: marek.szmigielski@up.lublin.pl

[2]University of Life Sciences in Lublin

Głęboka 28, 20-612 Lublin, Poland. E-mail: marek.szmigielski@up.lublin.pl

Summary. The impact of political and economic events on the price of crude oil on global commodity exchanges has been estimated. The price of oil is dependent on political events that diminish its production and tends to drop as a result of reduced demand or overproduction.

Key words: crude oil, geopolitical determinants, price.

INTRODUCTION

The average user of a motor vehicle does not often wonder about the factors that determine its communication capabilities. His perception generally does not go beyond a local petrol station, where the fuel prices are dictated for a certain period of time.

It is well known that fuel prices in Poland are determined by manufacturers depending on market conditions controlled by the factors and trends of global fuel markets as well as the state of Poland's economy and fiscal policy. The prices of petroleum products are determined by the following, most often listed, factors:

- taxes and charges (excise, VAT, reserve)
- dollar exchange rate (the currency commonly used in the oil market);
- conditions created by the competitive game,
- development of technologies for the production of alternative energy sources or alternative machines and devices [2-4, 9].

However, the most important of these factors is the market price of crude oil. The supply of raw materials, dominated by the biggest tycoons in the market, and demand-driven by the world economy have a big impact on the price of crude oil. Among the producers, the dominant influence on oil output and price is the OPEC organization, which has 12 producers from the Persian Gulf, Africa and South America.

The share of OPEC countries in global production is about 40% (in 2010 it was 44% of world production) [11]. A particular importance in OPEC is attributed to Saudi Arabia, which is the world's largest producer of oil. The United States of America is a major producer and consumer of this raw material. The importance of the US as a producer of oil has increased considerably due to the development and introduction of hydraulic fracturing technology, which has enabled the extraction of raw materials from previously unavailable deposits in bituminous shale, although such extraction is much more difficult and costly compared to traditional deposits. Since the turn of the twentieth and twenty-first centuries Russia has also become an important oil producer (Figure 2) [11].

OIL PRICE ANALYSIS IN THE CONTEXT OF HISTORICAL EVENTS

The price of a barrel of crude oil on the global stock market, which ranged between $ 15 and $ 20, has been subject to significant fluctuations as a result of various historic events that could have hindered the regular supply of this strategic energy resource. It should be noted that the Persian Gulf that has 60% of the world's estimated oil reserves is a potential area of religious and national conflict. In this region the influences of the world powers clash, while the near-by Middle East with Israeli-Palestinian and Israeli-Arab conflicts is still another source of various conflicts.

One such threat was Iran's intensive research into nuclear energy. The official reason for the development of nuclear technology in Iran was the development and use of alternative energy sources for oil, with their experience of using fissionable energy resources easily transferrable to the construction of nuclear weapons and used, for example, to jeopardize the existence of the Jewish state, the biggest enemy of Iran in the Middle East.

The Arab world is also not a monolith, and has been the arena of many conflicts, among others the important conflicts of Iraque with Iran (from September 22, 1980 to August 20, 1888) [8] and Iraq with Kuwait (from August 1990 until the spring of 1991, when the forces of the US-led coalition intervened) [1]. The latter conflict had been the likely cause of a significant increase in oil price observed during this period, although this rise has also been largely attributed to the effects of the global economic downturn at the time [1, 8]. For example, the price of a "brent" oil barrel in the period preceding this conflict was $ 14.83 (June 18, 1990) [10], and after the Iraqi invasion increased more than twice to $ 34.11 a barrel (18.10.1990) [10] (Figure 1).

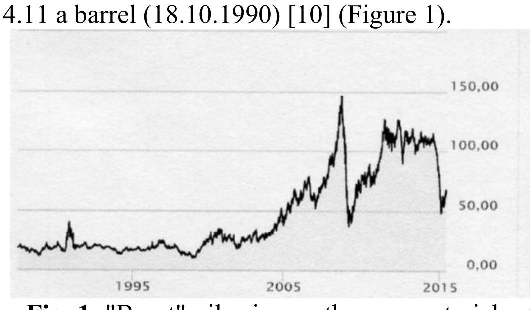


Fig. 1. "Brent" oil price on the raw materials stock exchange [10]

The decline of the twentieth and the beginning of the twenty-first century abounded in the various events that jeopardized the stability of the world economy: significant socio-economic effects of the break-up of the Soviet Union, the emergence of numerous al-Qaeda terrorist organizations and political problems in many parts of the world, including Iraq, Iran and Afghanistan (11.10.1999 - Chechen war, September 11, 2001 - World Trade Center attack, October 7, 2001 - Afghan War, March 20, 2003 - Gulf War) [5, 6, 7, 1].

The rapid rise in oil prices during this period (from $ 24.35 - March 21, 2003 to $ 144.43 a barrel - July 4, 2008) [10] was one of the likely consequences of these geopolitical events. The rise in this raw material's prices coincided with the increase in oil production by Russia and the US as a result of the widespread exploration in the shale oil fields (Figure 2) [11].

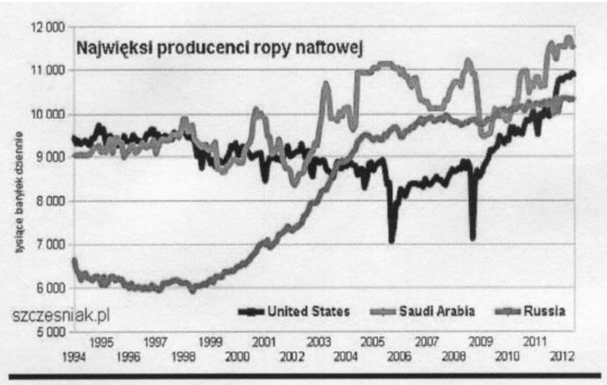


Fig. 2. The largest oil producers in the past twenty years [11]

As a result, the oversupply of the raw material was soon deepened by the onset of the economic crisis and resulted in a sharp fall in prices to $ 42.91 a barrel (January 12, 2009) - Figure 1 [10].

In subsequent years oil demand increased following the overcoming of the economic crisis, which was a likely stimulus for commodity prices and coincided with the outbreak of civil war in Libya (15.02.2011). The rise in prices was also likely to be fueled by the continued war in Afghanistan and the instability of the Iraqi economy in connection with the Iranian supply embargo. As a result, oil prices got stabilized at a high level between $ 100 and $ 125 a barrel since early 2011 to mid-2014 [10].

In mid-2014, the ongoing conflict in Libya and the growing tension in Iraq associated with the creation of the so-called self-proclaimed Caliphate named the State of Iraq and Levant, favored the raising of oil prices, while its large supply by Saudi Arabia and other OPEC countries as well as the US was likely to reduce the price. As a result, the price fell significantly, by 55%, to reach $ 48.91 a barrel by mid-January [10]. Saudi Arabia's official rationale for high oil production is the rivalry for the producers' dominance and eliminating the more expensive hydraulic fracturing technology from the market (especially in the US), but a large amount of oil stocks in the US and a high level of production there would rather indicate that this strategy is probably part of the economic sanctions against Russia for the annexation of the Crimea (21 March 2014) and the support of the separatists in eastern Ukraine in Donbas.

CONCLUSION

1. Prices of crude oil and petroleum fuels are strictly dependent on political events.
2. Crude oil price rises are triggered by economic crises and overproduction of this raw material.
3. The rise in crude oil prices is most often linked to political events, which may lead to the limiting of crude oil extraction.

REFERENCES

1. **Bielecki R. 1991**. Desert Storm. Bellona Publishing Company ISBN 83-11-07939-0. Warsaw.
2. **Gielnik A., Rosicki R. 2013**. Wind Power in Poland - Opportunities for Development and Threats. in: Energy Security - Fossil Fuels vs. Alternative Energy Sources, 191-205. Publisher of the Higher School of Security, ISBN 976-83-61304-57-9. Poznań.
3. **Hoffman T. 2013**. Support for Renewable Energy with EU Funds in: Energy Security - Fossil Fuels vs. Alternative Energy Sources, 281-290. Publisher of the Higher School of Security, ISBN 976-83-61304-57-9. Poznań.
4. **Kęska W. 2012**. Electric Drives in Agricultural Machinery - Prospects of Application. Journal of Research and Applications in Agricultural Engineering. 57 (1), ISSN 1642-686X. Poznań.
5. **Kiwerska J. 2005**. VI. Chechnya in the struggle for independence, in: World in 1989-2004: Events-Conflicts-Processes 204-250. Poznań Publishing Company ISBN 83-7177-308-0.
6. **Kiwerska J. 2005**. VII. From the Desert Storm to "Iraq Freedom", in: The World in 1989-2004: Events-Conflicts-Processes, 251-322. Poznań Publishing Company, ISBN 83-7177-308-0.
7. **Kiwerska J. 2005**. VIII. International Terrorism - the Challenge of the 21st Century. in: The World in 1989-2004: Events-Conflicts-Processes, 323-368. Poznań Publishing Company, ISBN 83-7177- 308-0.
8. **Kwiatkiewicz P**. **1980**. The Iraqi and Iranian War and its Impact on the Oil Market, in the First Half of the, in: Energy Security - Fossil Fuels vs. Alternative Energy Sources, 161-171. Publisher of the Higher School of Security, ISBN 976-83-61304-57-9. Poznań.
9. **Szczerbowski R**. 2013. Safety and Operation of Nuclear Power Plants in the Power System, in: Energy Security - Fossil Fuels vs. Alternative Energy Sources, 207-222. Publisher of the Higher School of Safety ISBN 976-83-61304-57-9. Poznań.
10. www.bankier.pl/.(12.10.2016).
11. hydrocarbons.com/.(12.10.2016).

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 29-33

NAUCZANIE MATERIAŁOZNAWSTWA Z WYKORZYSTANIEM NARZĘDZI INFORMATYCZNYCH DO BUDOWY MAP WIEDZY

Monika Krzywicka, Jerzy Grudziński
Uniwersytet Przyrodniczy w Lublinie
Ul. Doświadczalna 44, 20-280 Lublin, Poland. E-mail: monika.gruszecka@up.lublin.pl

Streszczenie. Celem pracy było badanie opinii studentów na temat map wiedzy jako narzędzia do nauczania materiałoznawstwa. W pracy przedstawiono przykład wykorzystania programu komputerowego InfoRapid KnowledgeMap do tworzenia map wiedzy. Wyniki badań ankietowych studentów Wydziału Inżynierii Produkcji Uniwersytetu Przyrodniczego w Lublinie potwierdziły ich pozytywną opinię o celowości wykorzystywania programów komputerowych do zajęć dydaktycznych. Zastosowanie map wiedzy w edukacji byłoby nowością dla ponad 80% studentów. Pomimo tego respondenci deklarowali chęć korzystania z nieznanych dotąd technik uczenia się. Większość badanych wykazywała zainteresowanie doborem materiałów na przedmioty którymi się posługują. Zastosowanie nowych metod nauczania mogłoby zwiększyć zaangażowanie studentów w problematykę zajęć dydaktycznych i ułatwić im przyswajanie wiedzy z przedmiotu uznawanego za trudny.

Słowa kluczowe: mapy wiedzy, metody nauczania, materiałoznawstwo.

WSTĘP

Rozwój technologii informacyjnych umożliwia wykorzystywanie wielu nowych środków dydaktycznych. Zróżnicowane sposoby nauczania zachęcają uczniów do samodzielnej nauki i innowacyjnej edukacji [4]. Proces uczenia się jest bardziej efektywny jeżeli uczeń jest zainteresowany poruszanymi zagadnieniami i formą ich przekazu. Należy pamiętać, że uczenie się jest procesem indywidualnym, osoby uczące się posiadają różne tempa pracy, inne zagadnienia sprawiają im większe trudności rozumienia i przyswajania wiedzy. Zastosowanie technologii informatycznych na zajęciach umożliwia zindywidualizowanie tempa uczenia się [6,8]. Szczególnie pomocne stają się technologie internetowe. Allen i in. [1] podkreślają, że materiały dostępne on-line umożliwiają ich wielokrotną analizę w dowolnym miejscu i czasie.

Jedną z faz przekazywania i zdobywania wiedzy jest notowanie [10]. Alternatywą dla tradycyjnych notatek linearnych mogą być mapy wiedzy. Davies [7] definiuje mapy wiedzy jako wizualne, nieliniowe połączenie za pomocą sieci zagadnień związanych z danym pojęciem. Dodatkowo Race i Pickford [15] wskazują, że mapy wiedzy są indywidualnie przygotowywane przez studentów, co może ograniczyć zjawisko plagiatu, które w ostatnich latach stało się poważnym problemem uczelni wyższych na całym świecie. Ponadto, otwarty i samodzielny charakter pracy dodatkowo motywuje do nauki [14]. Multisensoryczny charakter map wiedzy ułatwia konwersję informacji z okresów krótkiej do długiej pamięci [5, 6]. Davies [7] wskazuje także, że mapy wiedzy wymagają bardziej aktywnego zaangażowania ze strony studentów, co przyczynia się do intensywniejszego uczenia się i lepszych efektów. Mapy wiedzy mogą pomóc skrócić czas spędzony na przygotowywaniu się do egzaminu i pomóc zorganizować informacje [2]. Stosowanie tradycyjnych technik uczenia się obciąża tylko lewą półkulę mózgu, podczas gdy mapy wiedzy stymulują obie półkule, co przyspiesza i usprawnia proces uczenia się [2,13,14]. Ponadto sporządzanie notatek w postaci map wiedzy zajmuje mniej czasu niż sporządzanie tradycyjnych notatek linearnych i umożliwia dodawanie nowych informacji bez zaburzenia czytelności zapisków, tak jak ma to miejsce w przypadku notatek tradycyjnych [10]. Rosciano [17] wskazuje, że 93% badanych uważa, że tworzenie map wiedzy podnosi ich kreatywność, co dla większości respondentów jest umiejętnością niezbędną w wykonywaniu zawodów inżynierskich [18].

Interesującą koncepcję wykorzystywania map myśli przy egzaminowaniu studentów opisuje Buzan [3]. Polega ona na przyjęciu założenia, ze zadaniem egzaminu nie jest sprawdzenie umiejętności pisarskich studentów ale sprawdzenie stanu ich wiedzy i stopnia zrozumienia materiału. Poza oszczędnością czasu egzaminatora, który jednym spojrzeniem na rysunek egzaminacyjny może ocenić, czy egzaminowany posiada wiedzę w tematyce egzaminu, nauczyciel ma obiektywne pojęcie o wiedzy ucznia nie zakłócone jego umiejętnościami, jak gramatyka, ortografia, charakter pisma.

Do wad map wiedzy zalicza się: ograniczenie informacji do prostych skojarzeń, brak wyraźnych powiązań między ideami, niespójność w poziomie szczegółowości, trudność w odczytywaniu, niekiedy zbyt skomplikowana forma zapisu [14]. Janowicz [10] wskazuje także, że mapy wiedzy mogą być nieefektywne podczas sporządzania notatek z wykładów, ale doskonale nadają się do sporządzania streszczeń, podsumowań.

Wbrew niektórym poglądom nowe formy edukacji nie mają na celu wyparcia metod tradycyjnych [12]. Wprowadzanie nowych metod nauczania ma na celu zachęcenie studentów do samodzielnej nauki i innowacyjnej edukacji. Ponadto otwarty i samodzielny charakter pracy działa motywująco [14].

Działanie komputerowych programów do tworzenia map wiedzy odbywa się następująco. W centralnej części ekranu monitora umieszcza się ikonę / nazwę głównego tematu. Od niego prowadzone są rozgałęzienia. Im dalej od centrum tym pojęcia są bardziej szczegółowe. Gałęzie są ustawiane automatycznie, jedynie program iMindMap umożliwia ich kształtowanie. Wśród bezpłatnych narzędzi informatycznych stosowanych do tworzenia map wiedzy można wyróżnić między innymi: bubbl.us [www.bubbl.us], Cmaptools [https://cmap.ihmc.us/cmaptools/], iMindMap [https://imindmap.com/], InfoRapid Know ledgeMap [9], Mind Mup [www.mindmup.com], MindManager [www.mindjet.com], Mindmeister [www.mindmeister.com], Visual Understanding Environment (VUE) [www.vue.tufts.edu], XMind [www.xmind.net]. Na rynku dostępne są także płatne programy komercyjne, które zawierają bardziej rozbudowane funkcje, jak na przykład eksport do wszystkich możliwych typów plików. Najbardziej rozpowszechnione w tej grupie to: Buzan's iMindMapwww [imindmap.com], Creately [www.creately.com], Debategraph [www.debategraph.org], iMindQ [www.imindq.com], Inspiration-Mind42 [mind 42.com]. Programy bezpłatne z powodzeniem mogą być stosowane w edukacji, ponieważ zawierają wszystkie niezbędne funkcje dydaktyczne, takie jak na przykład dołączanie obrazów, linków, notatek [10].

Celem pracy było badanie opinii studentów na temat map wiedzy jako narzędzia do nauczania materiałoznawstwa.

OBIEKT I METODYKA BADAŃ

Do sporządzenia mapy wiedzy został użyty program InfoRapid KnowledgeMap wersja 2005e [9], która jest najnowszą, bezpłatną wersją oprogramowania W 2017 roku przeprowadzono badania ankietowe w grupie studentów pierwszego roku kierunku Inżynieria Rolnicza i Leśna (IRiL) (29 respondentów).

Ankieta anonimowa zawierała 20 pytań: personalnych, dotyczących subiektywnej oceny znajomości języka angielskiego, obsługi komputera, pytania sprawdzające, badające motywację studentów do nauki materiałoznawstwa, dostęp i akceptację do wykorzystywania technologii informatycznych, preferowanych stylów uczenia się oraz wykorzystywania map wiedzy w edukacji.

Wyniki badań zostały opracowane w programie Statistica 13.1 (Dell).

WYNIKI BADAŃ I DYSKUSJA

Wśród studentów kierunku IRiL 83% ankietowanych uważało, że wykorzystywanie narzędzi multimedialnych i komputera na zajęciach laboratoryjnych powoduje wzrost ich atrakcyjności, a 17 % z nich nie miało swojego zdania w powyższej kwestii. We wcześniejszych badaniach ankietowych przeprowadzonych w 2013 roku 82% studentów podzielało powyższy pogląd, a 18% nie miało zdania [8].

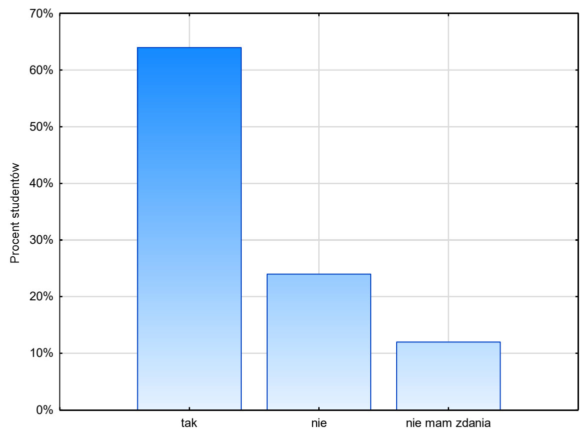
Czynnikiem warunkującym celowość zastosowania narzędzi informatycznych na zajęciach jest między innymi poziom umiejętności obsługi komputera przez studentów. Tabela 1 przedstawia porównanie wyników badań przeprowadzonych w roku 2013 [8] i 2017. Swoją znajomość obsługi komputera 68% badanych oceniło jako dobrą lub bardzo dobrą. Wyniki ankiety przeprowadzanej cztery lata wcześniej są zbliżone, jedynie znacznie zmniejszyła się liczba studentów oceniających bardzo nisko swoje umiejętności pracy z komputerem na ocenę 2.

Tabela 1. Subiektywna ocena znajomości obsługi komputera w opinii studentów

Table 1. Subjective assessment of computer skills in student opinion

Respondenci	Ocena				
	1	2	3	4	5
IRiL, 2017	0%	0%	32%	50%	18%
TRiL, 2013	0%	18%	12%	52%	18%

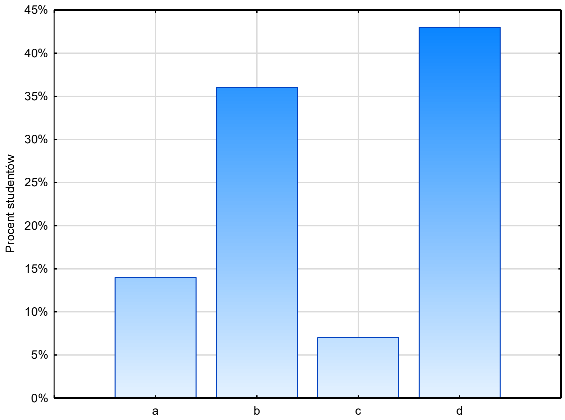
Obserwacje własne autorów oraz przeprowadzone badania dowodzą, że studenci wykazują zainteresowanie zagadnieniami związanymi z materiałoznawstwem i doborem materiałów do konkretnych zastosowań. Twierdząco na pytanie: „Czy przy pomocy programu komputerowego chcesz się dowiedzieć jakie czynniki decydują o doborze materiałów na obudowy telefonów komórkowych?" odpowiedziało 64% badanych (rys. 1). W badaniach ankietowych przeprowadzonych w 2013 roku aż 75% studentów podzielało powyższy pogląd, a 18% studentów nie miało swojego zdania [8].



Rys. 1. Deklaracja chęci uczestnictwa w zajęciach na których źródłem wiedzy o materiałach byłby program komputerowy.

Fig. 1. Declaration of desire to participate in activities in which the source of knowledge about materials would be a computer program.

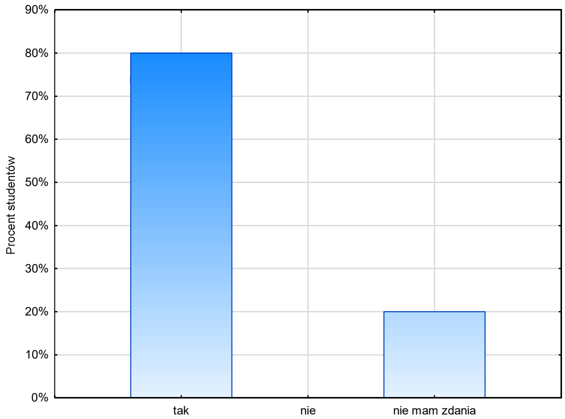
Za najatrakcyjniejsze zajęcia laboratoryjne 43% badanych uznało takie, które łączą różne form prowadzenia zajęć tj. prezentację filmów edukacyjnych, wykonywanie powierzonych zadań samodzielnie lub w grupach, odwzorowywanie mikrostruktur, które omawia prowadzący. Badania ujawniły chęć studentów do pozostawania biernymi odbiorcami treści prezentowanych w filmach dydaktycznych lub przez prowadzącego zajęcia. 36% badanych za najatrakcyjniejsze uznało odwzorowywanie mikrostruktur omawianych przez prowadzącego (rys. 2).



Rys. 2. Odpowiedzi studentów na pytanie: „Która forma prowadzenia zajęć jest najbardziej atrakcyjna: a) wykonywanie powierzonych zadań samodzielnie lub w grupach, b) odwzorowywanie mikrostruktur, które omawia prowadzący, c) oglądanie filmów dydaktycznych, d) połączenie form a, b, c ?"

Fig. 2. The students' answer to the question: "Which form of teaching is most attractive: a) doing tasks alone or in groups, b) copying microstructures that lecturer discusses, c) watching didactic films, d) combination forms a, b, c ?".

Tradycyjne notatki linearne, które studenci wykonują podczas zajęć, mogłyby zostać urozmaicone o mapy wiedzy. Umożliwiłoby to studentom dopisywanie własnych skojarzeń związanych z zastosowaniem lub właściwościami omawianych materiałów inżynierskich. Wprowadzenie nowej metody uaktywniłoby studentów i skłoniło do kreatywnego notowania, co umożliwiłoby głębsze przetworzenie omawianego zagadnienia. Wprowadzenie narzędzi informatycznych do tworzenia map wiedzy byłoby nowością dla większości studentów. Tylko 43% badanych spotkało się z omawianym pojęciem, a 18% respondentów korzystało z map wiedzy we wcześniejszej edukacji. 80% studentów, korzystających we wcześniejszej edukacji z map wiedzy, uznało, że przyswajanie wiedzy było łatwiejsze (rys. 3).

