INTERNATIONAL SCIENTIFIC JOURNAL



INNOVATIONS

YEAR V ISSUE 