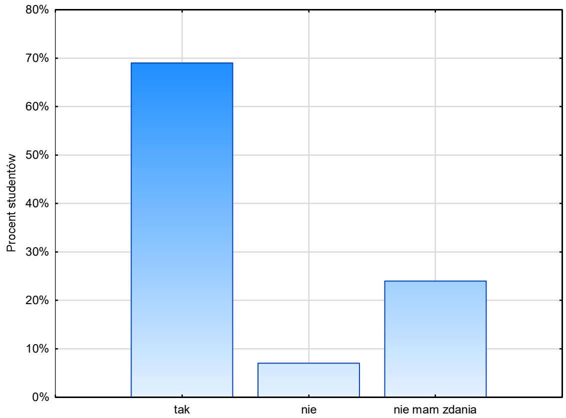


Rys. 3. Odpowiedzi studentów na pytanie: „Czy przyswajanie wiedzy było łatwiejsze ?".

Fig. 3. The students' answer to the question: "Was learning easier ?".

Rood [16] wskazuje, że studenci, którzy korzystali z map wiedzy mieli lepsze wyniki egzaminu, ponieważ byli w stanie przypomnieć sobie duże ilości złożonych informacji. D'Antoni i in. [5,6] nie stwierdzili istotnych różnic w średnich wynikach egzaminu.

Współcześni studenci mają szeroki dostęp do informacji. Opracowując zagadnienia wielu studentów korzysta z informacji dostępnych w Internecie i z łatwością przetwarza je w edytorze tekstu, co nie przyczynia się do ich analizy i lepszego zapamiętywania. Studenci są zainteresowani nowymi technikami uczenia się. Chęć uczestnictwa w zajęciach na których przyswajanie wiedzy ułatwiałyby narzędzia informatyczne zadeklarowało 76% respondentów. Analizując wyniki badań własnych można stwierdzić, że wprowadzenie zmian w programie nauczania i wykorzystywanie technologii informatycznych na zajęciach jest potrzebne i wpłynęłoby na zwiększenie atrakcyjności zajęć. Większość studentów (69%) jest skłonna korzystać z nieznanych do tej pory technik edukacyjnych (rys. 4).

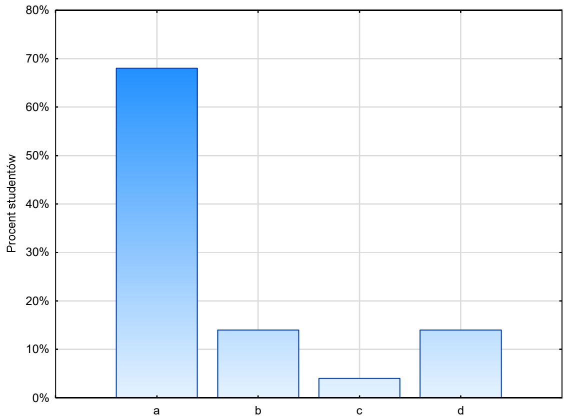


Rys. 4. Odpowiedzi studentów na pytanie: „Czy byłabyś/byłbyś skłonna korzystać z nieznanych do tej pory technik edukacyjnych ?".

Fig. 4. The students' answer to the question: "Would you be willing to use the hitherto unknown educational techniques ?".

Z map wiedzy mogą korzystać studenci, którzy posiadają różne style uczenia się (wzrokowy, kinestetyczny) [4]. 68% respondentów deklaruje, że są wzrokowcami, a 4% – kinestetykami (rys. 5).

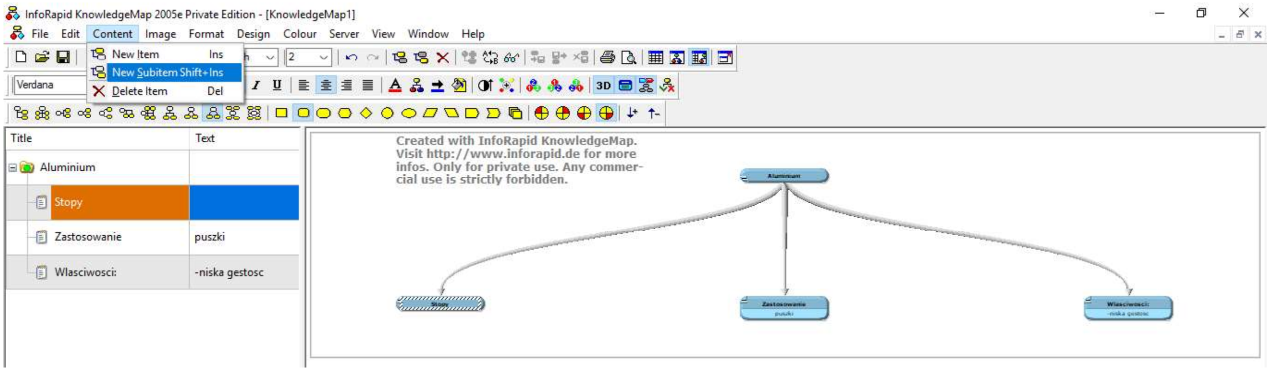
Mapy wiedzy mogą być także pomocne w usystematyzowaniu wiedzy. Do sporządzenia mapy wiedzy został użyty program InfoRapid KnowledgeMap wersja 2005e. Program umożliwia tworzenia graficznie zaawansowanych map wiedzy oraz gromadzenia informacji pełnotekstowych (rys. 6).



Rys. 5. Preferowane style uczenia się: a) wzrokowiec, b) słuchowiec, c) kinestetyk, d) nie wiem.

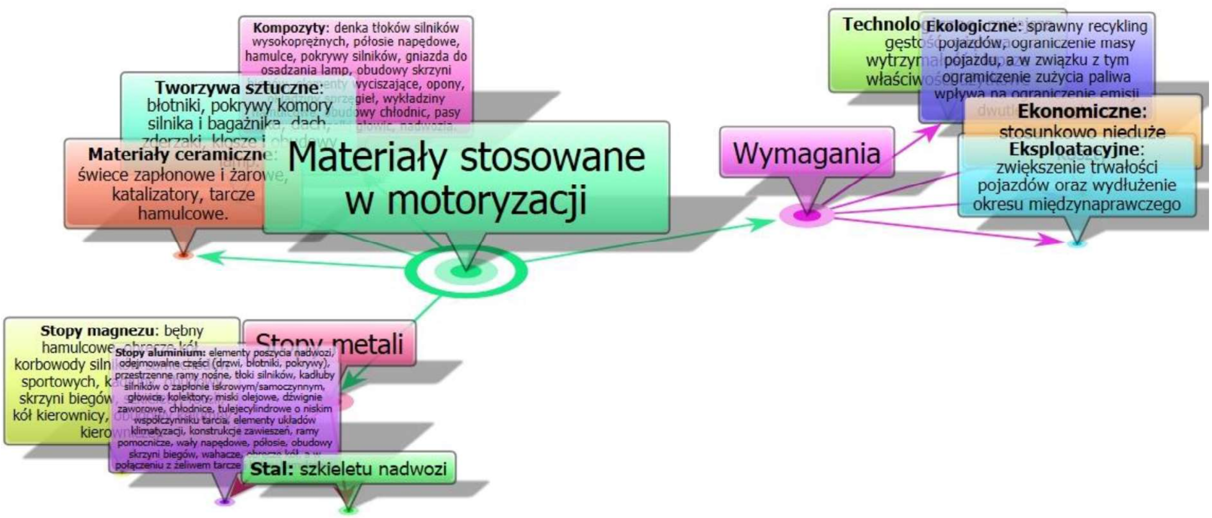
Fig. 5. Preferred learning style: a) visual, b) auditory, c) kinesthetic, d) I do not know.

Korzystanie z programu InfoRapid KnowledgeMap umożliwia studentowi w bardzo szybki i prosty sposób tworzenia map wiedzy, które mogą być formą podsumowania danej partii materiału (rys. 7). Program umożliwia tworzenie dowolnej ilości relacji między zagadnieniami oraz wstawianie opisów, które wyświetlają się dopiero po najechaniu kursorem myszy na dane zagadnienie, dzięki czemu mapy wiedzy są przejrzyste i czytelne.



Rys. 6. Przykład zrzutu z ekranu programu InfoRapid KnowledgeMap.

Fig. 6. Example of the screenshot in InfoRapid KnowledgeMap.



Rys. 7. Przykładowa mapa wiedzy dotycząca materiałów stosowanych w motoryzacji sporządzona w programie InfoRapid KnowledgeMap

Fig. 7. Sample mind map of materials used in the car industry created in InfoRapid KnowledgeMap

PODSUMOWANIE

Przeprowadzone badania wskazują, że dla 82% badanych studentów mapy wiedzy były nieznanym pojęciem. Pomimo tego, po ich prezentacji studentom, 69% badanych wyraziło chęć korzystania z nowych środków dydaktycznych opartych na technologiach informacyjnych. Uwzględniając zalety korzystania z map wiedzy oraz prosty sposób ich tworzenia warto je wykorzystywać w edukacji w celu sporządzania notatek.

Dalsze badania będą miały na celu poszerzenie zakresu tematycznego zajęć dydaktycznych prowadzonych w oparciu o techniki map wiedzy oraz weryfikację hipotezy o ich korzystnym wpływie na wyniki egzaminów i na czas uczenia się.

LITERATURA

1. **Allen B., Crosky A. 2009:** Learning Styles and Constructing Understanding. Why learning theory matters to Materials Engineering educators. Journal of Materials Education, 31 (1-2), 117-130.
2. **Buzan T. 2003:** Use Your Memory. BBC Active., Edinburgh.
3. **Buzan T. 2015:** Mapy twoich myśli. JK Łódź
4. **Chen K.C., Vanasupa L., London B., Harding T., Savage R., Hughes W., Stolk J. 2009:** Creating a project-based curriculum in Materials Engineering. Journal of Materials Education, 31 (1-2), 37-44
5. **D'Antoni A.V., Zipp G.P., Olson V.G., Cahill T.F. 2010:** Does the Mind Map Learning Strategy Facilitate Information Retrieval and Critical Thinking in Medical Students? BMC Medical Education, 10 (6), 10-61
6. **D'Antoni A.V., Zipp G.P., Olson V.G. 2009:** Interrater Reliability of the Mind Map Assessment Rubric in a Cohort of Medical Students. BMC Medical Education, 9 (19), 9-19.
7. **Davies M. 2011:** Concept mapping, mind mapping and argument mapping: what are the differences and do they matter? Higher Education, 62, 279-301.
8. **Grudziński J., Krzywicka M., Stępniewski A. 2014:** Motivations and abilities of students for laboratory classes aided by computer software in English. TEKA. Commission of Motorization and Energetics in Agriculture, 11 (3), 25-28.
9. InfoRapid KnowledgeMap [dostęp online 7.09.2017] www.inforapid.de/html/know ledge-mapeng.htm.
10. **Janowicz M. 2011:** Using mind maps in didactics. Folia Pomeranae Universitatis Technologiae Stetinensis seria Oeconomica, 287 (63), 65-72.
11. **Krzywicka M., Dobrowolski D., Gru-dziński J. 2015:** Application of tools for creating maps of knowledge in teaching Materials Science to students of University of Life Sciences. Annales UMCS Informatica, 1, 16-20.
12. **Lieu D. 1999:** Using interactive multimedia computer tutorials for engineering graphics education. Journal for Geometry and Graphics, 3 (1), 85-91.
13. **Marian M. 2008:** Mnemotechnika i mapy myśli jako narzędzia wspomagające proces uczenia się. Zeszyty Naukowe WSOWL, 4 (150), 91-103.
14. **Noonan M. 2013:** Mind maps: Enhancing midwifery education. Nurse Education Today, 33, 847-852.
15. **Race P., Pickford R. 2007:** Making Teaching Work 'Teaching Smarter'. Post-Compulsory Education. Sage, London.
16. **Rood L.A. 1994:** Effects of mind mapping on student achievement in a nursing research course. Nurse Education, 19 (6), 25-7.
17. **Rosciano A. 2015:** The effectiveness of mind mapping as an active learning strategy among associate degree nursing students. Teaching and Learning in Nursing, 10 (2), 93-99.
18. **Zampetakis L., Tsironis L., Moustakis V. 2006:** Creativity development in engineering education: the case of mind map ping. Journal of Management Development, 26, 370-380.

TEACHING MATERIAL SCIENCE USING IT TOOLS TO BUILD KNOWLEDGE MAPS

Summary. The aim of the work was to present knowledge maps as a tool for teaching material science. The paper presents an example of the use of the InfoRapid KnowledgeMap computer program for mapping knowledge. The survey results of the students of the Faculty of Production Engineering at the University of Life Sciences in Lublin confirmed their positive opinion about the usefulness of using computer programs for didactic classes. Applying knowledge maps in education would be new to more than 80% of students. In spite of this, respondents declared their willingness to use previously unknown learning techniques. Most of the respondents showed interest in the selection of materials for the items they use. The use of new teaching methods could increase students' engagement in the problem of teaching and facilitate their understanding of the subject matter considered difficult.

Key words: knowledge maps, teaching methods, materials science.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 35-39

DOCHODOWOŚĆ PRODUKCJI BURAKÓW CUKROWYCH W KAMPANII 2016/2017 NA PRZYKŁADZIE WOJEWÓDZTWA LUBELSKIEGO

Zbigniew Krzysiak
Uniwersytet Przyrodniczy w Lublinie
ul. Głęboka 28, 20-612 Lublin, Poland. E-mail: zbigniew.krzysiak@wp.pl

Streszczenie. W pracy przedstawiono kompleksową analizę i kalkulacje kosztów uprawy buraków cukrowych w kampanii 2016/2017, Zwrócono uwagę na wynik finansowy tj. wzrost kosztów uprawy i dochodu z produkcji.

Słowa kluczowe: burak cukrowy, koszty, opłacalność, dochodowość produkcji.

WPROWADZENIE

Kampania cukrownicza 2016/2017 w państwach Unii Europejskiej jest przełomową kampanią, ponieważ system kwotowy zostanie zniesiony w dniu 30 września 2017 roku. W kolejnym roku gospodarczym zostanie uwolniony rynek cukru, a funkcjonujące limity produkcyjne przestaną obowiązywać.

Charakterystyczną cechą kampanii 2016/2017 w Krajowej Spółce Cukrowej S.A. (KSC SA) było zwiększenie ilości przerobionych buraków cukrowych w stosunku do kampanii z zeszłego roku. W obecnym sezonie było przerobione 13512244 ton surowca, co daje wynik o 44 % wyższy niż w kampanii 2015/2016. Jest to najwyższy wynik od roku gospodarczego 2002/2003 [2, 3]. Przedstawione wyliczenia to oczywiście wynik zwiększonej kontraktacji buraka cukrowego oraz warunków pogodowych, wyjątkowo sprzyjających ich uprawie.

Średni plon buraków cukrowych wyniósł 66,53 t/ha, a średnia zawartość cukru to 17,32 %. Podane wartości są oczywiście uśrednione i należy wziąć pod uwagę różnice regionalne, do których przyczyniły się warunki pogodowe [3, 18].

Przy minimalnie zmniejszonej względem roku poprzedniego liczbie plantatorów w KSC, która w tej kampanii wyniosła 34071, obszar uprawy uległ znacznemu zwiększeniu z poziomu 171425,79 ha do 203100,00 ha [18].

Ten ponad 18 % wzrost w porównaniu do poprzedniej kampanii odbył się przy zwiększeniu średniej wielkości powierzchni uprawy buraków cukrowych do poziomu 5,96 ha.

W analizowanej kampanii warunki atmosferyczne i agrotechniczne sprzyjały uprawie i wegetacji buraków cukrowych. Pod koniec marca zeszłego roku nastąpił wzrost temperatury i niższe opady co umożliwiło rozpoczęcie siewów. W kwietniu nastąpiło spowolnienie wschodów buraków z powodu ochłodzenia. W maju i czerwcu nastąpiły dobre lub umiarkowane warunki do wzrostu roślin. Duże przyrosty masy buraków cukrowych po opadach deszczu, miały miejsce w lipcu. W sierpniu i we wrześniu nastąpił dalszy wzrost masy korzeni i zawartości cukru, ale już nie tak intensywny jak wcześniej [3].

Natomiast warunki zbioru były względnie dobre, tylko w zachodnich rejonach gdzie wystąpiło mało opadów we wrześniu zbiór był utrudniony, ponieważ przesuszona gleba utrudniała kopanie, co powodowało powstawanie nadmiernych strat.

Produkcja cukru w Polsce odbywa się obecnie w 18 cukrowniach należących do czterech koncernów są to: Krajowa Spółka Cukrowa S.A., Nordzucker Polska S.A, Pfeifer & Langen Polska S.A i Sudzucker Polska S.A.

Ogólnie produkcja cukru w kampanii 2016/17 wyniosła 2 084 443,80 ton. Wynika z tego, że wynik zeszłoroczny został przekroczony o 620 073,00 ton, a przyznana Polsce kwota produkcyjna o 678 835,80 t. Zbiory w tym roku rozpoczęły sięwyjątkowo wcześnie. Jako pierwszy kampanię rozpoczął Pfeifer & Langen Polska S.A. w swoich cukrowniach w Gostyniu, Miejskiej Górce i Środzie Wielkopolskiej – 1 września 2016 roku. Najdłużej pracowała cukrownia Cerekiew, należąca do Südzucker Polska S.A. – do 13 stycznia 2017 r.

Średnia długość kampanii u wszystkich czterech producentów w Polsce wyniosła 112 dni [4].

W oddziałach Krajowej Spółki Cukrowej skup surowca na kampanię 2016/2017 rozpoczął się w pierwszej dekadzie września 2016 roku, a zakończył się w pierwszej dekadzie stycznia 2017 r. Średni czas trwania kampanii wyniósł 105 dni. Kampanię prowadziło 7 oddziałów KSC S.A.: Dobrzelin, Kluczewo, Krasnystaw, Kruszwica, Malbork, Nakło i Werbkowice. We wszystkich siedmiu cukrowniach Spółka skupiła łącznie ponad 5 mln ton buraków cukrowych i wyprodukowała łącznie ponad 800 tys. ton cukru. Najwyższy średni plon uzyskano w Cukrowni Nakło – 78,5 t/ha. Średnia polaryzacja wyniosła ponad 17% i była wyższa niż rok wcześniej. W 2016 roku buraki cukrowe uprawiane były na areale ponad 83 tys. ha, uprawiało je ponad 15 tys. Plantatorów [15].

W Oddziale Krajowej Spółki Cukrowej „Cukrownia Krasnystaw" skupiono 1108000 ton buraków cukrowych. Średni plon z wyniósł 61,6 t/ha, przy średniej powierzchni uprawy wynoszącym 4,41 ha. Średnia polaryzacja ukształtowała się na poziomie 17,73 %, przy średnim zanieczyszczeniu surowca wynoszącym 9,57 %. W omawianej kampanii do Oddziału KSC „Cukrownia Krasnystaw surowiec dostarczało 3802 plantatorów.

Przedstawiona kalkulacja kosztów produkcji buraków cukrowych jest kompleksowa, ze szczególnym uwzględnieniem nakładów pracy własnej i kosztów ogólnogospodarczych. W podobnych kalkulacjach często pomijane są również pozostałe koszty zaangażowania czynników produkcji np. koszty oprocentowania kapitału. W zamieszczonej kalkulacji zostało to uwzględnione. Kalkulację sporządzono dla kampanii 2016/2017, a więc z uwzględnieniem ustabilizowanych warunków produkcji po reformie rynku cukru, a przed zniesieniem kwot cukrowych Kalkulacja obena jak i pozostałe prezentowane przez autora, zawiera kompleksową analizę kosztów produkcji buraków cukrowych oraz jej opłacalności dla gospodarstw indywidualnych rejonu lubelskiego [7-17]. Obecnie z tego regionu około 3802 plantatorów dostarcza buraki cukrowe do Oddziału KSC S.A. „Cukrownia Krasnystaw".

ZAŁOŻENIA METODYCZNE PRZYJĘTE DO KALKULACJI KOSZTÓW UPRAWY BURAKÓW CUKROWYCH

Do analizy kosztów wybrano gospodarstwa indywidualne ukierunkowane na produkcję buraków cukrowych, posiadające sprzęt do tego rodzaju produkcji. Po przeanalizowaniu ok. 123 gospodarstw, do dalszej analizy przyjęto gospodarstwo modelowe odzwierciedlające specyfikę regionalną.

Większość danych zawartych w pracy to własne obserwacje autora lub uzyskane bezpośrednio od plantatorów oraz Oddziału KSC S.A. „Cukrownia Krasnystaw" w Siennicy Nadolnej. Z założenia starano się wszędzie gdzie było to możliwe, zamiast kosztów szacunkowych przyjmować koszty rzeczywiste.

Poszczególne kategorie obliczania kosztów i dochodu określono według poniższego schematu:

1. Wartość produkcji.
2. Koszty bezpośrednie.
3. Nadwyżka bezpośrednia.
4. Koszty pośrednie.
5. Dochód.
6. Koszty ogółem.
7. Koszty produkcji 1 dt [2].

KOSZTY PRACY WŁASNEJ

Koszt pracy własnej został oszacowany według stawki parytetowej za 1 godzinę. Stawkę parytetową wyliczono na podstawie średniorocznego wynagrodzenia netto w całej gospodarce narodowej (według danych GUS), przyjmując, że nominalny czas pracy jednego pełnozatrudnionego w rolnictwie indywidualnym wynosi w ciągu roku 2200 godzin, stawkę przyjęto dla roku 2016 – 15.29 zł [1, 2].

KOSZT PRACY CIĄGNIKA I MASZYN ROLNICZYCH

Koszt pracy ciągnika ustalono na podstawie metodyki kalkulacji kosztów eksploatacji maszyn rolniczych według literatury [5, 6] oraz danych uzyskanych z Lubelskiego Ośrodka Doradztwa Rolniczego w Końskowoli. Jest to kompleksowe zestawienie uwzględniające koszty: amortyzacji, paliwa, olejów i smarów, napraw, garażowania, ubezpieczenia, przeglądu technicznego, oprocentowania kapitału. Czas pracy ciągnika (o mocy 48,5 kW) określono na 400 h/rok (300 mth/rok) uzyskując koszt czasu pracy jednej godziny ciągnika – 84,70 zł. Wartości kosztów poszczególnych zabiegów uprawowych uwzględniają łączny koszt eksploatacyjny pracy ciągnika w połączeniu z maszyną rolniczą. Liczbę godzin poświęconą na poszczególne zabiegi ustalono na podstawie danych literaturowych [5, 6] i własnych doświadczeń autora.

Założono, że modelowe gospodarstwo posiada sprzęt rolniczy zużyty (w 50%) – pług, brona talerzowa i zębata, opryskiwacz i przyczepa rolnicza oraz sprzęt nowy w postaci ciągnika rolniczego, agregatu uprawowego i rozrzutnika nawozów.

POZOSTAŁE ZAŁOŻENIA

Charakterystyka danych do kalkulacji kosztów uprawy buraków cukrowy:

- powierzchnia uprawy buraków cukrowych 2-10 ha;
- uprawa średnio intensywna na glebach kompleksu pszennego dobrego oraz żytniego bardzo dobrego, o pH 6 - 6,5;
- liście buraczane zostają na polu użyźniając glebę;
- gospodarstwo posiada w większości własny sprzęt do produkcji rolnej;
- cena sprzedaży buraków do producenta cukru – 130 zł/t (dla polaryzacji standardowej 16%);
- cena wysłodków mokrych (2,05 zł/dt) przyjęta na poziomie ceny obowiązującej w Oddziale „Cukrownia Krasnystaw" w kampanii 2016/2017;
- ceny środków ochrony roślin i nawozów sztucznych aktualne na kampanię 2016/2017;
- gospodarstwo uprawia buraki cukrowe bez obornika;
- gospodarstwo korzysta z usług – wapnowania, siewu i zbioru buraków cukrowych.

W przeprowadzonym rachunku oszacowano również ilości i wartości produktów ubocznych uzyskiwanych przy uprawie buraków cukrowych (wysłodki). Jak również dodatkowe czynniki zaangażowane w proces produkcji, tj. częściowe koszty: użytkowania samochodu osobowego, telefonu, zużycia energii elektrycznej i wody (uwzględnione w kosztach ogólnogospodarczych.

W kalkulacji przyjęto, że surowiec zostanie zabrany z plantacji transportem producenta cukru (tzw. "odbiór z pola").

KALKULACJA KOSZTÓW

Analizę kosztów produkcji buraków cukrowych z uwzględnieniem wszystkich wcześniej przedstawionych założeń zawarto w tabeli 1.

Tabela 1. Kalkulacja kosztów produkcji 1 ha buraków cukrowych w sezonie 2016/2017
Table 1. Calculation of production costs of 1 ha white sugar beet in season 2016/2017

Lp.	Wyszczególnienie	J.m.	Cena jedn.	Ilość	Wartość zł	Udział %
1.	**Produkcja - korzenie buraków cukr.**	**dt**	**13,00**	**500**	**6500,00**	
1.1	Zwrot podatku VAT ryczłtowego	%	7,00	6500,00	455,00	
1.2	Produkcja uboczna - wysłodki	dt	2,05	250,00	513,50	
1.3	Dopłata bezpośrednia obszarowa	ha	944,44	1,00	944,44	
1.4	Dopłata cukrowa od 2015 do ha	ha	1952,25	1,00	1952,25	
	Razem przychód z produkcji				**10365,19**	
2.	**KOSZTY BEZPOŚREDNIE**					
2.1	**Nasiona:**					
2.2	Odmiana -Jampol Rh Cr (KHBC)	jdn.	599,40	1,25	749,25	10,57%
2.3	**Środki ochrony roślin :**					
2.4	Środki chwastobójcze :					
2.5	Pyramin Turbo 520 S.C.	l	79,00	5,00	395,00	5,57%
2.6	Betanal maxxPro 209 OD	l	127,00	2,50	317,50	4,48%
2.7	Targa Super 0,5 EC	l	95,00	1,50	142,50	2,01%
2.8	Środki grzybobójcze :					
2.9	Optan 183 SE	l	195,00	0,70	136,50	1,93%
2.10	Duet Ultra 497 S.C	l	105,00	1,00	105,00	1,48%
2.11	**Razem koszty środków ochr. roślin**				**991,50**	**13,99%**
2.12	**Potrzeby nawozowe :**					
2.13	N - saletra amonowa 34%	dt	130,00	3,53	458,90	6,48%
2.14	P - superfosfat pot. granulowany 46%	dt	164,00	1,96	321,44	4,54%
2.15	K - sól potasowa 60%	dt	160,00	2,83	452,80	6,39%
2.16	CaO - wapno dolomitowe (co 4 lata)	dt	1,73	40,00	17,30	0,24%
2.17	**Razem koszty nawozów**	**-**	**-**	**-**	**1250,44**	**17,65%**
2.18	**RAZEM KOSZTY BEZPOŚREDNIE**	**-**		**-**	**2991,19**	**42,21%**
3.	**NADWYŻKA BEZPOŚREDNIA**	**-**		**-**	**7374,00**	
4.	**KOSZTY POŚREDNIE**					
4.1	**Koszt kompleksowej obsługi (odbiór z pola)**	**dt**	**0,30**	**500,00**	**150,00**	2,12%
4.2	**Opłata produkcyjna**	**dt**	**0,37**	**500,00**	**182,50**	2,58%
4.3	**Usługi:**					
4.4	Siew nasion		235,78	1,50	353,67	4,99%
4.5	Zbiór korzeni (komb. Holmer)		850,00	1,00	850,00	11,99%
4.6	Wapnowanie (co 4 lata)		252,00	1,00	63,00	0,89%
4.7	**Razem koszty usług**				**1266,67**	**17,87%**
4.8	**Uprawa i ochrona**					
4.9	Talerzowanie	godz.	92,02	2,00	184,04	2,60%
4.10	Bronowanie (2x0,7godz.)	godz.	88,21	1,40	123,49	1,74%
4,11.4.12	Orka głęboka	godz.	92,69	2,50	231,73	3,27%
4.12	Siew nawozów PK (2x0,7godz.)	godz.	96,23	1,40	134,72	1,90%
4.13	Uprawa przedsiewna (agregat 2x0,7godz.)	godz.	105,90	1,40	148,26	2,09%
4.14	Nawożenie pogłówne N (2x0,7godz.)	godz.	96,23	1,40	134,72	1,90%

4.15	Opryski (5x0,5godz.)	godz.	101,33	2,50	253,33	3,57%
4.17	Odbiór korzeni od kombajnu	godz.	102,10	2,00	204,20	2,88%
4.18	**Razem koszt uprawy i ochrony**				**1414,49**	**19,96%**
4.19	**Koszty ogólnogospodarcze**					
4.20	Podatek rolny				132,00	1,86%
4.21	Ubezpieczenie OC				15,00	0,21%
4.22	Amortyzacja budynków				100,39	1,42%
4.23	Pozostałe koszty ogólnogospodarcze				100,25	1,41%
4.24	**Razem koszty ogólnogospodarcze**				**347,64**	**4,91%**
4.25	**Koszty pracy własnej**	**godz.**	**15,29**	**48,00**	**733,92**	**10,36%**
4.26	**RAZEM KOSZTY POŚREDNIE**				**4095,22**	**57,79%**
5.	**DOCHÓD ROLNICZY**				**3278,78**	
6.	**RAZEM KOSZTY**				**7086,41**	

Jak wynika z przeprowadzonej analizy największy udział w uprawie buraków cukrowych (tab 1) miały koszty pośrednie (57,78) a wśród nich największy wpływ na ich udział miały: koszty usług zasiewu i zbioru buraków cukrowych oraz wapnowania - udział 17,87%, koszty uprawy i ochrony roślin - udział 19,98 %, koszty ogólnogospodarcze – udział 4,91 %, koszty pracy własnej – udział 10,36 %.

Duży wpływ miały też koszty bezpośrednie (42,21 %) a w śród nich: koszty nawozów – udział 17,65 %, koszty nasion - udział 10,57%, koszty środków ochrony roślin - udział 13,99 %.

OPŁACALNOŚCI PRODUKCJI BURAKÓW CUKROWYCH

Opłacalność produkcji określono na podstawie wskaźnika opłacalności produkcji zdefiniowanego poniżej.

$$W = \frac{P}{K}, \qquad (1)$$

gdzie: W – wskaźnik opłacalności; P – wartość produkcji w zł; K – koszt produkcji w zł.

Wartość wskaźnika większa od 1 wskazuje na opłacalność produkcji, natomiast wartość mniejsza od jedności świadczy o jej nieopłacalności. Na podstawie tak wyliczonego wskaźnika możemy określić również procentową wartość zysku z produkcji.

Tabela 2. Wartości wskaźnika opłacalności produkcji i kosztu jednostkowej produkcji

Table 2. Values of production cost efficiency and unit cost of production

Rodzaj produkcji	Wskaźnik opłacalności (W)*	Koszt jednostkowej produkcji* (1dt w zł)
Burak cukrowy	1,46	14,17

* Wartości wyliczone z uwzględnieniem: wartości produkcji ubocznej – wysłodków oraz dopłaty obszarowej (JPO+zazielenienie+redystrybu-cyjna) i cukrowej.

Wskaźnik opłacalności jest wyższy od jedności, tak więc produkcja buraków cukrowych jest opłacalna, ale na niskim poziomie dochodowości.

OMÓWIENIE WYNIKÓW

W analizowanym regionie lubelskim reprezentowanym przez plantatorów dostarczających surowiec do produkcji cukru do Oddziału KSC S.A. „Cukrownia Krasnystaw” kampanię skupową 2016/2017, można uznać za udaną. Sprzyjające warunki pogodowe w czasie wegetacji buraków cukrowych, jak również zbioru sprawiły, że skupiono o 68000 ton surowca niż zakontraktowano (1022000 ton). Pochodził on od 3802 plantatorów. Plantatorzy uprawiali buraki na powierzchni 16760 ha osiągając rekordowe plony dochodzące nawet do poziomu 80 t/ha. Taki plon był satysfakcjonujący dla plantatorów tym bardziej, że polaryzacja była też zadawalająca 17,73 %. Te wszystkie korzystne czynniki, jak również podwyższenie ceny za surowiec o 15 zł w stosunku do poprzedniej kampanii, spowodowały osiągnięcie dochodu z produkcji buraków cukrowych do kwoty 3278,78 zł/ha.

Korzystny wynik finansowy spowoduje, że uprawa buraków cukrowych może być opłacalna po uwolnieniu rynku cukru. Dotychczas była to jedna z najbardziej dochodowych, tradycyjnych upraw rolnych w rejonie lubelskim pomimo zróżnicowanego dochodu w poszczególnych latach [7-17] Zdecydowane zwiększenie dochodu plantatorów wpłynie na zwiększenie siły nabywczej producentów rolnych w kolejnych latach realizacji funduszy unijnych. Wpłyną na to, również wysokie dochody lub ich brak z innych rodzajów upraw rolnych spowodowany niesprzyjającymi warunkami agrotechnicznymi i pogodowymi, głównie ze względu na ubiegłoroczną suszę na Lubelszczyźnie.

Zachowanie niskiego lub wysokiego dochodu z upraw rolnych w kolejnych latach przyczyni się do zmniejszenia lub zwiększenia inwestycji w gospodarstwach rolnych.

Omawiana kampania zakończyła się polepszeniem koniunktury w dochodowości uprawy buraków cukrowych. Nastąpiło to przy prawie nie zmienionych cenach na środki produkcji i niezmiennych regulacjach rynku cukru. Po roku 2017 warunki ekonomiczne mogą się jeszcze bardziej zmienić, a uprawa buraków cukrowych przestanie się opłacać lub będzie ekonomicznie nieuzasadniona, gdyż przewiduje się zmniejszenie cen cukru białego.

Nakład niezbędny do wyprodukowania 1 tony cukru z buraka cukrowego spadnie. Produkcja cukru w Unii Europejskiej gwałtownie wzrośnie w latach 2017 i 2018 do ponad 19 mln t, aby następnie obniżyć się do poziomu około 18,5 mln t. Wzrost produkcji obejmie najwydajniejsze regiony, a napędzać go będzie utrzymujący się wzrost zbiorów buraka cukrowego [4].

Najnowsze prognozy wskazują na wolniejszy spadek spożycia cukru w Europie. Za przyczynę tego spadku można uznawać ustanowione przez Komisję Europejską obniżenie produkcji izoglukozy.

Prognozowane spożycie cukru w roku 2026 ma wynieść około 17,8 mln t. Prognozy w roku 2016 mówiły o spożyciu cukru na poziomie około 17,1 mln t. Niemniej jednak, w latach 2016–2026 spożycie cukru może obniżyć się o około 1 mln t rocznie [4].

WNIOSKI

1. Analiza kosztów produkcji buraków cukrowych wykazała jej dochodowość na poziomie średniej wartości dochodu 3278,78 zł/ha przy wskaźniku opłacalności wynoszącym: 1,46.

2. Stwierdzono, że przy produkcji buraków cukrowych na wartość dochodu decydujący wpływ mają koszty pośrednie (57,78 %) są one o 15,57 % większe od kosztów bezpośrednich. Duży udział w kosztach bezpośrednich miały koszty nawozów sztucznych (17,65 %), które w największym stopniu decydują o kosztach produkcji.

3. Głównym czynnikiem obniżającym dochód z uprawy buraków cukrowych było podwyższenie w rozważanym roku gospodarczym ceny za surowiec do 130 zł/t, w stosunku do sezonu ubiegłego (115 zł/t).

4. Uprawa buraków cukrowych charakteryzuje się wysokim kosztem produkcji pochłaniającym 68,37 % przychodu z produkcji.

BIBLIOGRAFIA

1. **Augustyńska-Grzymek I. 2015.** Produkcja, koszty i dochody z wybranych produktów rolniczych w latach 2013-2014. Instytut Ekonomiki Rolnictwa i Gospodarki Żywnościowej, Warszawa.
2. **Chudoba Ł. 2004.** Produkcja buraków cukrowych. Fundusz Współpracy, Warszawa.
3. **Gawryszczak M. 2017.** Wyniki kampanii cukrowniczej 2016/2017. Burak Cukrowy, Wiosna: 3.
4. **Gawryszczak M. 2017.** Średnioterminowe perspektywy dla cukru w latach 2016–2026. Burak Cukrowy, Wiosna: 8-9.
5. **Litwinow A. 2002.** Skrócone normatywy produkcji rolnej Regionalne Centrum Doradztwa Rozwoju Rolnictwa w Radomiu, Radom.
6. **Lorencowicz E. 2004.** Tabele do ćwiczeń z użytkowania maszyn rolniczych. Wydawnictwo Akademii Rolniczej w Lublinie.
7. **Krzysiak Z. 2006.** Koszty i opłacalność produkcji buraków cukrowych. Inżynieria Rolnicza 5: 355-363.
8. **Krzysiak Z. 2008.** Dochodowość produkcji buraków cukrowych w pierwszym roku trwania reformy rynku cukru UE. Gazeta Cukrownicza 8: 262-265.
9. **Krzysiak Z. 2009.** Dochodowość produkcji buraków cukrowych w drugim roku trwania reformy rynku cukru UE. Gazeta Cukrownicza 7-8: 206-208.
10. **Krzysiak Z. 2010a.** Dochodowość produkcji buraków cukrowych w trzecim roku trwania reformy rynku cukru UE. Gazeta Cukrownicza 2: 49-51.
11. **Krzysiak Z. 2010b.** Dochodowość produkcji buraków cukrowych w czwartym roku trwania reformy rynku cukru UE na przykładzie województwa lubelskiego. Gazeta Cukrownicza 5: 126-128.
12. **Krzysiak Z. 2011.** Dochodowość produkcji buraków cukrowych po reformie rynku cukru UE na przykładzie województwa lubelskiego. Gazeta Cukrownicza 3:71-74.
13. **Krzysiak Z. 2012.** Dochodowość produkcji buraków cukrowych w drugim roku po reformie rynku cukru UE na przykładzie województwa lubelskiego. Gazeta Cukrownicza 3:.112-115.
14. **Krzysiak Z. 2013.** Dochodowość produkcji buraków cukrowych w trzecim roku po reformie rynku cukru UE na przykładzie województwa lubelskiego. Gazeta Cukrownicza nr 5-6/2013, s. 185-188.
15. **Krzysiak Z. 2015.** Dochodowość produkcji buraków cukrowych w czwartym roku po reformie rynku cukru ue z uwzględnieniem kosztów transportu. Logistyka 3/2015, 2612-2617.
16. **Krzysiak Z. 2017.** Dochodowość produkcji buraków cukrowych w piątym roku po reformie rynku cukru UE na przykładzie województwa lubelskiego. Studium i Wiedza.
17. **Krzysiak Z. 2016.** Dochodowość produkcji buraków cukrowych w kampanii 2015/2016 na przykładzie województwa lubelskiego Motorol, Vol. 18, No. 9, 21-26.
18. http://www.polski-cukier.pl/ dostęp w dniu 31.03.3017.

PROFITABILITY OF SUGAR BEET CROP IN CAMPAIGN 2016/2017 ON THE EXAMPLE OF LUBELSKIE PROVINCE

Summary. The paper presents complex analysis and calculation of sugar beet crop profitability in campaign 2015/2016, It has been focused on the crop profitability.

Key words: sugar beet cultivation, cost and profitability of sugar beet production.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 41-44

ANALIZA PROCESU KONWEKCYJNO-MIKROFALOWEGO SUSZENIA PLASTRÓW CEBULI

Andrzej Krzykowski, Stanisław Rudy, Renata Polak, Dariusz Dziki, Beata Biernacka, Renata Różyło
Uniwersytet Przyrodniczy w Lublinie
Ul. Doświadczalna 44, 20 - 280 Lublin, Poland. E-mail: andrzej.krzykowski@up.lublin.pl

Streszczenie: Celem pracy była ocena wpływu temperatury powietrza suszącego oraz mocy promieniowania mikrofalowego, na kinetykę konwekcyjno-mikrofalowego suszenia cebuli odmiany Wolska. Określono sumaryczne nakłady energetyczne oraz współrzędne chromatyczne barwy suszu. Analiza wyników badań pozwoliła na wyznaczenie optymalnych parametrów procesu, które wyznacza temperatura powietrza suszącego 40°C, przy mocy mikrofal 50 W.

Słowa kluczowe: suszenie konwekcyjno-mikrofalowe, energochłonność, cebula, barwa.

WSTĘP

Cebula (*Allium cepa L.)* to dwuletnia roślina należąca do rodziny czosnkowatych, jest jedną z najstarszych roślin uprawnych, była szeroko stosowana nawet w czasach starożytnych, nie tylko do bezpośredniego spożycia, ale również jako przyprawa. W obecnych czasach, cebula jest uprawiana w większości krajów świata a jej głównym producentem są Chiny i Indie [11, 13, 6]. Warzywo to posiada specyficzny smak i zapach, ze względu na zawartość olejków eterycznych, zawiera dużą ilość flawonoidu (kwercetyny), o bardzo dobrej wchłanialności, dwukrotnie wyższej niż w przypadku herbaty i ponad trzykrotnie w porównaniu do jabłek. Związki siarki obecne w cebuli pomagają zapobiec rozwojowi komórek nowotworowych, jest ona również stosowana w leczeniu niedokrwistości oraz zaburzeń układu moczowego [1, 9, 5]. Cebula znajduje szerokie zastosowanie nie tylko w postaci surowej, ale również jako susz, najczęściej w formie sproszkowanej, płatków, grysiku oraz innych. Używana jest jako dodatek do mięs, sosów, zup, sałatek i marynat.

Suszenie zapewnia nie tylko dłuższy okres przechowywania żywności, ale wpływa na ograniczenie kosztów transportu i magazynowania [3]. Najczęściej stosowanym sposobem suszenia cebuli jest metoda konwekcyjna, jednak ze względu na długi czas i często wysoką temperaturę procesu powoduje wiele niepożądanych zmian w materiale [7]. Dlatego prowadzone są badania w kierunku zastosowania nowych technik suszenia, zwiększających szybkość procesu i poprawiających jakość uzyskanego suszu. Tymi metodami są: suszenie próżniowe oraz przy użyciu promieniowania podczerwonego i mikrofalowego. Zastosowanie promieniowania mikrofalowego powoduje zwiększenie szybkości suszenia, przyczynia się do zachowania barwy i aromatu suszu, wpływa także korzystnie na skurcz, porowatość i właściwości rekonstytucyjne suszu [4, 7, 8, 12]. Jednak sam proces suszenia mikrofalowego może powodować nierównomierne ogrzewanie surowca, co skutkuje uszkodzeniami teksturalnymi suszu [15], dlatego coraz częściej stosowana jest kombinacja dwóch lub więcej metod suszenia jak np. wspomaganie procesu suszenia konwekcyjnego mikrofalami [14, 10].

Celem przeprowadzonych badań było zbadanie wpływu parametrów mikrofalowo – konwekcyjnego suszenia cebuli na kinetykę i energochłonność procesu oraz barwę suszu.

MATERIAŁ I METODY BADAŃ

Materiał badany stanowiły bulwy cebuli odmiany Wolska, rozdrobnione przed procesem suszenia w plastry o grubości 3 mm. Proces suszenia konwekcyjnego, oraz konwekcyjno - mikrofalowego wykonano w laboratoryjnej suszarce, umożliwiającej regulację temperatury powietrza, mocy mikrofal oraz pomiar zmian masy. Proces prowadzono przy prostopadłym do warstwy materiału przepływie powietrza suszącego o temperaturze 40°C i 60°C, stałej prędkości przepływu 0,5 $m \cdot s^{-1}$, obciążenie sita wynosiło 3 $kg \cdot m^{-2}$. Badania przeprowadzono dla trzech poziomów mocy mikrofal 100 W, 50 W i 25 W oraz bez zastosowania wspomagania mikrofalowego. Suszeniu poddano próby rozdrobnionego surowca o masie 100 g. Rejestrację zmian masy materiału w trakcie suszenia dokonywano z dokładnością ±0,1 g. Badania zostały przeprowadzone do uzyskania wilgotności końcowej suszu wynoszącej 12%. W celu przedstawienia kinetyki procesu suszenia obliczono zredukowaną zawartość wody MR z następującego wzoru:

$$MR = \frac{u_\tau - u_r}{u_0 - u_r}, \quad (1)$$

gdzie: MR – zredukowana zawartość wody [–]; u_r – równowagowa zawartość wody [g $H_2O \cdot$g s.s^{-1}.]; u_0 – początkowa zawartość wody [g $H_2O \cdot$g s.s^{-1}.]; u_τ – zawartość wody po czasie τ [g $H_2O \cdot$g s.s^{-1}.].

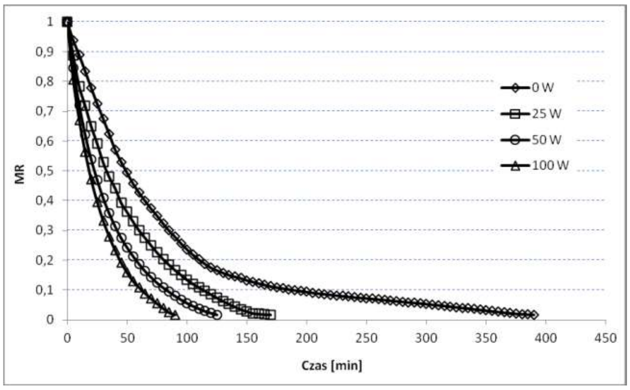
Ponieważ wartość u_r jest bardzo mała, w porównaniu z wartościami u_0 i u_τ, została pominięta. Takie uproszczenie jest powszechnie stosowane i nie ma większego wpływu na wyniki badań dotyczące kinetyki suszenia [2]. Zredukowana zawartość wody MR może być wyrażona jako:

$$MR = \frac{u_\tau}{u_0}. \quad (2)$$

Pomiary ilości energii elektrycznej, doprowadzanej do suszarki konwekcyjno- mikrofalowej przeprowadzono z użyciem cyfrowego trójfazowego miernika mocy DW 6093 firmy Lutron, wyposażonego w oprogramowanie SW- U811. Współrzędne barwy oznaczano w systemie CIE Lab metodą odbiciową, przy użyciu spektrofotometru sferycznego X- Rite 8200. Analizy badanego materiału wykonano w pięciu powtórzeniach. Dane eksperymentalne poddano analizie wariancji na poziomie istotności α = 0,05.

WYNIKI

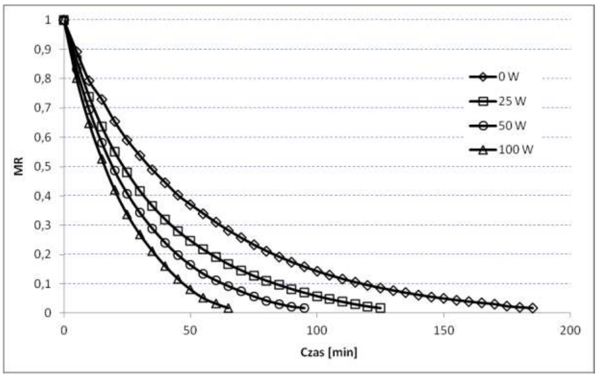
Na rysunkach 1-2 zestawiono krzywe suszenia, uzyskane przy temperaturze powietrza suszącego 40°C i 60°C, na czterech badanych poziomach mocy mikrofal (0 W, 25 W, 50 W, 100 W).



Rys. 1. Krzywe konwekcyjno – mikrofalowego suszenia plastrów cebuli (temperatura powietrza suszącego – 40°C)

Fig. 1. The convection - microwave drying curves of onion slices (air temperature – 40°C)

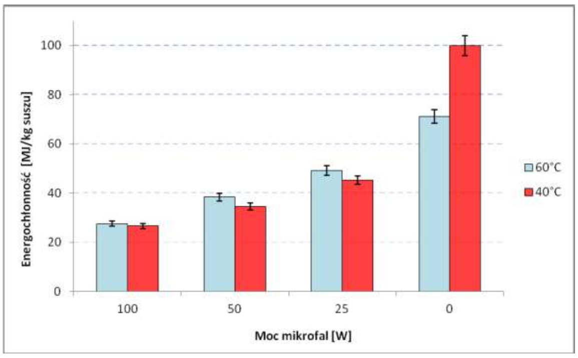
Na podstawie analizy danych eksperymentalnych można stwierdzić, że wzrost mocy mikrofal przyspiesza proces suszenia na każdym poziomie temperatury. Również podwyższenie temperatury powietrza od 40°C do 60°C powoduje zwiększenie intensywności usuwania wody z materiału na wszystkich poziomach mocy mikrofal. Wpływ zastosowania promieniowania mikrofalowego na kinetykę procesu jest najbardziej widoczny w temperaturze 40°C. Najkrótszym czasem suszenia charakteryzował się proces przeprowadzony w temperaturze 60°C, przy mocy mikrofal 100 W.



Rys. 2. Krzywe konwekcyjno – mikrofalowego suszenia plastrów cebuli (temperatura powietrza suszącego – 60°C)

Fig. 2. The convection - microwave drying curves of onion slices (air temperature – 60°C)

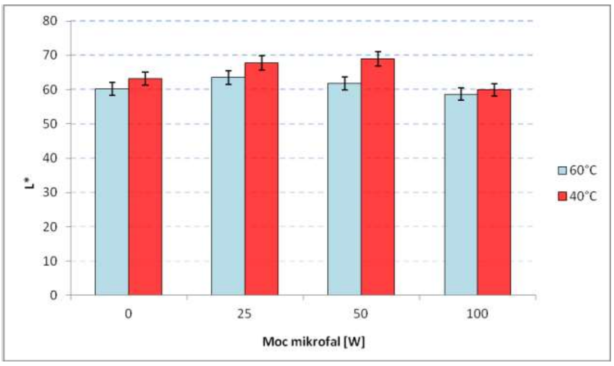
Rysunek 3 przedstawia całkowite nakłady energetyczne (energia niezbędna do podgrzania powietrza oraz energia promieniowania mikrofalowego) ponoszone w procesie konwekcyjno- mikrofalowego suszenia cebuli. Najmniejsze sumaryczne nakłady energii (dla obydwu badanych temperatur powietrza suszącego) odnotowano przy zastosowaniu wspomagania suszenia konwekcyjnego promieniowaniem mikrofalowym o mocy 100 W. Zmniejszenie mocy promieniowana mikrofalowego powoduje wzrost nakładów energetycznych. Dla obu badanych temperatur największa energochłonność występuje przy stosowaniu procesu konwekcyjnego suszenia, bez wspomagania promieniowaniem mikrofalowym. Sumaryczne nakłady energetyczne podczas suszenia konwekcyjno – mikrofalowego są mniejsze dla temperatury powietrza suszącego wynoszącej 40°C. W procesie suszenia konwekcyjnego (bez zastosowania promieniowania mikrofalowego) ilość energii dostarczanej do powietrza jest większa przy suszeniu w temperaturze 40°C o ok. 29%, co związane jest z dłuższym czasem suszenia.



Rys. 3. Całkowite nakłady energetyczne w procesie konwekcyjno – mikrofalowego suszenia plastrów cebuli

Fig. 3. Total energy use in the convection - microwave drying process of onion slices

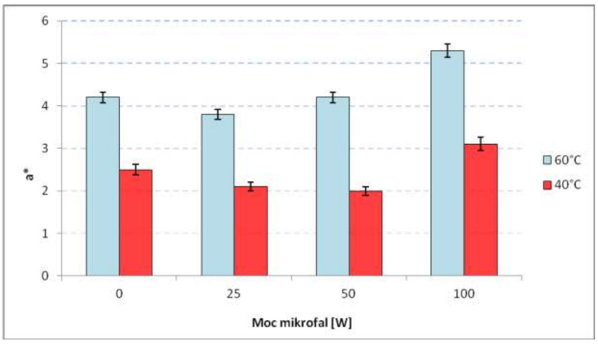
Wyniki badań dotyczące wartości chromatycznych współrzędnych barwy suszu, w zależności od warunków prowadzenia procesu suszenia, zestawione zostały na rysunkach 4 - 6. Surowiec charakteryzował się następującymi wartościami chromatycznych współrzędnych barwy: L* = 72,5; a* = -2,8; b* = 7,4.



Rys. 4. Wartość współrzędnej barwy L* suszu z cebuli

Fig. 4. The color values L* of dried onion

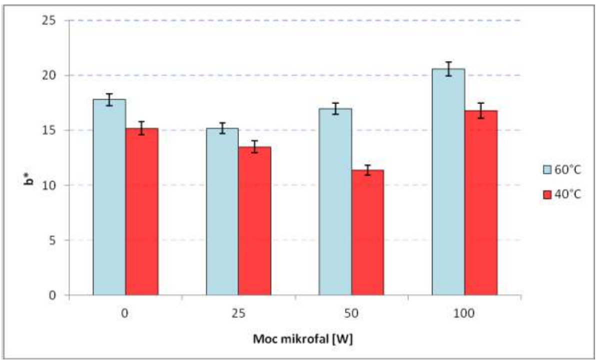
Susz o największej wartości współrzędnej L*, (najbardziej jasny) uzyskano w temperaturze 40°C podczas suszenia konwekcyjno – mikrofalowego o mocy mikrofal 50 W. Wartość współrzędnej barwy L* była zawsze większa dla temperatury powietrza suszącego 40°C, w całym zakresie mocy mikrofal. Suszenie wyłącznie konwekcyjne przyczynia się do zmniejszenia jasności barwy, ze względu na długi czas procesu, natomiast zastosowanie mocy mikrofal o największej wartości powoduje zmniejszenie wartości współrzędnej barwy L*, pomimo skrócenia czasu suszenia, co może być spowodowane wzrostem temperatury suszonego materiału.



Rys. 5. Wartość współrzędnej barwy a* suszu z cebuli

Fig. 5. The color values a* of dried onion

Współrzędna barwy a* (Rys. 5), w całym zakresie pomiarowym, posiada większą wartości niż w przypadku surowca, co świadczy o tym, że barwa suszu przesuwa się od zieleni do czerwieni. W procesie suszenia, w całym zakresie mocy mikrofal susz o korzystniejszej wartości współrzędnej a* (mniejsze zmiany w porównaniu z surowcem) uzyskano przy temperaturze powietrza suszącego 40°C. Najbardziej negatywne zmiany tej wartości współrzędnej barwy suszu występują przy zastosowaniu mocy mikrofal 100 W oraz po suszeniu konwekcyjnym bez wspomagania mikrofalami. Susz charakteryzujący się najmniej odbiegającą wartością współrzędnej a* w porównaniu z surowcem, uzyskano w temperaturze 40°C, przy mocy promieniowania mikrofalowego 50 W.



Rys. 6. Wartość współrzędnej barwy b* suszu z cebuli

Fig. 6. The color values b* of dried onion

Na rysunku 6 zobrazowano wartości chromatycznej współrzędnej barwy b* suszu, które są większe niż w przypadku surowca, co świadczy o tym, że barwa suszu staje się bardziej żółta. Charakter zmian tej współrzędnej barwy jest zbliżony do tego, który został opisany dla współrzędnej a*. Również w tym przypadku susz o najlepszym zachowaniu barwy, w odniesieniu do surowca, otrzymano przy temperaturze powietrza 40°C i mocy mikrofal 50 W.

PODSUMOWANIE I WNIOSKI

Wspomaganie suszenia konwekcyjnego promieniowaniem mikrofalowym może wpływać na zwiększenie kinetyki suszenia, zmniejszenie energochłonności procesu i poprawę cech jakościowych suszu. Uwarunkowane jest to jednak doborem optymalnych parametrów procesu, temperatury powietrza suszącego a szczególnie mocy mikrofal, mając na uwadze ilość suszonego materiału. Analiza wyników przeprowadzonych badań pozwoliła na wysunięcie następujących wniosków:

1. Zwiększenie mocy promieniowania mikrofalowego w procesie konwekcyjno – mikrofalowego suszenia plastrów cebuli powoduje wzrost intensywności odprowadzania wody z materiału i przyczynia się do skrócenia czasu suszenia, co szczególnie uwidacznia się w temperaturze 40°C.
2. Najmniejsze sumaryczne nakłady energii (dla obydwu badanych temperatur powietrza suszącego) odnotowano przy zastosowaniu wspomagania suszenia konwekcyjnego promieniowaniem mikrofalowym o mocy 100 W. Zmniejszenie mocy promieniowana mikrofalowego powoduje wzrost nakładów energetycznych.
3. Uzyskanie suszu z cebuli przy temperaturze 40°C, na wszystkich poziomach mocy mikrofal, wymaga mniejszych nakładów energetycznych niż w temperaturze 60°C.
4. Susz uzyskany w temperaturze 40°C i mocy mikrofal 50 W charakteryzował się współrzędnymi barwy najbardziej zbliżonymi do współrzędnych L*, a*, b* surowca.
5. Biorąc pod uwagę zakres prowadzonych badań, proces konwekcyjno – mikrofalowego suszenia plastrów cebuli, ze względu na czas trwania, energochłonność oraz barwę suszu, należy przeprowadzać w temperaturze 40°C przy mocy mikrofal 50 W.

LITERATURA

1. **Bebartta J.P., Sahoo N.R., Dash S.K., Panda M.K., Pal U.S. 2014.** Kinetics modeling and moisture diffusivity of onion slices in fluidized bed drying. Journal of Food Processing and Preservation, 38 (1), 193-199.
2. **Goyal, R.K, Kingsly, A.R.P, Manikantan, M. R & Ilyas S. M. 2007.** Mathematical modelling of thin layer drying kinetics of plum in a tunnel dryer. Journal of Food Engineering 79 (1), 176–180.
3. **Khan M.K.I., Ansar M., Nazir A., Maan A.A. 2016.** Sustainable dehydration of onion slices through novel microwave hydro-diffusion gravity technique. Innovative Food Science & Emerging Technologies 33, 327-332.

4. **Mitra J., Shrivastava S.L., Rao P.S. 2011.** Vacuum dehydration kinetics of onion slices. Food and Bioproducts Processing 89 (1), 1-9.
5. **Mitra J., Shrivastava S.L., Rao P.S. 2012.** Onion dehydration: a review. Journal of Food Science and Technology 49 (3), 267-77.
6. **Mota C.L., Luciano C., Dias A., Barroca M.J., Guine R.P.F. 2010.** Convective drying of onion: Kinetics and nutritional evaluation. Journal of Food Engineering 88, 115–123.
7. **Nowacka M., Śledź M., Wiktor A., Witrowa-Rajchert D. 2012.** Fizyczne i chemiczne właściwości produktów spożywczych suszonych z wykorzystaniem mikrofal. ŻYWNOŚĆ. Nauka. Technologia. Jakość, 6 (85), 5–20.
8. **Praveen K.D.G., Umesh H.H., Sukumar D., Ramesh M.N. 2005.** Infrared and hot-air drying of onions. Journal of Food Processing and Preservation, 29, 132-150.
9. **Sampath K.P.K., Bhowmik D., Chiranjib B., Tiwari P. 2010.** *Allium cepa*: A traditional medicinal herb and its health benefits. Journal of Chemical and Pharmaceutical Research, 2, 283-291.
10. **Sharma G.P., Prasad S. 2004.** Effective moisture diffusivity of garlic cloves undergoing microwave-convective drying. Journal of Food Engineering 65, 609–617.
11. **Sharma G.P., Verma R.C., Pathare P. 2005.** Mathematical modeling of infrared radiation thin layer drying of onion slices. Journal of Food Engineering 71 (3), 282–286.
12. **Sumnu G., Turabi E., Oztop M., 2005.** Drying of carrots in microwave and halogen lamp–microwave combination ovens. Food Science and Technology/LWT, 38, 5, 549-553.
13. **Sutar P.P., Gupta D.K. 2007.** Mathematical modeling of mass transfer in osmotic dehydration of onion slices. Journal of Food Engineering 65, 609–617.
14. **Wang Z., Sun J., Chen F., Liao X., Hu X., 2007.** Mathematical modelling on thin layer microwave drying of apple pomace with and without hot air pre-drying. Journal of Food Engineering, 80, 536-544.
15. **Zhang M., Tang J., Mujumdar A., Wang S. 2006.** Trends in microwave-related drying of fruits and vegetables. Trends in Food Science & Technology, 17, 524-534.

THE ANALYSIS OF HOT AIR-MICROWAVE DRYING PROCESS OF ONION SLICES

Summary: The aim of the work was evaluation air temperature and microwave irradiation power, on the convection - drying process, kinetics of the onion (cv. Wolska). The total energy consumption and the color coordinates of the dried onion were determined. The analysis of the results of the study allowed to determine the optimal parameters of the process: drying air temperature 40° C and microwave power 50 W.

Key words: hot air - microwave drying, energy consumption, onion, color.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 45-53

TO THE ISSUE OF CUTTING ELASTIC BODIES WITH A RIGID CUTTER

Aleksandr Nanka, Denis Boiko, Ivan Ievlev, Vitaliy Sementsov
Kharkiv Petro Vasylenko National Technical University of Agriculture
Alchevskyh St., 44, Kharkiv, Ukraine. E-mail: kaf_mtf@ukr.net

Summary. The process of elastic body crushing by means of a rigid cutter (press tool) has been considered with the involvement of contact problems of linear elasticity theory. The problem is solved in a two-dimension formulation when the elastic body occupies a half-space. Two statements of problems are presented: the first one when the press tool has the form of a wedge with an acute cutting edge and the second one when the cutting edge of the press tool is rounded. The obtained numerical results are presented in the form of relevant graphs.

Key words: cutting, crushing, press tool, contact problem, cutter, blunt cutter, linear elasticity.

INTRODUCTION

There are various methods of dividing rigid bodies, such as grain, straw and other agricultural products, into small parts. They are cutting, fracture and crushing [1, 2]. In this case, the dynamics of crushing depends both on the type of the material of the body being destroyed and the way it is crushed [3-14]. There may be either brittle fracture, when, up to the division of the body into parts, it remains in the elastic state, or formation of developing plastic zones [6, 7]. In any case, under loading, the body at first undergoes elastic deformations under the action of the laws of the linear theory of elasticity.

Normally, cutting of an elastic body V_1 is carried out by means of another more rigid V_2 (in the limit absolutely rigid) body, called a press tool (cutter, cutting tool, see Fig.1).

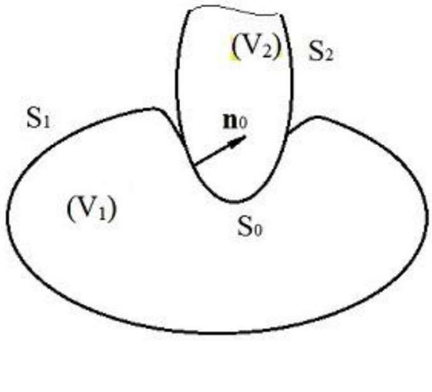


Fig.1. The scheme of contact of the body with a press tool

Thus, cutting of the body is accompanied by a contact interaction of bodies through the contact surface S_0. The contact of bodies can be considered as imposing simplex communication on the bodies. It can take place under certain conditions – the voltages should be compressive. In the case of contact of bodies on the surface S_0, the normal component of the displacement of the points of the elastic body is given. On other boundaries S_1, S_2, the standard boundary conditions of either the first or the second kind occur [8, 9]. Equilibrium equations are satisfied in the domains V_1, V_2. The problems of determining the stress-strain state in this formulation are related to the section of contact problems in the theory of elasticity [8–11]. Further we will consider a static stress-strain state, and assume a press tool to be an absolutely rigid body. It should be noted that the contact surface S_0 is previously unknown and is determined in the process of solving the problem. This makes it very difficult to find solutions to such problems. In the linear theory of elasticity, deformations are considered small, which allows one to neglect the change in its shape when the body is loaded.

Below we consider the contact problem about the action of the press tool V_2 in the shape of an infinitely long wedge (cutter) on the elastic half-space V_1 (Fig. 2).

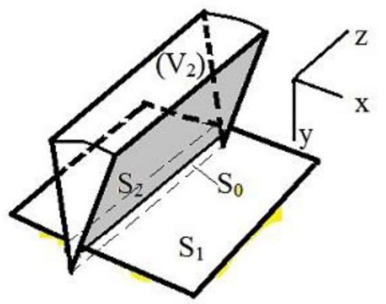
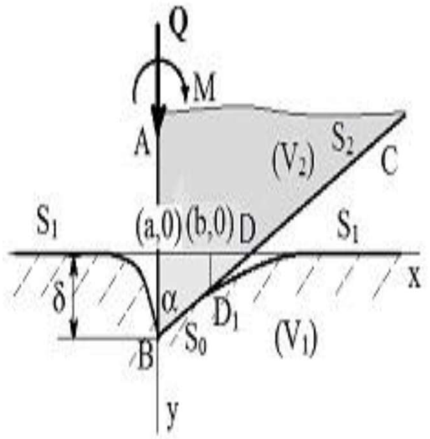


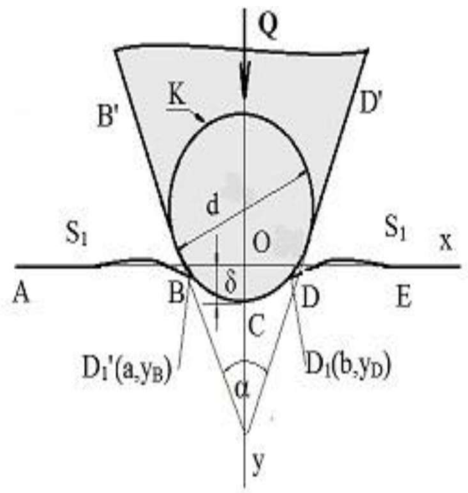
Fig.2. The intrusion of a long wedge into elastic half-space

This allows us to seek a solution in the framework of a plane problem, when the desired functions depend only on two spatial variables $x = x_1$, $y = x_2$, and the cross section of the bodies along the axis $Oz\,(z = x_3)$ does not change. The last assumption corresponds to the fact that the press tool can be made in the shape of a wedge-shaped cylindrical body with a cutting edge directed along the axis Oz.

Theoretically, the cutting edge should be sharp to form a wedge (Fig. 3*a*). However, as the microscopic examination shows, the cutting edge of the cutter turns out to be rounded (Fig. 3*b*) [4]. The presence of the rounding of the cutting edge has a significant effect on the distribution of stresses on the contact surface of the bodies. For a wedge with a sharp edge, the stresses at the points of the edge take infinite values.



a)



b)

Fig.3. For problems 1 and 2

STATEMENT OF THE BOUNDARY PROBLEM ON THE PENETRATION OF A RIGID PRESS TOOL INTO ELASTIC HALF-SPACE

We introduce the Cartesian coordinate system $Oxyz$. We consider the plane problem. Let an elastic body occupy a half-space $y > 0$, and a press tool be a wedge either with a sharp or rounded cutting edge with a cylindrical lateral surface, the generatrix of which is directed along the axis Oz (Fig. 3). The press tool moves progressively and penetrates the elastic body to the depth of δ. Thus, the body surface is deformed and deviates from the horizontal plane.

On the assumption of the linear elasticity theory, we suppose the deformations to be small, and the connection between the stress tensor and the deformation tensor to be linear, defined by Hooke's law [8, 9]. In this case, the shape of the elastic body is neglected – the body occupies the same area of space before and after loading. On the boundary of the elastic body $S = S_1 \cup S_0$ the outward normal is $\vec{n} = \vec{n}_0 = \vec{n}_1 = (0, -1, 0)$. The action of mass forces is neglected, but we take into account the effect of the press tool in the form of surface forces applied in the zone of contact of the press tool with the body. We assume that, in the zone of contact S_0, the tangential stress component is zero $\tau_n\big|_{S_0} = 0$ (the frictional force between the press tool and the body is absent), and the normal component is negative $\sigma_n\big|_{S_0} =\leq 0$ (the tool presses onto the elastic body). Under the action of the press tool the vertical components of the displacement of the points of the press tool and elastic body in the zone of their contact coincide. Hence, the vertical component of displacements of points of a surface S_0 is known. This stress state is caused by the action of forces applied to the press tool with the principal vector $\vec{Q} = \vec{e}_y Q$ and the principal moment $\vec{M} = \vec{e}_z M$ with regard to the axis Oz.

We denote the displacement vector of the points of the elastic body by $\vec{u}$, the third component of which, due to the assumptions about the plane deformed state, is zero:

$$\vec{u} = \left(u(x,y), \mathrm{v}(x,y), 0)\right), \tag{1}$$

and the stress tensor by $\hat{\sigma} = \left\{\sigma_{ij}\right\}_{i,j=1}^{3}$, with the matrix:

$$\hat{\sigma} = \begin{pmatrix} \sigma_x & \sigma_{xy} & 0 \\ \sigma_{xy} & \sigma_y & 0 \\ 0 & 0 & \sigma_z \end{pmatrix}. \tag{2}$$

The stress tensor is associated with the strain tensor $\hat{\varepsilon} = \left\{\varepsilon_{ij}\right\}_{i,j=1}^{3}$:

$$\hat{\varepsilon} = \begin{pmatrix} \varepsilon_x & \varepsilon_{xy} & 0 \\ \varepsilon_{xy} & \varepsilon_y & 0 \\ 0 & 0 & 0 \end{pmatrix}$$

using Hooke's law:

$$\varepsilon_{ij} = \frac{1}{2\mu}\left(\sigma_{ij} - \frac{\nu}{1+\nu}\sigma\delta_{ij}\right)$$
$$\left(i, j = 1,2,3;\ \sigma = \sigma_x + \sigma_y + \sigma_z\right) \tag{3}$$

or in the form:

$$\sigma_x = \frac{2\mu}{1-2\nu}\left[(1-\nu)\varepsilon_x + \nu\varepsilon_y\right], \quad \sigma_{xy} = 2\mu\varepsilon_{xy}$$
$$\sigma_y = \frac{2\mu}{1-2\nu}\left[\nu\varepsilon_x + (1-\nu)\varepsilon_y\right], \quad \sigma_z = (\sigma_x + \sigma_y) \tag{4}$$

where: μ, ν – are Lame and Poisson coefficients, respectively.

The general formulation of the problem of the equilibrium of an elastic body in the linear elasticity theory is stated as follows [8, 9]. In the zone V_1 there are equations of equilibrium:

$$\frac{\partial \sigma_{ki}}{\partial x_k} = 0 \quad (i, k = 1,2,3)$$

which can be represented as the system:

$$\frac{\partial \sigma_x}{\partial x} + \frac{\partial \sigma_{xy}}{\partial y} = 0, \quad \frac{\partial \sigma_{xy}}{\partial x} + \frac{\partial \sigma_y}{\partial y} = 0\ . \tag{5}$$

On the free boundary S_1 stresses are absent: normal $\sigma_n\big|_{S_1}=0$ and tangential $\tau_n\big|_{S_1}=0$ are equal to zero. There are no tangential stresses $\tau_n\big|_{S_0}=0$ in the zone of contact S_0, but the displacement of points in the direction normal to S_0 are given:

$$u_n=\vec{U}\cdot\vec{n}, \tag{6}$$

where: $\vec{n}$ is a unit normal to S_0, external to the volume V_1,, $\vec{U}=-U(x)\,\vec{e}_y$ $(U>0)$ is a displacement of the body points touching the press tool S_0.

At infinity, the behavior of the solution must be set in the form:

$$|\vec{u}|\xrightarrow[|\vec{r}|\to\infty]{}0,\ |\sigma_{ij}|\xrightarrow[|\vec{r}|\to\infty]{}0\ \ \left(|\vec{r}|=\sqrt{x^2+y^2}\right)\ . \tag{7}$$

Thus, a plane deformed state is determined by three unknown components of the stress tensor $\sigma_x,\sigma_y,\sigma_{xy}$ that satisfy the homogeneous equilibrium equations (5) in the area $y>0$. In the application to this problem, a straight line combined with a horizontal axis is the boundary of the area $L=\{\mathrm{y}=0,(-\infty<x<\infty)\}$. This boundary can be represented as the union of the boundaries $L=L_{-\infty}U\,L_0\,U\,L_\infty$, where $L_{-\infty}=\{-\infty<x\le a,\ y=0\}$, $L_0==\{\ a\le x\le b,\ y=0\}$, $L_\infty=\{b<x<\infty, y=0\}$.

The absence of stresses on $L_{-\infty},L_\infty$ leads to the boundary conditions:

$$\sigma_{xy}(x,0)=0, \tag{8}$$

$$\sigma_y(x,0)=0. \tag{9}$$

There are no tangential stresses on the contact line with the press tool:

$$\sigma_{xy}(x,0)=0 \qquad (\mathrm{L}_0), \tag{10}$$

and normal displacements of points of the line L_0 are given:

$$\mathrm{v}(x,0)=U(x) \qquad (\mathrm{L}_0). \tag{11}$$

In the contact zone, normal stresses q, which are related to the stress tensor by the Cauchy ratio, arise:

$$q(x)=-\sigma_y(x,0). \tag{12}$$

AUXILIARY BOUNDARY VALUE PROBLEM

Let's assume the press tool displacement δ, pressure $q=q(x)$ and contact zone location, or value a, b to be specified. Then, ratios and represent the second boundary value problem of statics. Its solution can be determined by invoking the principle of superposition and solution of so-called the Flamant problem [8, 9].

Let the concentrated force Q, directed along the axis Oy, act in the point $A(\xi,0)$ located on the axis Ox (Fig. 4).

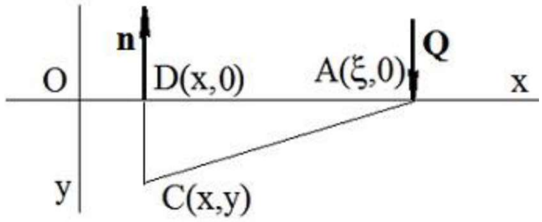


Fig.4. The solution of the Flamant problem

We introduce a scalar function $F=F(x,y)$, called Airy stress function related to the components of the stress tensor by the relations:

$$\sigma_x=\frac{\partial^2 F}{\partial y^2},\quad \sigma_y=\frac{\partial^2 F}{\partial x^2},\quad \sigma_{xy}=-\frac{\partial^2 F}{\partial x\,\partial y}. \tag{13}$$

Then, under an arbitrary choice of the function $F(x,y)$, equilibrium equations are carried out identically. To determine $F(x,y)$ uniquely the Beltrami-Michell equations are used, which in the absence of volume forces have the form [8]:

$$\Delta\sigma_{ik}-\frac{1}{1+\nu}\frac{\partial^2\sigma}{\partial x_i\partial x_k}=0 \qquad (i,k=1,2,3) \tag{14}$$

where:

$$\sigma=\sigma_x+\sigma_y+\sigma_z=(1+\nu)(\sigma_x+\sigma_y)=\partial F/\partial x+\partial F/\partial y$$

is a trace of stress tensor.

Producing convolution in ratio (14) with respect to the indices i,k, as a consequence, we obtain the Laplace equation for the trace of the stress tensor:

$$\Delta\sigma=0, \tag{15}$$

where:

$$\Delta=\frac{\partial^2}{\partial x_1{}^2}+\frac{\partial^2}{\partial x_2{}^2}$$

which results in the biharmonic equation for F:

$$\Delta\Delta F\equiv\frac{\partial^4 F}{\partial x^4}+2\frac{\partial^4 F}{\partial x^2\partial^2 y}+\frac{\partial^4 F}{\partial y^4}=0. \tag{16}$$

In the case of action of a concentrated normal force Q at the point $A(\xi,0)$, the normal stresses $\mathrm{q}(x)$ are expressed in terms of the delta function in the form:

$$\mathrm{q}(x)=Q\,\delta(x,\xi). \tag{17}$$

The necessary boundary conditions for the biharmonic equation follow from (12) with the use of the ratios (13):

$$\sigma_y(x,0)\equiv\frac{\partial^2 F}{\partial x^2}(x,0)=-Q\,\delta(x,\xi). \tag{18}$$

Taking into account that the function F can be determined up to a linear polynomial with respect to variables x,y, and integrating twice (18) over x with respect to the properties of the delta function, we obtain the following boundary condition

$$F(x,0)=-Q\,x\,Hev(x-\xi)\ , \tag{19}$$

where: $Hev(x-\xi)$ represents the Heaviside function [14].

The second condition is expressed by means of ratios, (without tangent stresses in L) and after x integration is in the form of:

$$\frac{\partial F}{\partial y}(x,0)=0 \tag{20}$$

Biharmonic F, satisfying the condition, can be presented in the form of ([8], p.516, formula (3.2.2))

$$F(x,y)=\varphi(x,y)-y\frac{\partial\varphi(x,y)}{\partial y} \tag{21}$$

where φ is a harmonic function satisfying boundary condition from the ratio:

$$\varphi(x,0,\xi)=-Q\,x\,Hev(x-\xi) \tag{22}$$

Thus, defining Airy function F comes down to solving Laplace's equation for function φ, satisfying Dirichlet boundary condition. The final expression for F is in the form of ([8], p. 517, (3.2.6)):

$$F(x,y,\xi)=Q\frac{x-\xi}{\pi}arctg\frac{y}{x-\xi}\,. \tag{23}$$

Inverse relationship of Hooke's law expresses the component of deformation tensor. It allows reconstructing a displacement vector $\vec{u}$. Components u,v accurate to terms corresponding to absolutely solid body displacement and are in form of [8, p. 518]

$$\begin{aligned}u(x,y,\xi)&=\frac{Q}{2\pi\mu}\left[(1-2\nu)\theta+\frac{1}{2}\sin 2\theta\right]\\ \mathrm{v}(x,y)&=-\frac{Q}{2\pi\mu}\left[2(1-\nu)\ln r+\cos^2\theta\right]\end{aligned}, \tag{24}$$

where:

$\theta=arctg\left(y/\left(x-\xi\right)\right)$,

$r=r(x,y,\xi)=\sqrt{(x-\xi)^2+y^2}$ – is the distance between points A and C (Fig.4).

Knowing the solution of Flaman problem, we can find the solution for tension which is the result of distributed normal stress acting in limit L_0, considering the stress in the elementary section of length as concentrated force $d\xi$ of magnitude $\mathrm{q}(\xi)d\xi$. Superposition principle results in integrating the expression for given elementary stresses in section $(-\mathrm{a}\le\xi\le b)$:

$$F(x,y)=\frac{1}{\pi}\int_a^b\left(x-\xi\right)arctg\frac{y}{x-\xi}\,\mathrm{q}(\xi)d\xi\,. \tag{25}$$

There are expressions for displacement vector $\vec{u}=(u,\mathrm{v},0)$ in much the same way as for the formula (24):

$$\begin{aligned}\mathrm{u}(x,y)&=\frac{1}{2\pi\mu}\int_a^b\left[(1-2\nu)\theta+\frac{1}{2}\sin(2\theta)\right]\mathrm{q}(\xi)d\xi\\ \mathrm{v}(x,y)&=-\frac{1}{2\pi\mu}\int_a^b\left[2(1-\nu)\ln r+\cos^2\theta\right]q(\xi)d\xi\end{aligned}\,. \tag{26}$$

There is a ratio of vertical displacements for limit points $y=0$:

$$\mathrm{v}(x,0)=\beta\int_a^b\ln\frac{1}{|x-\xi|}\mathrm{q}(\xi)d\xi\,, \tag{27}$$

where: $\beta=(1-\nu)/\pi\mu$.

Boundary condition (11) may be considered as a ratio about unknown function $q(x)$ for given vertical displacements of L_0 line points:

$$\int_a^b\ln\frac{1}{|x-\xi|}\mathrm{q}(\xi)d\xi=\frac{1}{\beta}\mathrm{U}(x)\,. \tag{28}$$

The given ratio is Fredholm integral equation of the first class where an inverse operator is unlimited, solution is unstable relative to disturbance of the right parts [15]. Numerical solution of these equations deals with the issue of instability of algorithm of making approximate solutions. To avoid this problem, we use Lorier method [8].

Let the following ratio be the equation of the press tool edge:

$$\Phi(x,y)=0\,, \tag{29}$$

which can be noted down in the form resolved according to variable y:

$$y\equiv U(x)=h(x)\,, \tag{30}$$

where: $h(0)=\delta$, $x\in[\mathrm{a},\mathrm{b}]$.

We will consider two cases. In the first one a sharp press tool (Fig. 3a), contact line BD_1 is a straight line:

$$\mathrm{h}(x)=\delta-x\,ctg\alpha \tag{31}$$

$a=0$. The second variant is that with a blunted press tool (Fig. 3b), $b=|a|$, $a<0$, contact line D'_1CD_1 is the arc of the circle K, the equation of which is in the form of:

$$\Phi(x,y)\equiv x^2+\left(y+\frac{d}{2}-\delta\right)^2-\frac{d^2}{4}=0$$

and consequently:

$$h(x)=\delta+\sqrt{\frac{d^2}{4}-x^2}-\frac{d}{2}\,. \tag{32}$$

In the second case, obviously, the problem solution has symmetry with respect to the axis Oy.

Point D_1 is the place where disconnecting of the surfaces of the body and the press tool takes place. It has x coordinate $x_{D_1}=b$. We denote x coordinate of the cross point of circle K and horizontal axis $y=0$ as x_D:

$$x_D=\sqrt{\left(\frac{d}{2}\right)^2-\left(\frac{d}{2}-\delta\right)^2}\,. \tag{33}$$

In the condition of low deformation, obviously, point D_1 will lie in the field of point D.

We consider potential of common layer ω having the following form for flat problems [15]:

$$\omega(x,y)=\int_a^b\ln\frac{1}{r(x,y,\xi)}\mathrm{q}(\xi)d\xi\,. \tag{34}$$

The given potential is a harmonic function which is continuous in the field $y>0$ until the boundary. On the boundary $y=0$ it is expressed as:

$$\omega(x,0)=\int_a^b\ln\frac{1}{|x-\xi|}\mathrm{q}(\xi)d\xi$$

matching the expression of the left part of equation.

Potential has the property – its normal derivative to contour L_0 has different values moving to L_0 within the area ($y>0$) and outside ($y<0$). I.e. normal derivative of the potential of a common layer in contour L_0 has a gap. This complies with the terms of Plemelj ratio:

$$\left.\frac{\partial\omega}{\partial n}\right|_{y\to+0}=\pi q(x)+\overline{\frac{\partial\omega}{\partial n}},\quad \left.\frac{\partial\omega}{\partial n}\right|_{y\to-0}=-\pi q(x)+\overline{\frac{\partial\omega}{\partial n}},\qquad (35)$$

where the notations are agreed:

$$\left.\frac{\partial\omega}{\partial n}\right|_{y\to-0}=\lim_{y\to0,y<0}\frac{\partial\omega(x,y)}{\partial n},\quad \left.\frac{\partial\omega}{\partial n}\right|_{y\to+0}=$$

$$=\lim_{y\to0,y>0}\frac{\partial\omega(x,y)}{\partial n},\quad \overline{\frac{\partial\omega}{\partial n}}=-\frac{\partial\omega}{\partial y}(x,0)=\qquad (36)$$

$$=-\int_a^b \mathrm{q}(\xi)\frac{\partial}{\partial y}\ln\left.\frac{1}{r(x,y,\xi)}\right|_{y=0}d\xi=\int_a^b\left.\frac{y}{r^2}\right|_{y=0}d\xi=0$$

including accordingly an inside limit, an outside limit and a direct value of derivative. It should be noted that the direct value of the derivative of the potential of a common layer equals to zero in the given problem. According to we obtain the expression denoting the distribution of L_0 pressure $q(x)$:

$$\mathrm{q}(x)=-\frac{1}{\pi}\left.\frac{\partial\omega}{\partial y}\right|_{y\to+0}.\qquad (37)$$

To identify function ω we may use the methods of the complex variable functions theory.

DEFINING ω HARMONIC

Let's carry out the procedure of defining function $\omega(x,y)$ for the second problem (Fig.3b). Solving the first problem (Fig.3a) is in much the same way. Function ω satisfies Laplace's equation in semiplane $(-\infty<x<\infty, y>0)$ and boundary condition of the first class on the boundary $\mathrm{L}_0:(a\le x\le b, y=0)$. We extend function $\omega(x,y)$ by an even way with respect to variable y along the plane xOy, reserving the former name. New function will be continuous and flat in the whole plane with the exception of segment $[a,\mathrm{b}]$ of axis Ox. The function possesses the value $U(x)/\beta$ in the internal segment points L_0 $(y=+0)$, the same value in the external segment points, i.e. the function is continuous. Its y variable derivative, however, changes moving through segment L_0 according to Plemelj formulas.

The function is determined by means of conformal conversion. We enter complex variable $z=x+iy$ and consider plane Z of this variable and cutting segment AB: $(\mathrm{a}\le x\le b)$ out (Fig.5a). We enter one more plane of complex variable $\overline{Z}$: $\zeta=\xi+i\eta$ with single circle $|\zeta|\le1$ (Fig. 5b). We consider conformal conversion of the second plane into the first one:

$$z=\frac{b}{2}\left(\zeta+\frac{1}{\zeta}\right)\quad \left(b=|a|\right).\qquad (38)$$

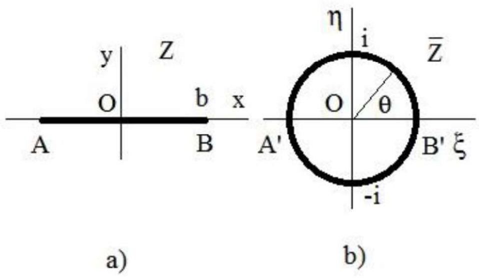


Fig. 5. To ω harmonic defining

The given conversion according to displays a circle core $|\zeta|\le1$ of plane $\overline{Z}$ on plane Z with cutting segment AB out.

We name the module of the complex number ζ: $\rho=\sqrt{\xi^2+\eta^2}$ as ρ and its amplitude as $\theta=arctg(\eta/\xi)$. Then using a trigonometrical entry format of a complex variable and Ailer's formula, the relation may be presented in the form of [18]:

$$z=\frac{b}{2}\left[\rho e^{i\theta}+\frac{1}{\rho}e^{-i\theta}\right]= =\frac{b}{2}\left[\left(\rho+\frac{1}{\rho}\right)\cos\theta+i\left(\rho-\frac{1}{\rho}\right)\sin\theta\right].\qquad (39)$$

Consequently, we have the ratios linking coordinates (x,y) of the points of Z plane and coordinates (ξ,η) of $\overline{Z}$ plane:

$$x=\frac{b}{2}\left(\rho+\frac{1}{\rho}\right)\cos\theta,\quad y=\frac{b}{2}\left(\rho-\frac{1}{\rho}\right)\sin\theta.\qquad (40)$$

Under conformal conversion, Laplace's equation, having new variables, preserves its type, i.e. harmonic having new variables is harmonic. Cut AB in plane Z transforms into circle $|\zeta|=1$ in plane $\overline{Z}$. Moving counterclockwise point B' in circle $(0\le\theta\le\pi)$, when $\rho=1-0$ point B in plane Z moves to the left in lower edge of segment AB. Moving further, point B' $(\pi\le\theta\le2\pi)$ (having the same value $\rho=1-0$) point B moves to the right in upper edge of segment. Thus, the lower half of the circle $|\zeta|\le1$ corresponds to the upper semiplane Z. Boundary conditions in the circle $|\zeta|=1$ for harmonic $\omega(\xi,\eta)$ are in the form:

$$\omega(1,\theta)=\varphi\left[x(1,\theta),+0\right]=\frac{1}{\beta}U\left[b\cos(\theta)\right].\qquad (41)$$

The following circumstances take place. Potential of a common layer at infinity behaves asymptotically in the form of:

$$\omega(x,y)\xrightarrow[r_0\to\infty]{}\mathrm{C}\ln\frac{1}{r_0}\quad\left(r_0=\sqrt{x^2+y^2}\right)\qquad (42)$$

where: C – is a constant.

A point at infinity in plane Z is zero point in plane $\overline{Z}$, i.e. there is complex number with zero module $\rho=0$. Thus, a leading term of asymptotic behavior of function ω where $\rho\to0$ is in the form of:

$$\omega(\rho,\theta) \square O\left(\ln\frac{2\rho}{b}\right). \tag{43}$$

We introduce a new unknown function containing constant C:

$$\Omega(\rho,\theta) = \omega(\rho,\theta) - C\ln\frac{2\rho}{b}, \tag{44}$$

which is harmonic but will be limited in the circle $|\zeta| \le 1$ and having zero limit at $\rho \to 0$:

$$\lim_{\rho\to 0}\Omega(\rho,\theta) \equiv \lim_{\rho\to 0}\left[\omega(\rho,\theta) - C\ln\frac{2\rho}{b}\right] = 0 \tag{45}$$

Boundary condition, obviously, for function Ω is the expression:

$$\Omega(1-0,\theta) = \frac{1}{\beta}U\left[b\cos(\theta)\right] - C\ \ln\left(\frac{2}{b}\right). \tag{46}$$

Solution of Dirichlet problem with boundary condition (46) for Laplace's equation is defined by Poisson integral [17]:

$$\Omega(\rho,\theta) =$$

$$= \frac{1}{2\pi}\int_0^{2\pi}\frac{(1-\rho^2)[1/\beta U(\mathrm{b}\cos(\tilde{\theta})) - C\ln(2/\mathrm{b})}{1+\rho^2-2\rho\cos(\tilde{\theta}-\theta)}d\tilde{\theta} =$$

$$= \frac{1}{2\pi\beta}\int_0^{2\pi}\frac{(1-\rho^2)\,\mathrm{U}\left[b\ \cos(\tilde{\theta})\right]}{1+\rho^2-2\rho\cos(\tilde{\theta}-\theta)}d\tilde{\theta} - C\ln\frac{2}{b} \tag{47}$$

Taking into account these ratios, we note down a final solution of the problem considered in the beginning in the form of:

$$\omega(\rho,\theta) = \frac{1}{2\pi\beta}\int_0^{2\pi}\frac{(1-\rho^2)\,\mathrm{U}\left[b\cos(\tilde{\theta})\right]}{1+\rho^2-2\rho\cos(\tilde{\theta}-\theta)}d\tilde{\theta} - \frac{C}{\rho}. \tag{48}$$

Constant C being a component of the last relation may be defined by means of the condition:

$$C = \frac{1}{2\pi\beta\ln(2/\mathrm{b})}\int_0^{2\pi}\mathrm{U}\left[b\ \cos(\theta)\right]d\theta. \tag{49}$$

Formulas (40) allow expressing function ω as a function of variables x, y.

We use the ratio to compute pressure $\mathrm{q}(x)$. We note that:

$$\frac{\partial\omega}{\partial y} = \frac{\partial\omega}{\partial\rho}\frac{\partial\rho}{\partial y} + \frac{\partial\omega}{\partial\theta}\frac{\partial\theta}{\partial y}$$

and formulas 40 give us:

$$\left.\frac{\partial\rho}{\partial y}\right|_{\rho=1,y=0} = \left.\frac{y}{\rho}\right|_{\rho=1} = 0,$$

$$\left.\frac{\partial\theta}{\partial y}\right|_{\rho=1,y=0} = \left.\frac{x}{x^2+y^2}\right|_{y=0} = \frac{1}{x} = \frac{1}{b\ \sin\theta}$$

Then normal pressure in L_0 will be expressed in the following way:

$$\mathrm{q}(\theta,\mathrm{b}) = \mathrm{q}(\mathrm{b}\cos\theta) = -\frac{1}{\pi\, b\cos\theta}\lim_{\rho\to 1-0}\frac{\partial\omega}{\partial\theta} =$$

$$= -\frac{1}{\pi^2\beta\, b\cos\theta} \tag{49}$$

$$\lim_{\rho\to 1-0}\int_0^{2\pi}\frac{(1-\rho^2)\rho\sin(\tilde{\theta}-\theta)}{\left[1+\rho^2-2\rho\cos(\tilde{\theta}-\theta)\right]^2}U\left[b\cos\tilde{\theta}\right]d\tilde{\theta}$$

Unknown magnitude b is latent in the right part of the relation (49), it adjoined to the line length of the contact body and the press tool. To compute it, we use such a hypothesis: pressure $q(\mathrm{x})$ equals to zero in the finite points of contact line $x = a, b$:

$$\mathrm{q}(\mathrm{b}) = 0. \tag{50}$$

the ratio $q(a) = 0$ follows from the problem symmetry. The given expression (taking into account (19)) may be considered as a transcendent equation to compute b.

The force exists in pressure allocation $q(x)$ and, thus, the press tool effects the elastic body:

$$Q = \int_a^b q(x)dx. \tag{51}$$

and force moment about point O is:

$$M = \int_a^b x\, q(x)\, dx. \tag{52}$$

PROBLEM SOLUTION ALGORITHM

The problem is solved in such a sequence.

1. We set the vertical movement of the press tool δ and, respectively, we find the vertical components of the displacements $U(x)$ of the points of the contact line BD_1, $D_1^{'}CD_1$ in accordance with the formulas.

2. The points of the lower semicircle of plane $\overline{Z}$ correspond to the 'internal' points of line L_0: $\rho = 1-0,\ \pi \le \theta \le 2\pi$. When we change the specified range θ, the variable $x = b\cos\theta$ varies from a to b. The load values $q(x) = q(\mathrm{b}\cos\theta)$ are calculated by the formulas.

3. We set a zone of change of the parameter b $\left(b \in \left[0, \mathrm{b}_{кон}\right]\right)$ so that the equation root could lie within this area. Obviously, $b_{кон}$ should lie in the area of the point $x = x_D$ (formula). We divide the interval $\left[0, \mathrm{b}_{кон}\right]$ into small parts $\left[b_{i-1}, b_i\right]$ $i = 1...m,\ b_0 = 0, b_m = b_{кон})$ $\left[b_{i-1}, b_i\right]$ $(i = 1...m,\ b_0 = 0, b_m = b_{кон})$. Consequently, we calculate $q\left(b_{i-1}\right)$, $q\left(b_i\right)$ by the formula. If these functions have opposite signs q, the equation root is situated within the interval $\left[b_{i-1}, b_i\right]$. Further, we carry out the division of the interval $\left[b_{i-1}, b_i\right]$ into subintervals with the definition of the equation root position. This division is conducted until the length of the corresponding subinterval, containing the equation root, is less than the target root finding accuracy.

4. After finding the equation root b_*: $q\left(b_*\right) = 0$, the distribution $q(x) = q\left(b_*\cos\theta\right)$ $\{a \le x \le b\}, \{\pi \le \theta \le 2\pi\}$ is calculated.

5. Force P and moment coefficient M are determined according to the formulae.

6. The distribution of the components of the stress tensor $\sigma_x(x,y)$, $\sigma_y(x,y)$, $\sigma_{xy}(x,y)$ are calculated using the formulae (13), (25):

$$\sigma_x = -\frac{2}{\pi}\int_a^b \frac{y(x-\xi)^2}{\left[(x-\xi)^2+y^2\right]^2} q(\xi)\,d\xi$$

$$\sigma_y = -\frac{2}{\pi}\int_a^b \frac{y^3}{\left[(x-\xi)^2+y^2\right]^2} q(\xi)\,d\xi \tag{53}$$

$$\sigma_{xy} = -\frac{2}{\pi}\int_a^b \frac{y^2(x-\xi)}{\left[(x-\xi)^2+y^2\right]^2} q(\xi)\,d\xi$$

and the components of the displacement vector are determined according to the formula (26).

ANALYSIS OF NUMERICAL RESULTS

The problem numerical solution was realized with the help of the mathematical package MATLAB. When calculating the integrals included in the equation (49), we take into account peculiar features in the integrand dividing the interval $\theta \in [0, 2\pi]$ into three intervals $[0, \theta - \varepsilon]$, $(\theta - \varepsilon, \theta + \varepsilon)$ and $[\theta + \varepsilon, 2\pi]$. The integral over the second interval is replaced by a mechanical quadrature where the number of nodes equals N_i and for two other intervals the total number of nodes equals N_e. For the first and third intervals we choose the number of nodes N_l, N_r proportional to the length of the corresponding segment:

$$N_l = \left[N_e \frac{\theta}{2\pi}\right], \quad N_r = \left[N_e \frac{2\pi - \theta}{2\pi}\right]$$

where the square brackets mean taking the nearest integer from the corresponding number). Thus, the total number of nodes at the numerical integration is equal to:

$$N_0 = N_e + N_i$$

The formula of trapezium numerical integration is used for each interval [20, 21]. The number of nodes, which are necessary to satisfy the specified accuracy of calculating integrals, is determined by the numerical experiment on a PC. It has been shown experimentally that when the number of nodes is $N_i > 40$, $N_e > 300$ and $\varepsilon \approx 0.1\pi$, the relative error of integral calculation is less than 1%.

The results of the calculations are presented graphically in Fig. 6-15. Fig. 6-10 concern the first task of implementing a sharp wedge. The distribution of pressure $q(x)$ on the contact line at different values of the parameters δ, α is shown in Fig. 6. Here, its characteristic feature is infinite growth when approaching a sharp edge of the press tool. Increase in δ and decrease in α lead to pressure reduction in the points of contact. In Fig. 7 in the upper row the dependences of the length of the contact line $b(\delta, \alpha)$, the values of the main force vector $Q(\delta, \alpha)$, and the axial torque of the forces $M(\delta, \alpha)$ applied to the press tool are presented. The lower row of this graph shows the lines of the levels of the corresponding functional dependences. It is necessary to mention that b, M increase with the increase of the angle α and Q does not change in the specified variation range of α.

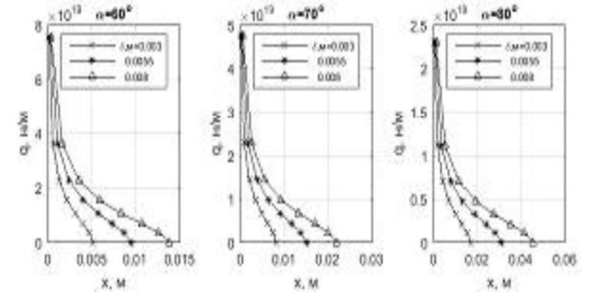


Fig. 6. Pressure in the contact zone of a sharp cutter

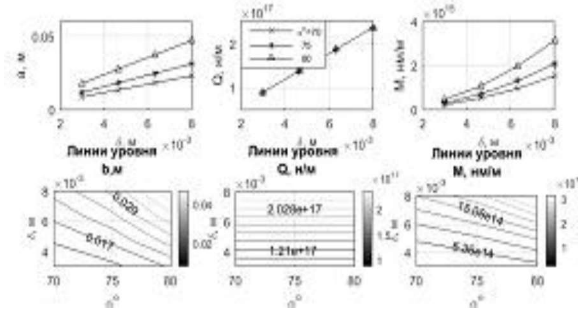


Fig.7. Dependences Q and M on δ and α

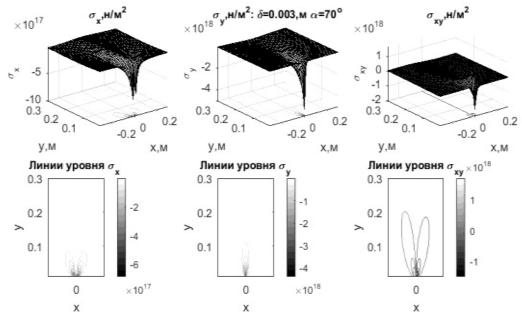


Fig. 8. Stress tensor

The nature of the stress distribution in the half-space $y > 0$ around the contact line is shown in Fig. 8: the upper row of the graphs are the dependences $\sigma_x(x, y)$, $\sigma_y(x, y)$, $\sigma_{xy}(x, y)$, the lower row presents the graphs of the lines of the level of corresponding dependences. We can see that there is stress concentration near the contact line.

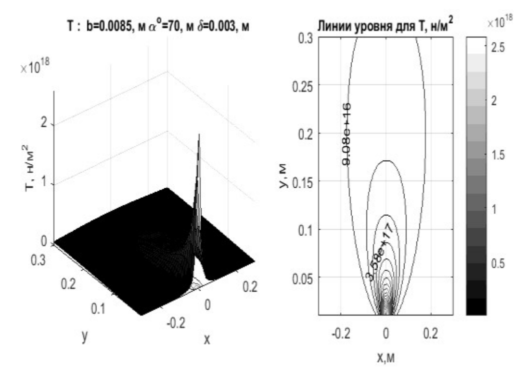


Fig. 9. Criterion T

The characteristic $T(x, y)$, which is important in terms of material destruction, is presented in Fig. 9 along with its level lines. According to the graphs given here, we can say that ductile failure will appear around the contact line directly at the point where a sharp edge of the press tool is located.

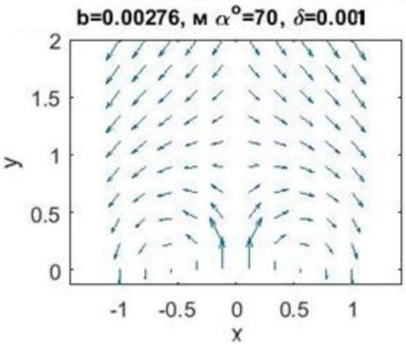


Fig. 10. Displacement field of the first poblemFig. 10 shows a vector field of the displacements of the points of the elastic half-space around the contact line. It appears under the influence of a press tool. The arrows here represent the natural process of pushing aside the particles of an elastic body when a press tool is inserted into it.

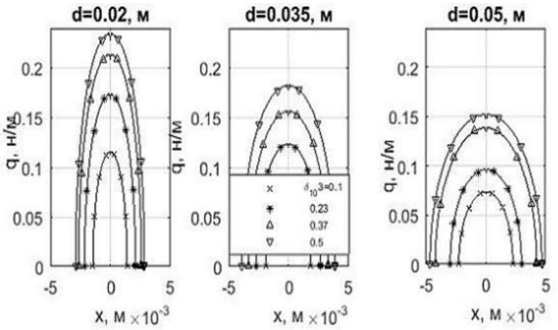


Fig. 11. Pressure in the contact zone of a blunted cutter

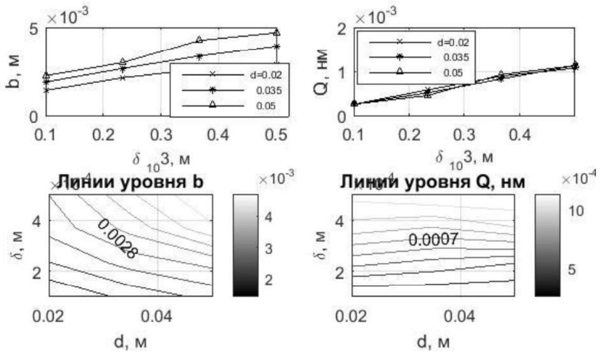


Fig. 12. Dependences Q and M on δ and d

Fig. 11-15 are related to the second task – to insert a blunt wedge into the half-space. Figure 11 presents graphical dependences $q(x,\delta,d)$. The change in the diameter d of the round edge of a press tool is, to a certain extent, equivalent to the change of an angle α in the first problem. The difference here is that the pressure q on the contact line is limited.

It is necessary to mention that the characteristic $T(x,y)$ also takes the peak value around the contact line. However, $\max\limits_{x,y}|T(x,y)|$ takes place in the internal point of an elastic body. This suggests that ductile failure can begin not at the edge of an elastic body but at some depth in it.

For the second problem, the force moment is about zero. Obviously, it is connected with the presence of symmetry with regard to the axis Oy.

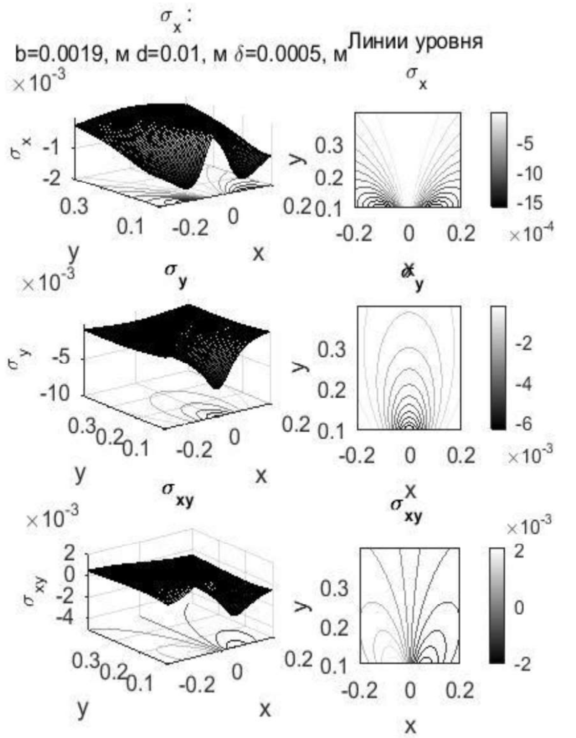


Fig. 13. Stress tensor

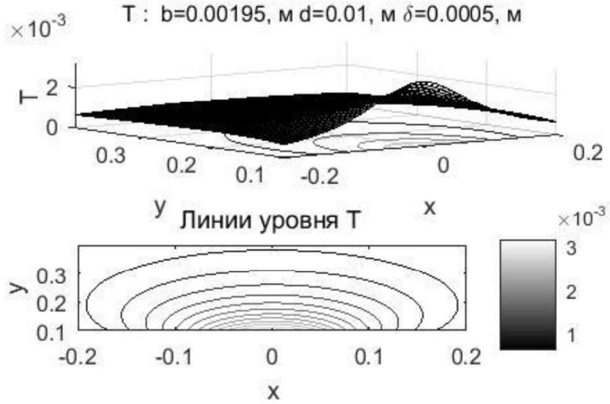


Fig. 14. Criterion T

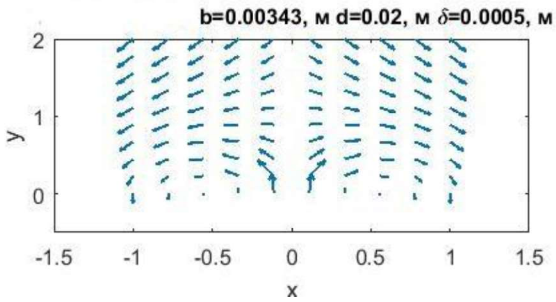


Fig. 15. Displacement field of the second poblem

REFERENCES

1. **Alexander Nanka, Ivan Boyko 2013. –** Analytical researches of methods and constructions of grinders of corn forage. [Text]: Alexander Nanka, Ivan Boyko. / Motrol, Motoryzacija I energetyca rolnictva. – Lublin. Vol. 15, No7.
2. **Vitaliy Sementsov, Ivan Boyko 2013** Development of energykeeping construction of gravity metering devise of friable forages. [Text]: Vitaliy Sementsov, Ivan Boyko / Motrol, Motoryzacija I energetyca rolnictva. – Lublin. Vol. 15, No7
3. **Yashcheritsyn P.I., Yeremenko M.L., Zhigalko N.I. 1975.** Fundamentals of cutting materials and cutting tools. Minsk: "The High School." 528.
4. **Reznik N.E. 1975.** The theory of blade cutting and the basis for calculating cutting machines. M .: Mechanical Engineering, 311.
5. **Johnson, K. 1989.** The mechanics of contact interaction. Moscow: The World, 510.
6. **Cherepanov G.P. 1974.** Mechanics of brittle fracture. Moscow: Nauka, 640.
7. **Guz A.N. 2014.** On the construction of the foundations of the mechanics of fracture of materials during compression along a crack (review). Applied Mechanics, vol. 50, No. 1, 5-88.
8. **Lurie A.I. 1970.** Theory of Elasticity. Moscow: Nauka, 939.
9. **Novatsky V. 1975.** Theory of elasticity. Moscow: Mir, 872.
10. **Galin L.A. 1980.** Contact problems of the theory of elasticity and viscoelasticity. Moscow: Nauka, 304.
11. **Galin L.V. 1976.** Development of the theory of contact problems in the USSR. Moscow: Nauka, 493.
12. **Rabotnov Yu.V. 1979.** Mechanics of a deformable solid. M .: Nauka, 744.
13. **Alexandrov V.M., Chebakov M.I. 2007**. Introduction to the mechanics of contact interactions. Rostov-on-Don: Publishing House LLC, "Central Research Institute of Information Technologies", 2007. - 114.
14. **Alexandrov V.M., Pozharsky D.A.** Nonclassical spatial problems of the mechanics of contact interactions of elastic bodies
15. **Korn G., Korn T. 1970.** Handbook of Mathematics for Scientists and Engineers. M .: Nauka, 720.
16. **Tikhonov A.N., Arsenin V.Ya. 1974.** Methods for solving ill-posed problems. Moscow: Nauka, 223.
17. **Koshlyakov N.S., Gliner E.B., Smirnov M.M. 1970.** Equations in partial derivatives of mathematical physics. Moscow: Publishing House "Higher School", 712.
18. **Lavrent'ev M.A., Shabat B.V. 1965.** Methods of the theory of functions of a complex variable. M .: Nauka, 716.
19. **Zabreiko P.P., Koshelev A.I. 1968.** Integral Equations. M .: Nauka, 448.
20. **Demidovich B.P., Maron I.A., Shuvalova E.Z. 1967.** Numerical methods of analysis. Approximation of functions, differential and integral equations. Moscow: Nauka, 368.
21. **Berezin I.S., Zhidkov N.P. 1966.** Methods of computation. . V.1.- Moscow: Science, -1966, 274.
22. Berezin I.S., Zhidkov N.P. 1962. Methods of computation. V.2.- Fizmatgiz, 326.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 55-58

THE JUSTIFICATION OF THE PARAMETERS OF THE DOSAGE DEVICE FOR THE ELECTRIC FRICTIONAL SEPARATOR

Kovalyshyn Stepan[1], Shvets Oleksii[1], Stanisław Sosnowski[2]
[1]Lviv National Agrarian University
Str. V. Vylokoho, 1, Dublyany, Ukraine. E-mail: opshvets@yahoo.com
[2]University of Rzeszow
Aleja Tadeusza Rejtana 16C, 35-001 Rzeszów, Poland

Summary. One of the main problems affecting the efficiency of the work of the electro-frictional separators with the inclined, moving frictional plane in the electric field (the canvas) is the intersection of trajectories of the motion of components of the seed mixture, which leads to their mutual collision and deterioration of the separation process. On the surface of the canvas of a separator, there appears a zone (part of the area of the canvas) in which a collision of the seeds happens. The dimensions of this zone depend to a large extent on the location of the separator dosing device relative to the canvas.

In this paper, the process of separation of a seed mixture of rapeseed, which consisted of qualitative and poor-quality (punched, injured) seeds in a pre-established optimal separation mode, was simulated, and a method for determining the area of the contact area of the mixture components was developed. As a result of the research, the position of the supply line of the seed from the dosing device was established, in which it is possible to completely equalize the phenomenon of collision of seeds during their electric separation on an electrical frictional separator.

Key words: electric frictional separator, rapeseed, trajectories of seed movement, mutual collision of seeds, dosage parameters, dosage line.

INTRODUCTION

In the works [10, 19], the effect on the process of electric separation of the seed mixture of winter rape was determined, the location of the dosing device and the value of the seed supply. In these studies, the condition was accepted that the seeds enter the separation plane at a certain point, which was taken as the beginning of the coordinate of their movement.

However, in real conditions of the separator, the seed mixture is fed by a dispensing device along a line of a certain length [8, 10, 19]. Under these conditions, the trajectories of the movement of seeds of different quality, which differ in physical, mechanical and electrical properties, are different and intersect. The area of contact of these seeds depends on the size (caliber) of the seed, the length of the feeding line and its location relative to the separation plane, the direction of its movement. Establishing the influence of these factors on the area of collision of seeds will allow to substantiate the optimum placement of the dosing device of the electric frictional separator and its parameters, which in turn will contribute to increasing the efficiency of separation from seed mixtures of low-quality seeds.

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

A series of papers [1-5, 9, 11, 13, 15-21, 22] is devoted to the study of the process of movement of seed mixtures on inclined planes. In some of them, the trajectory of motion of different seeds was studied on the friction moving surfaces in the electric field [4, 5, 9, 11, 13, 16-19, 21, 22]. The main objective of these studies was to obtain mathematical expressions for calculating the running values of the trajectory of motion and the coordinates of the ascension of components of seed mixtures from separation surfaces [3, 8, 11, 16, 17-19]. On the basis of the values of the initial, intermediate and final values of the coordinates of the movement of individual seeds, experimental trajectories of their motion were constructed and, based on their analysis, the optimal separation parameters were justified [3, 8, 11, 14, 16, 18, 19].

For experimental confirmation of the obtained mathematical dependences in the paper [18, 19] a method of studying the trajectories of the rape seed movement in a sloping moving plane with the electric field of the frictional separation is proposed. As a result of the experiments, numerical values of longitudinal (y) and transverse (x) coordinates of seed movement along the canvas were obtained for different modes of operation of the separator and experimental trajectories of the movement of high-quality, dazzling and various kinds of injured seeds were constructed.

Effective separation of the components of the seed mixture of rapeseed is achieved provided with the maximum difference between the trajectories of the movement of components that are part of it. This can be achieved by overlaying the high voltage electric field on the separation plane. Since qualitative, hollow and various injured seeds have different electrical properties, they interact differently with the working plane and move along it in different trajectories. The most significant effect on the displacement of these components of the mixture is the intensity of the electric field. According to [8, 9, 18, 19, 21, 22] at E = 1,5...2,2 kV/cm, the difference in the values of the coordinates of the ascension of qualitative and different kinds of injured seeds reaches 50...70%, which is a prerequisite for their effective separation. In addition to the intensity of the electric field, other regulated parameters, such as the angle of inclination of the plane to the horizon and the velocity of its gradual movement, are significantly influenced by the behavior of the seeds on the separation plane of the electro-friction separator [16-19]. Another important factor in the effective separation of the seed mixture of winter rape is the justification of the location of the dosing device. Having determined the optimal values of the place of supply of particles of this mixture to the separation surface, it is possible to achieve the desired effect of separating from it various kinds of injured seeds.

OBJECTIVES

The aim of the work was to improve the quality of seed material obtained during the process of electric separation, due to the optimal placement of the dosing device relative to the separation plane and to substantiate its parameters.

THE MAIN RESULTS OF THE RESEARCH

The movement of seed of different quality on the separation plane is shown in Fig. 1.

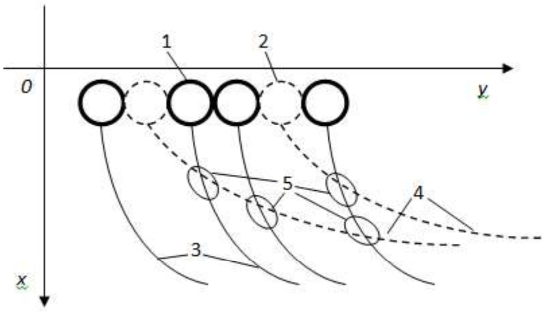


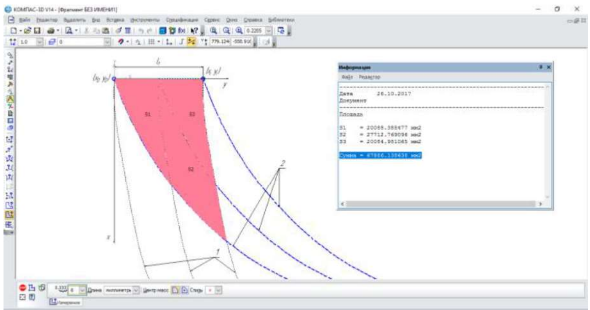
Fig. 1. Scheme of movement of seeds: 1 – high-quality seeds; 2 – low-quality seeds; 3 – the trajectories of the movement of high-quality seeds; 4 – the trajectory of the movement of low-quality seeds; 5 – areas of collision of seeds

To study the movement of seeds on the separation plane and the location of their possible collisions, the seed line l_1 should be projected on the separation plane and bound to the $x0y$ coordinate system. (Fig. 2). Later, using the method shown in [11, 16, 19, 22], it is necessary theoretically to calculate the coordinates of movement of high-quality and various damaged seeds for optimal parameters of the separation process.

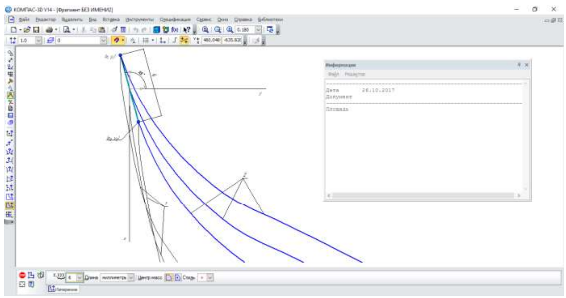
The seed mixture comes to the separation plane from the dosing device for the entire length of the seed line l_1. By constructing the initial coordinates of the (coordinate x_0; y_0) and the end coordinates (coordinate x_i; y_i) of the line of the trajectory of the flow of high-quality and various damaged seeds, we obtain a figure whose area determines the zone of possible collision of the components of the seed mixture (Fig. 2a).

The area of this figure can be determined both by analytical and graphical methods. However, these methods are time-consuming and do not always ensure that it is calculated with the necessary accuracy. In this regard, a methodology based on the use of the area of flat shapes of the "2D Area Measurement" functions in the COMPASS-3D environment is proposed.

In order to determine the effect of supplying seeds of different quality to the separation plane and to determine the areas of their possible collision, we have graphically simulated and constructed a series of trajectories and determined the areas of shapes that they form, depending on the location of the supply line. We have considered the cases in which the dosing line was located at different angles γ to the direction of motion of the separation plane from 0 to 180° in a 15° step. For all these variants the area of the zone of possible collision of seeds was determined. Examples of some of them are shown in Fig. 2.



a)



b)

Fig. 2. Results of simulation of the areas of collision of seeds: *a* – angle between the line of feeding and the direction of movement of the canvas 0 (180)°; *b* – the angle between the line of flow and the direction of movement of the canvas 105°; 1 – the trajectory of the movement of high-quality seeds; 2 – the trajectory of the movement of low-quality seeds

Determination of the area of the zone of possible collision of high quality and various damaged seeds of winter rape was carried out for optimal parameters of the separation process, namely the angle of inclination of the separation plane $\alpha = 9\ deg.$, its velocity $V_n = 0.07\ m / s$ and the electric field intensity $E = 2\ kV / cm$. The area of the separation plane at that was 1 m^2.

The resulting simulation of the area is reflected in the diagram (Fig. 3).

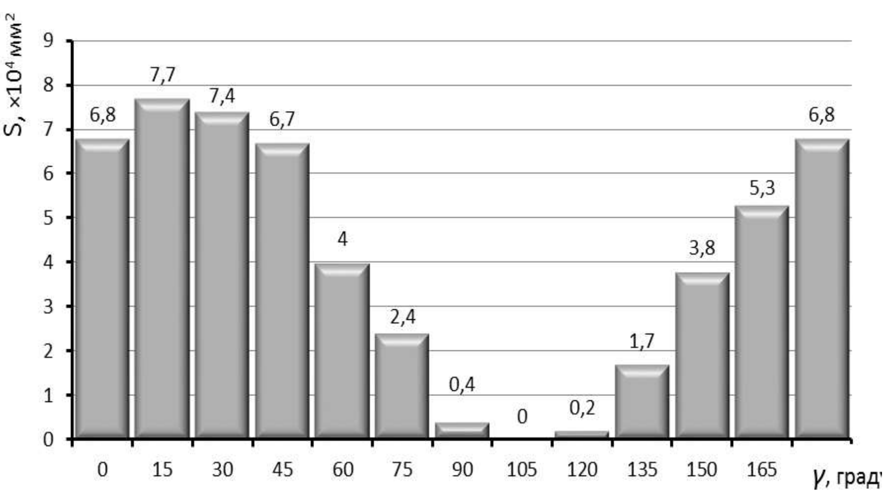


Fig. 3. Square areas of possible collision of components of the seed mixture on the working plane of the electro-frictional separator for various variants of placing the line of their feeding

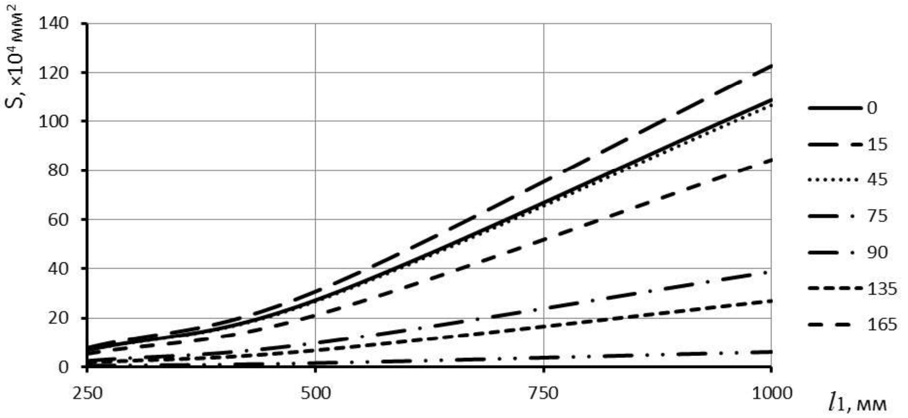


Fig. 4. Dependence of the area of the zone of possible collision of seeds on the length of the feeding line dosing device for the electro-frictional separator

Analyzing the results presented in Fig. 3 it can be argued that when placing the feeding line in parallel with the direction of the separation plane (0 or 180°), the area of the zone of possible collision will be $6{,}8\times10^4$ mm^2, or 6,8% of the area of this plane.

At the angle of the location of the feeding line 12...25°, the area of the collision reaches its maximum value of $7{,}7\times10^4$ mm^2.

The minimum value of the collision zone of seeds, which is $0{,}2 \times 10^4$ mm^2, can be achieved by placing the line of supply of the seed mixture relative to the direction of movement of the canvas at an angle of 95...120°. At angles of 100...110° the collision of seeds will not occur at all (Fig. 2*b*).

On the area of the zone of possible collision of different-quality seeds is significantly influenced by the length of the supply line of the dosing device, which confirms the graphic dependencies shown in Fig. 4.

The analysis of the presented dependencies shows that an increase in the supply line of the dosing device leads to an increase in the area of the possible collision zone of the seeds. For lengths up to 275 mm this growth is insignificant. With an increase in the length of the supply line of more than 275 mm, a sharp increase in the area of the zone of possible collision of the seeds is observed. The given data testify that in order to achieve the greatest separation effect, the supply line of the dosing device of the electro-frictional separator should be in the vicinity of 275 mm.

CONCLUSIONS

1. Separation efficiency of seed mixtures is significantly influenced by the location of the canvas of the electro-frictional separator of the dosing device and the value of the feed line. This effect results in the formation on the surface of the canvas of possible zones of contact between components of the seed mixture with different physical, mechanical and electrical properties, which is an undesirable phenomenon of the process of electric separation on inclined moving planes enforced by electric field.

2. Based on the simulated different parameters of the electric separation of the trajectories of motion on the separation plane of various-quality seeds and analysis of the zones of their possible collisions, the location and size of the dosing device supply line were justified. In order to avoid possible zones of collision of various seeds, and as a consequence, to increase the efficiency

of their electric separation becomes possible due to the location of the seed feeding line relative to the direction of the separation plane at an angle of 100 ... 110 ° and to ensure its value in the vicinity of 275 mm.

REFERENCES

1. **Vasilenko P.M. 1960**. Theory of the motion of particles on rough surfaces of agricultural machines / UASHN – Kiev, 284.
2. **Zavgorodniy AI. Obykhvost AV 2009.** To the study of the motion of round-shaped particles along the working surfaces of machines . "Sectoral Mechanical Engineering, Construction": Coll. science works of PNTU n.a. Yu Kondratyuk, Ed. 3 (25), Volume 1. 119-125.
3. **Kovalyshyn S.Y. Nishchenko I.O., Shvets O.P. 2008**. Investigation of the process of seed separation of winter rape on a sloping moving field in an electric field / Journal of the NAU "Agroinengineering Research" №9, T.12. 225-230.
4. **Kovalyshyn S.Y. 1999**. Substantiation of technological parameters of processing of seeds of perennial grasses on electric frictional separator: dis. Cand. tech Sciences: – Obroshino, 236.
5. **Kovalyshyn S.Y. 1998.** Separation of seed mixtures of herbs in a moving electric field of a sloping vibrational plane // Agricultural machines. - Collection of scientific articles. - Issue 4., 69-73.
6. **Kovalyshyn S. Y., Shvets O.P. 2011**. Application of an electric field of crown discharge during presowing treatment of winter rape seeds / Motrol: Motoryzacia I energetyca rolnictwa. Tom 13D - Lublin: Ukrainian Technological University., 276-283.
7. **Kovalyshyn S., Shvets O., Salo Ya., Kuzma Y.R. 201**5. Influence of additional electric force on the efficiency of separation of rape seeds on an electric friction separator / VNIC of the LNAU "Agroengineering Research" No. 19. 45-51.
8. **Kovalyshyn S.Y., Shvets O.P. 2010**. Justification of the design parameters of the working surface of the canvas of electric frictional separator of winter rape / Scientific Bulletin of the National University of Life and Environmental Sciences of Ukraine. Ed. 144, p. 2, 125-131.
9. **Kovalyshyn S.Y., Shvets O.P. 2012.** Results of studies of the process of additional cleaning of winter rapeseed on an electric frictional separator / Scientific works. Rosen University "Angel Kanchev", volume 51, series 1.1. Agricultural machinery and technology. Agrarian Sciences and Veterinary Medicine. Repair and reliability. – Ruse. 56-60.
10. **Kovalyshyn S.Y., Shchur T.G., Shvets O.P. 2011**. Simulation of the process of dosing of seed mixture of rape into the working zone of the electro-friction separator / Bulletin of the Kharkiv National Technical University of Agriculture named after Petr Vasilenko: Modern problems of the improvement of systems and technologies in livestock breeding. Whip No. 108. 87-92.
11. **Nishchenko I.O., Shvets O.P. 2009**. Investigation of trajectories of motion of particles of a spherical form of seed mixture in a moving electric field in a friction plane / Bulletin of DDAU. Special Issue No.2-09. 256-259.
12. **Paranuk V.O., Kovalyshyn S.Y., Melnychuk V.I., Shvets O.P. 2007**. Physical bases of separation technology of seeds of agricultural crops / Collection of scientific works of UkrNIIPVT them. L. Burned: Techno-technological aspects of the development and testing of new technology and technologies for agriculture in Ukraine. Ed. 10 (24), K.1. 77-86.
13. **Paranyuk V.O. 1983**. Separation of seed mixtures in an electric field on an inclined plane moving at a constant speed: dis. Cand. tech. Sciences: - Chelyabinsk, 152.
14. **Paranyuk V.A. 1979**. Productivity and dimensions of the canvas of the electric friction separator. / "Electrotechnology of agricultural production processes", vol. 152. 57-60.
15. **Paranyuk V.A. 1983**. Sorting of seeds in an electrostatic field on a moving inclined plane. / Scientific works "Application of EIT apparatuses and tools in seed and poultry farming". 74-78
16. **Shvets O.P. 2013**. Analysis of the results of the mathematical description of the movement of rape seeds on the separation plane of the electro-friction separator / Visnyk LNAU "Agroinengineering Research" № 17. 144-149.
17. **Shvets O.P. 2010**. Investigation and influence of the angle of equilibrium of winter rape seed on its trajectory on the working surface of the electro-friction separator / National inter-departmental sciences. -techn. save Kirovogradsk NTU: Construction, production and operation of agricultural machines. Ed. 40, Ch.2. 235-241.
18. **Shvets O.P. Duganets V.I. 2014**. Results of researches of trajectories of movement of rape seeds on a sloping moving plane / Visnyk LNAU "Agroinengineering research" №18. 148-152.
19. **Shvets O.P. 2012**. Substantiation of parameters and modes of operation of separator of winter rape seed: dis. Cand. tech Sciences: – Lviv, 165.
20. **Shvets O.P. Schur T.G. 2015**. Substantiation of the technology of post-harvest processing of rape seeds on the basis of research results of its quality during harvesting / Bulletin KhTU n.a. P.M. Vasylenko is dedicated to the 85th anniversary of the University, issue 157. 215-222.
21. **Kovalyshyn S. Shvets O., Holodnyak R. 2010**. Description of parameters of electric separator of rape seed mixtures / Teka. Commision of motorization and power industry in agriculture – Volume X. Lublin: Lublin university of tehnology, 186-193.22.
22. **Kovalyshyn S. Shvets O., Grundas S., Tys J. 2013.** Use of the electro-separation method for improvement of the utility value of winter rapeseeds / Int. Agrophys. 27. 419-424.

MOTROL. Commission of Motorization and Energetics in Agriculture – 2017. Vol.19. No.4. 59-67

PROPOSED IMPLEMENTATION OF THE REGISTER OF BUILDING STRUCTURES IN UKRAINE DRAWING ON POLAND'S EXPERIENCE – SPATIAL DATA

Malgorzata Busko[1], Oleksandra Kovalyshyn[2]
[1]AGH University of Science and Technology
Aleja Adama Mickiewicza 30, Kraków, Poland. E-mail: mbusko@agh.edu.pl
[2]Lviv National Agrarian University
Str. V. Vylokoho, 1, Dublyany, Ukraine. E-mail: kovalyshynlesya@ukr.net

Summary. The article presents legal bases and state of progress in construction of the real estate cadastre regarding building structures as objects of this cadastre. The legal status and practical solutions were referred to both Poland and Ukraine.

Based on the analysis of the currently applicable laws in Poland, the authors formulated definitions of the contour of a building structure and its development area. The applicability of these definitions in surveying practice has been illustrated in photographs of the existing building structures.

Formulation of the definition of the contour of a building structure and its development area, prior to the implementation of the register of building structures in Ukraine, was preceded by an in-depth analysis of the legislation applicable in Poland in recent years, as well as extensive studies of consequences of incorrectly formulated definitions which may occur in practice. Applying in Ukraine the definitions of the contour of a building structure and its development area proposed in this paper will allow to avoid numerous problems encountered in Poland when entering building structures into the database of the real estate cadastre.

Key words: building structure, real estate cadastre, register of buildings, contour of a building structure, development area, spatial data

INTRODUCTION

Both in Poland and in Ukraine, the registers of land and buildings have their formal and legal bases which, in a more or less strict and legible manner, define principles of their maintenance, establishment or modernization. Numerous interesting publications on this subject have occurred in both countries, including [6, 9, 4] in Poland, and [23, 28] in Ukraine. In this article, the author formulated proposals for a definition of the contour of a building structure and its development area. Their formulation, prior to the possible implementation of the register of building structures in Ukraine, was preceded by an in-depth analysis of the definitions applicable in Poland in recent years. Application of the definitions proposed in this paper in Ukraine, will allow to avoid numerous problems encountered in Poland when entering building structures into the database of the real estate cadastre [3].

ANALYSIS OF RECENT RESEARCHES AND PUBLICATIONS

Problems of maintenance and accuracy of the records in the system of cadastre of real estate objects are studied in the researches of the scientists in Poland and Ukraine. There are still many problems, connected with formation of real estate objects, legitimization of the rights for them and entering of the data into real estate cadastre.

OBJECTIVES

The task of the research is to make a comparative analysis of methodic approaches to determination of constructive elements of a real estate object in the cadastre system of Poland and Ukraine.

THE MAIN RESULTS OF THE RESEARCH

As far as building structures are concerned, the legal acts in Poland in chronological order were as follows: Decree on the cadastre of land and buildings [12] and Decree of 2 February 1955 on the register of land and buildings [13]. According to this legal provision, the parcel and the building became basic elements of the register. The Decree was to be provided with detailed guidance on establishing and maintaining records, but it was implemented only 14 years later, by the Order of the Ministers of Agriculture and Municipal Affairs of 20 February 1969 on land register [21].

Although this Order is no longer in force, knowledge of its contents is necessary due to a large number of documents that were issued and entered into the records under it. The above-mentioned Decree was repealed only by the current law of 17 May 1989 - the Geodetic and Cartographic Law [15], which has been the main legal regulation in the field of surveying in Poland until this day. Since 1989, this law has been amended several times. Pursuant to art. 2 clause 8 of the Geodetic and Cartographic Law, the terms of the real estate cadastre and of the register of land and buildings can be used interchangeably.

In addition, art. 2 clause 8 of the Law stipulates that the real estate cadastre is an information system that provides for the collection, update and making available the information on land, buildings and premises, their owners and other entities who hold or manage land, buildings or premises, in a manner uniform for the whole country. According to the Law, maintenance of the register of land and buildings is governor's responsibility, who is a representative of the local administration. The updatedness and reliability of the data contained in the register of land and buildings is of great importance, as pursuant to the Geodetic and Cartographic Law, they form the basis for various fields of the country's economy (Fig. 1).

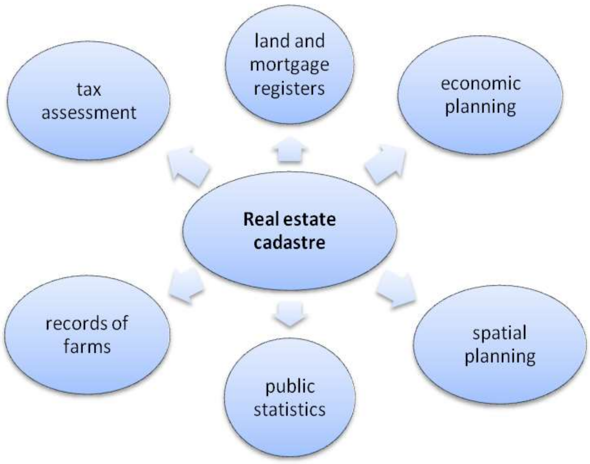


Fig. 1. Utilization of the data of the real estate cadastre in Poland*.

*Source: own study based on [15]

The first secondary legislation to the Geodetic and Cartographic Law was the Regulation of the Minister of Land Management and Construction of 17 December 1996 on the register of land and buildings [14]. The issuance of this Regulation was aimed at adapting the maintenance and manner of establishing the register of land and buildings to the requirements of the Geodetic and Cartographic Law, and in §28.1, a list of the building's cadastral and descriptive data was formulated for the first time. Based on this Regulation, register of buildings and premises was implemented in pilot areas in Poland, but it did not cover a large area of the country. However, the 1996 Regulation was quickly recognized as non-compliant and, after four years, the Regulation of the Minister of Regional Development and Construction of 29 March 2001 on the register of land and buildings was issued [15]. This Regulation is the secondary legislation currently in force, but it has been amended twice: in 2013 [17] and in 2015 [18]. With regard to buildings, these amendments were very significant as they changed numerous definitions related to a building structure and expanded significantly the number of attributes, i.e. descriptive data of a building, which should be entered in the database of the real estate cadastre.

These amendments to the Regulation on the register of land and buildings were one of the effects of Poland's accession to the European Union and the resulting need to comply with the European Parliament Directive of 14 March 2007 establishing the Infrastructure for Spatial Information in the European Community (INSPIRE) [22]. The consequence of this directive was the adoption of the Act on Spatial Information Infrastructure [20]. Amongst numerous aspects of spatial data listed in the Directive and in the Act, there are also building structures, but only with regard to their geographic location, or spatial location.

The database of the register of land and building is one of the registers occurring in the Act on Spatial Information Infrastructure. This Act provides that spatial databases are to enable reciprocal relationships of conceptual models of data contained in them. At the same time, they must be interoperable, which means that it must be possible to reciprocally supply and update the databases. In order to enable such information flow between the databases, data harmonization is necessary, i.e. consistency of conceptual models. Therefore, correct functioning of the databases for which the cadastral database is a reference base, depends on high quality of reference spatial data, avoidance of data redundancy (repetition of data) and avoidance of excess information. These issues were dealt with in detail in [1, 5, 10,].

The Regulation on the register of land and buildings was amended in 2013, resulting in development of a conceptual model of the data of the register of land and buildings and a GML application scheme for this data exchange, based on the methodology of conceptual modeling of geographic information, used e.g in the International Standards ISO 19100 series [7, 8, 11,]. Considering the information contained in the databases, it can be concluded that in Poland the database of the real estate cadastre forms the basis for the national spatial information infrastructure.

In Ukraine, supply, use and disposal of residential property by a person, as well as rights and responsibilities of the subjects of legal housing relations, are regulated by the Housing Code, Civil Code, Laws "On privatization of the state housing fund", "On local self-government in Ukraine" and others. State Committee of Building, Architecture and Housing Policy of Ukraine is the body of special competence in housing sphere, which makes proposals concerning development of the state housing policy, supports implementation of reforms in the housing and utilities sector. Managerial activity of the state has long been focused on building of houses in big cities. Such policy has resulted in misbalance in supply and landscaping of housing in the settlements of different sizes, as well as caused degradation of villages and small settlements. Acting legislature and other normative acts, approved in the years of Ukraine's independence, need crucial changes. The current housing legislature, being valid since 1985, does not correspond to the changes, having happened in the last twenty years in the economy of the state and needs urgent changes in the direction of correspondence to the system of market economy. Recently, one has observed spreading of new reveals of anti-public actions in the field of house purchase and disposal of it, requiring direct participation of the state in order to protect citizens' rights. Thus, Ukraine has approved the Law "On registration of property rights for real estate objects and their restrictions" and the Order of the rights registration. Ministry of Justice is authorized to legitimate rights of citizens for residential property. Accordingly, registration of real estate objects is made after implementation of technical inventory or acceptance into service of finished building objects of real estates. Basing on the materials of technical inventory, one completes property inventory files and technical data sheets, determining actual area and volume, results of inspection and estimation of technical conditions, value of the object. The mentioned materials make base for introduction of information into the register of property rights for real estate objects and supply of information certificate for citizens from the State register of property rights for real estate objects concerning the object of real estate.

In recent years, Poland saw very intensive and thorough modernization of the register of land and buildings. These projects are largely financed by the European Union and are carried out under the construction of the so-called Integrated Real Estate Information System. Fig. 2 is a proof of how important it is. It illustrates cadastral districts of two poviats in the Podkarpackie province, which are directly neighboring the territory of Ukraine. Areas after the modernization of the register are marked in dark green, cadastral districts where the register has not been modernized yet are marked in pink, and in blue-areas where, in 2017, the modernization of the records is currently being carried out.

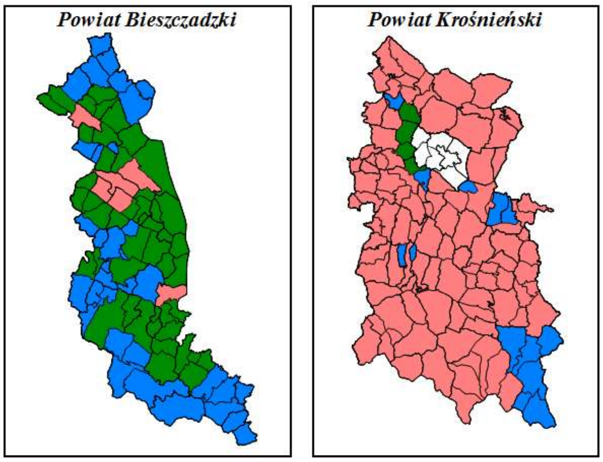


Fig. 2. Modernization progress in poviats in the Podkarpackie province*

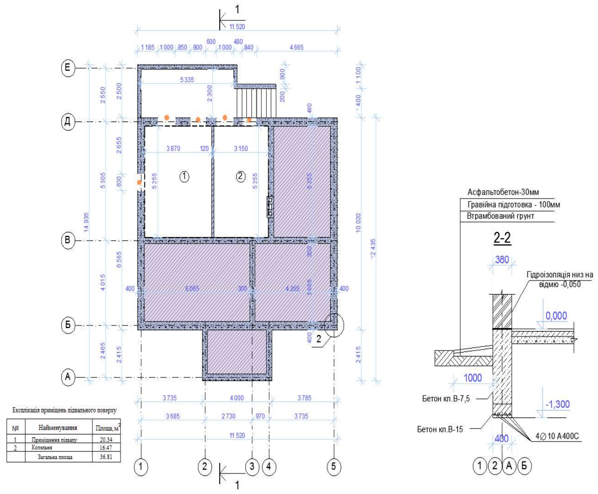
*Source: own study

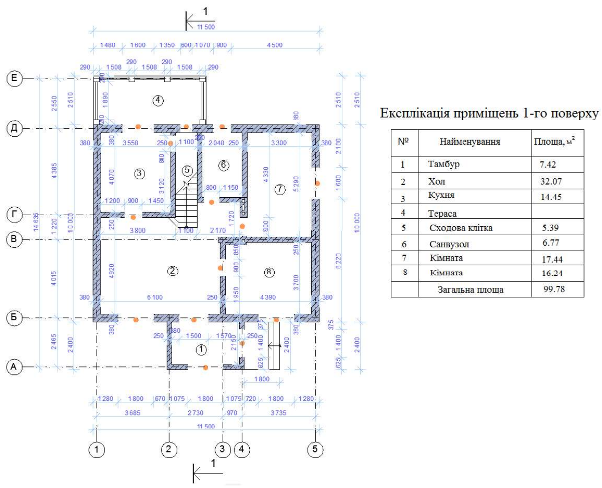
Figure 2 clearly demonstrates that progress of the modernization of the Polish register is very diversified. As a rule, there are very few building structures in the register of land and buildings in the districts before the modernization; they are entered into the cadastre after the modernization.

Technical data sheet is a primary document, supplying base for other documents, which are necessary for the real estate object to be registered in cadaster and other state registers [27, 34].

Plan of a flat or house, with determination of its all sizes and application, i.e. description of each room of the object and its size, is an obligatory part of a technical data sheet. In case of different number of stores in different parts of the house, and when the house is located on a slope land parcel, and thus, number of stores increases because of the slope, the number of stores is mentioned for each part of the house. Determining number of stores of the terrestrial part of a house, it is necessary to include all stores on the surface, including technical, attic and basement, if top of its flooring is not less than 2 m above the average plan mark of the land [31, 32, 33].

Design of technical data sheet is made with ArchiCAD software [26]. The program enables a detailed development of architectural-building constructions and documents of it. The program is very important for preparation of calculations, because after loading of an appropriate initial information into the ArchiCAD system, the program gives characteristic and calculations of a budget plan. An inbuilt "virtual building" technology is the main peculiarity of the program, as it creates a space model of a real construction. It supplies different information for completing of the information of municipal information system of the settlement. Such system accumulates and generalizes data, supports appropriate level of interaction of local authority subdivisions or other institutions, which are concerned with life of settlements, provides convenient mechanisms of information supply, which can be useful, and asked by population.





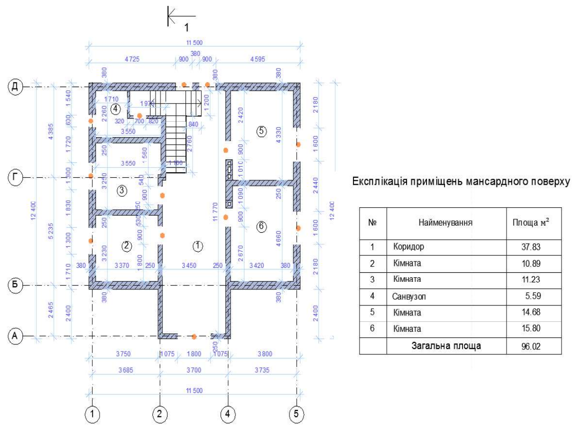


Fig. 3. Elements of technical data sheet

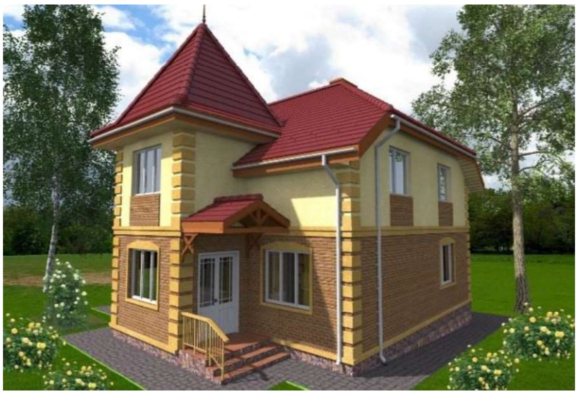


Fig. 4. Development of a "virtual building" in ArchiCAD system

When dealing with establishing and updating the database of the real estate cadastre for building structures, the surveyor must comply with the definition of the contour. In Poland, the definition of the contour of a building structure was formulated in the Regulation on the register of land and buildings of 2001 [14], and then amended twice in the amending regulations: in 2013 and 2015. Thus, over the last 17 years, the third version of the definition of the contour is currently in force in the Polish legislation. Therefore, the same building may be seen in a significantly different cartographic form, depending under which regulation it was mapped. Detailed analyses of these cases were presented in [2]. Table 1 contains definitions of the contour of a building structure, according to the three versions of the register of land and buildings.

Table 1. Definitions of the contour of a building structure in the existing Polish legislation*

REGULATION ON THE REGISTER OF LAND AND BUILDINGS OF 2001, § 63:	REGULATION ON THE REGISTER OF LAND AND BUILDINGS OF 2013, § 63 sections 1a-1c:	REGULATION ON THE REGISTER OF LAND AND BUILDINGS OF 2015, § 63 sections 1a-1b:
3) numerical description of the contour defined by rectangular projection of the outer planes of the outer walls of the building's ground floor onto the horizontal plane, and for the buildings on pillars, the storey based on these pillars – further referred to as the contour of a building structure	1a. The contour of a building structure, referred to in section 1 clause 3, is understood to be a closed line defined by rectangular projection of the lines of intersection of the outer walls of a building with the surface of the ground onto the horizontal plane. 1b. If foundation of a building intersects with the surface of the ground, or if a building is constructed on pillars, the contour of a building structure shall be, respectively, a line defined by rectangular projection of the line of intersection of the outer edges of the foundation or the outer edges of the pillars with the surface of the ground onto the horizontal plane. 1c. In the case of building structures with underground floors only, the contour is a closed line defined by rectangular projection of the outer edges of that building onto the horizontal plane.	1a. The contour of a building structure, referred to in section 1 clause 3, is understood to be a closed line defined by rectangular projection of the lines of intersection of the outer walls of a building with the surface of the ground onto the horizontal plane. 1b. If foundation wall of a building intersects with the surface of the ground, or if a building, or its part, is constructed on pillars, the contour of a building structure, or part of this contour, shall be, respectively, a line defined by rectangular projection of the lowest outer edges of the building's walls which are based on these foundation walls or on the pillars onto the horizontal plane, and in the case where the roof of a building is based on the pillars - the outer edges of the roof.

*Source: own study based on [15, 17, 18].

Unfortunately, these definitions contained in Table 1 do not allow for a uniform approach to a broad spectrum of building structures with different architectural solutions. Therefore, in this paper, the authors formulated new definitions of the contour, which will help to avoid errors currently occurring in Poland. Photographs of building structures (Fig. 4 – Fig. 10) will be presented as a comment to Table 1, and new definitions of the contour of a building structure will be proposed in Table 2.

Due to the technological process of erecting a building structure, the most common situation in the field is that the foundation wall, based on foundations buried underground, intersects with the surface of the ground [16] (Fig. 4). This is the most common case in practice, and therefore it will be mentioned first in the definition of the contour (§ 1.1 in Table 2). The places where the contour of a building structure is measured (measurement point) were marked with red arrows – Fig. 5.

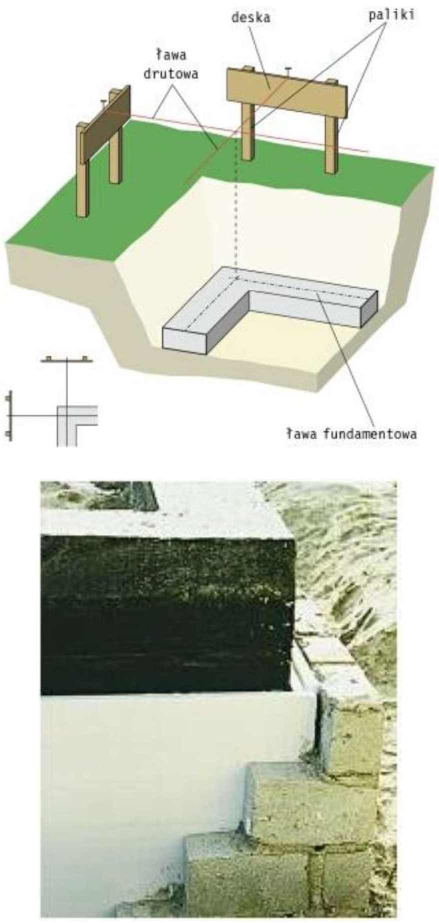


Fig. 4. Foundation and foundation wall of the building*

*Source: [http://www.jak-zrobic-dom.pl]

Fig. 5. § 1.1 - Measurement point of the foundation wall of the building*

*Source: own study, photo by: M. Buśk

In the Polish legislation regarding registers, there is a concept of a block of a building structure. This is this part which is not covered by its contour, as illustrated by the examples in Fig. 9. In the architectural and construction nomenclature, such parts of a building structure are referred to as overhangs. Overhangs can be supported by pillars (as illustrated on the left of Fig. 9 or not supported by pillars (as illustrated on the right of Fig. 9). Overhangs should be treated as blocks of building structures.

Fig. 6. § 1.2 - invisible foundation wall*
*Source: own study, photo by: M. Buśko

Table 2. Proposed definition of the contour of a building structure*

No.	Content of the definition of the contour of a building structure	Remarks Fig. No.
§ 1	The contour of a building structure is understood as follows:	
§ 1.1	If foundation walls of a building structure intersect with the surface of the ground, the contour of a building structure shall be a line defined by rectangular projection of the line of intersection of these foundation walls with the surface of the ground onto the horizontal plane.	Fig. 5
§ 1.2	If foundation walls of a building structure do not intersect with the surface of the ground, the contour of a building structure shall be a line defined by rectangular projection of the line of intersection of the lowest outer edges of the building's overground walls with the surface of the ground onto the horizontal plane.	Fig. 6
§ 1.3	If a building is entirely constructed on pillars only, the contour of a building structure shall be a closed line defined by rectangular projection of the lowest outer edges of the building's walls which are based on these pillars onto the horizontal plane.	Fig. 7
§ 1.4	In the case of a specific type of a building structure, such as a pavilion, to be entered into the database of the real estate cadastre, the contour of a building structure shall be a line defined by rectangular projection of the outer edges of the roof onto the horizontal plane.	Fig. 8
§ 1.5	If, in a multi-storey building, rectangular projections of some of its stories onto the horizontal plane are not consistent with the contour, or if neighboring buildings are connected by skyways or subways, those parts of a building that extend beyond the contour or are connections, are distinguished in the cadastral database as blocks of a building structure, using numerical description.	Fig. 9 Fig. 10

*Source: own study.

Fig. 7. § 1.3 - A building entirely constructed on pillars*
*Source: own study, photo by: M. Buśko

Fig. 8. § 1.4 - Contour of a pavilion as a specific type of a building structure*
*Source: own study, photo by: M. Buśko

Fig. 9. § 1.5 – A building with overhang supported by pillars and overhang not supported by pillars – block of a building structure*

*Source: own study, photo by: M. Buśko

A skyway between two buildings is also considered to be a block of a building structure, as illustrated in Fig. 10.

Fig. 10. § 1.5 - Skyway between buildings - block of a building structure*

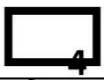
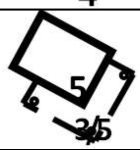
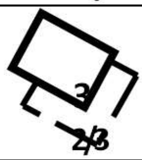
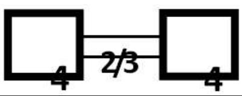
*Source: own study, photo by: M. Buśko

In any case, regardless of the presence of pillars or their lack, overhangs as blocks of a building structure should be included on the map. For this purpose, cartographic symbols are required, examples of which are presented in Table 3.

The legislation on the register of land and buildings in Poland, introduced with the amendment to the Regulation in 2013, require the collection of numerous cadastral data on building structures in the real estate cadastre. A great deal of these data are duplicated from architectural and construction records and they are unnecessary load to the cadastral database. In addition, provisions of law, especially those relating to the contour of a building structure, are incomprehensible and chaotic. For this reason, instead of literal application of legal regulations, space is created for their arbitrary interpretation.

However, the biggest mistake is discrepancy between definitions related to building structures contained in surveying regulations and in construction law. In Poland, unfortunately, such discrepancy has occurred, and therefore the provisions of law should be amended as soon as possible.

Table 3. Cartographic symbols for building structures*

Name	Cartographic symbol	Remarks
Contour of a building structure – 4 storeys		The number refers to the highest storey of a building
Contour and block of a building structure – overhang supported by pillars		5 storeys of a building structure Overhang on storeys 3, 4 and 5
Contour and block of a building structure – overhang not supported by pillars		3 storeys of a building structure Overhang on storeys 2 and 3
Contour and block of a building structure – passages		4 storeys of a building structure Skyway at the height of storeys 2 and 3

*Source: own study.

It is equally important to correctly define the development area of a building structure. Currently in Poland, the development area in surveying regulations is consistent with the contour of a building structure, while in the construction law it is consistent with the external outline of a building structure. This discrepancy is particularly noticeable when overhangs or passages between buildings occur. Thus, in the revised version, definition of the development area of a building structure in surveying regulations should be as follows: Development area of a building structure is the surface area of a geometric figure defined by its contour, together with the area of a geometric figure defined by its blocks, if applicable.

CONCLUSIONS

It is not recommended to enter too many attributes of a building into the cadastral database, both due to the difficulty of capturing them and their frequent variability. As a result, the cadastral database of building structures will not be up to date. It is important to precisely specify those registers that will use the cadastral data, and those that will automatically implement the data into the register of buildings. In these registers, definitions of the building structure, the contour of a building, the development area, and other elements of a building should be uniform. Then, between the register of buildings and other registers for which the cadastre is the reference base, as well as the registers which are reference for the cadastral database, harmonization of data will be ensured.

When building an IT system for data flow in the register of buildings, it is important to ensure that cadastral information is automatically circulated between registers, preferably in real time, or in series - in small time intervals.

In the appendixes to the Regulation, it is essential to precisely specify the form and content of the forms in which cadastral data on buildings will be collected, both during a field inspection and surveys, and in the database of the register of land and buildings. These forms should be uniform for the country.

REFERENCES

1. **Bac-Bronowicz J., Głażewski A., Liberadzki P., Wilczyńska I., 2015.** Harmonization of conceptual models of the reference databases BDOT10k and BDOT500 considering data exchange. Annals of Geomatics, Vol. XIII, Issue No. 4(70). 295–305.
2. **Busko M. 2016a.** Bulding contour line in the database of the real estate cadastre in Poland pursuant to applicable laws. ECONTECHMOD. AN INTERNATIONAL QUARTERLY JOURNAL, Vol. 5. No. 3. 183-190.
3. **Busko M. 2016b.** Analysis of the influence of amendments to the legal provisions relating to building structures on keeping the real estate cadastral database updated. Infrastructure and Ecology of Rural Areas. ISSN 1732-5587. II/1. 395-410.
4. **Busko M. 2017.** Modernization of the register of land and buildings with reference to entering buildings into the real estate cadastre in Poland. The 10th International Conference Environmental Engineering: selected papers: April 27–28, 2017, Vilnius Gediminas Technical University, Environmental Engineering Faculty, Vilnius, Lithuania.
5. **Chrobak T., Szombara S., Kozioł K., Lupa M., 2017.** A method for assessing generalized data accuracy with linear object resolution verification. Geocarto International; ISSN 1010-6049, vol. 32 no. 3. 238–256. https://goo.gl/cAO0td.
6. **Dawidowicz A., Zrobek R. 2014.** Analysis of concepts of cadastral system technological development. Procedia Engineering. 9th International Conference "Environmental Engineering" Vilnius Gediminas Technical University, May 22, 2014 – May 23,
2014, http://dx.doi.org/10.3846/enviro.2014.201
7. **Glazewski A. 2016.** Towards harmonization - structural attributes of models of topographic objects used in reference databases. Annals of Geomatics, Vol. XIV, Issue No. 5 (75). 573-582.
8. **Gozdz K., Parzynski Z., Radzio W. 2014.** Polish real estate cadastre as the element of INSPIRE. Annals of Geomatics, Vol. XII, Issue No. 1 (63). 51-66.
9. **Noszczyk T., Hernik J. 2016.** Modernization of the land and property register. Acta Scientiarum Polonorum-Formatio Circumiectus Volume: 15 Issue: 1. ISSN:1644-0765,
DOI: 10.15576/asp.fc/2016.15.1.3. pp: 3-17.
10. **Pachelski W. 2004.** Present status of european and national standardization in geographic information. Annals of Geomatics, Vol. II, Issue No. 2. 96-105.
11. **Wroblewska K., Pachelski W. 2015.** Analysis of adaptability of existing structures and contents of the register of land and buildings to INSPIRE requirements. Annals of Geomatics, Vol. XIV, Issue No. 2 (72). 253-269.
12. Decree of 28 September 1947 on the cadastre of land and buildings. Journal of Laws of 1947 No. 61, item 344 (repealed).
13. Decree of 2 February 1955 on the register of land and buildings (Journal of Laws of 1955, No. 6, item 32. (repealed).
14. Regulation of the Ministers of Spatial Management and Construction, and Agriculture and Food Economy of 17 December 1996 on the register of land and buildings. Journal of Laws of 1996, No. 158, item. 813. (declared to be repealed).
15. Regulation of the Minister of Regional Development and Construction of 29 March 2001 on the register of land and buildings, Journal of Laws of 2001, No 38, item 454.
16. Regulation of the Minister of Infrastructure of 12 April 2002 on technical conditions to be met by buildings and their location. Journal of Laws of 2002, No. 75, item 690.
17. Regulation of the Ministry of Administration and Digitization of 29 November 2013 amending the Regulation on the register of land and buildings, Journal of Laws of 2013, item 1551.
18. Regulation of the Ministry of Administration and Digitization of 6 November 2015 amending the Regulation on the register of land and buildings, Journal of Laws of 2015, item 2109.

19. The Act of 17 May 1989, Geodetic and Cartographic Law, Journal of Laws of 1989, No. 30, item 163, as amended.
20. The Act of 4 March 2010 on Spatial Information Infrastructure. Journal of Laws of 2010, No. 76, item 489.
21. Order of the Ministers of Agriculture and Municipal Affairs of 20 February 1969 on land register. Official Gazette of the Republic of Poland of 1969, No. 11, item 98.
22. DIRECTIVE 2007/2/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). Official Journal of the European Union, 25.4.2007, L 108/1. http://www.jak-zrobic-dom.pl/2011/07/wykopy-i-fundamenty-szkoa-budowania.html – access on 12.08.2017.
23. **Asaul, A.M., Bryzhan, I.A., Chevhanova V.Ya. 2009.** Economics of real estate. Kyiv: Libra.
24. On state registration of property rights for real estate objects and their restrictions [online]: Law of Ukraine on July, 1, 2004 № 1952-IV; Edition of November, 2, 2016. Available at: http://zakon2.rada.gov.ua/laws/show/1952-1.
25. On state registration of property rights for real estate objects and their restrictions, [online]: Resolution of the Cabinet of Ministers of Ukraine of December, 25, 2015 №1127; edition of November, 16, 2016. Available at: http://zakon0.rada.gov.ua/laws/show/1127-2015-п
26. Development of a municipal GIS, [online] Available at: http://expert-centr.com.ua/content/services-land_management-stvorenya_munithipalnoi_gis.
27. Instruction concerning division, determination and calculation of the shares of real estate objects", approved by the Order of the Ministry of Housing and Utilities Sector of Ukraine on June, 18, 2007 №55, registered at the Ministry of Justice of Ukraine on July, 6, 2007 at №774/14041, [online] Available at: http://zakon2.rada.gov.ua/laws/show/z0774-07.
28. **Kovalyshyn A. Kryshenyk N., Len P. 2015.** Effect of engineering factors of the land plot on the efficiency of its use in the event of division. ECONTECHMOD : an interntionl quarterly journal on economics of technology and modelling processes, Vol. 4. No 5, p. 76-79.
29. Law of Ukraine №687-XIV, Kyiv, May, 20, 2000, "On architectural activity", [online]. Available at: http://zakon2.rada.gov.ua/laws/show/687-14.
30. On regulation of city planning activity", [online] Available at: http://zakon.rada.gov.ua/laws/show/3038-17
31. SBS 360-92 **. City planning. Planning and building of urban and rural settlements, [online] Available at: http: // dbn.at.ua/load/normativy/dbn/dbn_360_92_ua/1-1-0-116.
32. SBS B.2.2-15-2005. Residential buildings for individual builders of Ukraine, [online] Available at: dbn.at.ua/load/normativy/dbn/dbn_360_92_ua/1-1-0-116.
33. SBS B.3.2-2-2009. Residential buildings, Reconstruction and major repairs, [online]. Available at: dbn.at.ua/load/normativy/dbn/1-1-0-333.
34. Instruction (with changes and supplements) about the order of technical inventory of real estate objects", approved by the Order of the State Committee of Building, Architecture and Housing Policy of Ukraine on May, 24, 2001 №127, registered at the Ministry of Justice of Ukraine on July, 10, 2001 at №582/5773, [online] Available at: http://zakon4.rada.gov.ua/laws/show/z0582-01.

C O N T E N T S

List of the Reviewers

1.	R. Kuzminskyi	5.	S. Kovalyshyn
2.	I. Palamarchuk	6.	O. Kalahan
3.	V. Tymochko	7.	M. Student
4.	V. Shevchuk	8.	V. Dmytriv

Editors of the "MOTROL" magazine of the Commission of Motorization and Power Industry in Agriculture would like to inform both the authors and readers that an agreement was signed with the Interdisciplinary Centre for Mathematical and Computational Modelling at the Warsaw University referred to as "ICM". Therefore, ICM is the owner and operator of the IT system needed to conduct and support a digital scientific library accessible to users via the Internet called the "ICM Internet Platform", which ensures the safety of development, storage and retrieval of published materials provided to users. ICM is obliged to put all the articles printed in the "MOTROL" on the ICM Internet Platform. ICM develops metadata, which are then indexed in the "Agro" database.

We are pleased to announce that the magazine "MOTROL – Motorization and Energetics in Agriculture" (ISSN 1730-8658) has undergone a positive evaluation of the IC Journals Master List 2013, the result of which is granting the ICV Index (Index Copernicus Value) 6.56 pts. The resulting score was calculated on the basis of a survey submitted by the Editorial Team as well as assessments made by the professionals from Index Copernicus. We invite you to familiarize yourself with the methodology of IC Journals Master List evaluation:

http://journals.indexcopernicus.com/masterlist.php?q=motrol

Impact factor of the "MOTROL" journal according of the Commission of Motorization and Energetics in Agriculture is 0,5 (December 2017).

GUIDELINES FOR AUTHORS (2017)

The journal publishes the original research papers. The papers (min. 8 pages) should not exceed 12 pages including tables and figures. Acceptance of papers for publication is based on two independent reviews commissioned by the Editor.

Authors are asked to transfer to the Publisher the copyright of their articles as well as written permissions for reproduction of figures and tables from unpublished or copyrighted materials.

Articles should be submitted electronically to the Editor and fulfill the following formal requirements:
- Clear and grammatically correct script in English,
- Format of popular Windows text editors (A4 size, 12 points Times New Roman font, single interline, left and right margin of 2,5 cm),
- Every page of the paper including the title page, text, references, tables and figures should be numbered,
- SI units should be used.

Please organize the script in the following order (without subtitles):
Title, Author(s) name (s), Affiliations, Full postal addresses, Corresponding author's e-mail
Abstract (up to 200 words), Keywords (up to 5 words), Introduction, Materials and Methods, Results, Discussion (a combined Results and Discussion section can also be appropriate), Conclusions (numbered), References, Tables, Figures and their captions

Note that the following should be observed:
An informative and concise title; Abstract without any undefined abbreviations or unspecified references; No nomenclature (all explanations placed in the text); References cited by the numbered system (max 5 items in one place); Tables and figures (without frames) placed out of the text (after References) and figures additionally prepared in the graphical file format jpg or cdr.

Make sure that the tables do not exceed the printed area of the page. Number them according to their sequence in the text. References to all the tables must be in the text. Do not use vertical lines to separate columns. Capitalize the word 'table' when used with a number, e.g. (Table1).

Number the figures according to their sequence in the text. Identify them at the bottom of line drawings by their number and the name of the author. Special attention should be paid to the lettering of figures – the size of lettering must be big enough to allow reduction (even 10 times). Begin the description of figures with a capital letter and observe the following order, e.g. Time(s), Moisture (%, vol), (%, m^3m^{-3}) or (%, gg^{-1}), Thermal conductivity (W $m^{-1}K^{-1}$).

Type the captions to all figures on a separate sheet at the end of the manuscript.

Give all the explanations in the figure caption. Drawn text in the figures should be kept to a minimum. Capitalize and abbreviate 'figure' when it is used with a number, e.g. (Fig. 1).

Colour figures will not be printed.

Make sure that the reference list contains about 30 items. It should be numbered serially and arranged alphabetically by the name of the first author and then others, e.g.
7. Kasaja O., Azarevich G. and Bannel A.N. 2009. Econometric Analysis of Banking Financial Results in Poland. Journal of Academy of Business and Economics (JABE), Vol. IV. Nr 1, 202–210.

References cited in the text should be given in parentheses and include a number e.g. [7].

Any item in the References list that is not in English, French or German should be marked, e.g. (in Italian), (in Polish).

Leave ample space around equations. Subscripts and superscripts have to be clear. Equations should be numbered serially on the right-hand side in parentheses. Capitalize and abbreviate 'equation' when it is used with a number, e.g. Eq. (1). Spell out when it begins a sentence. Symbols for physical quantities in formulae and in the text must be in italics. Algebraic symbols are printed in upright type.

Acknowledgements will be printed after a written permission is sent (by the regular post, on paper) from persons or heads of institutions mentioned by name.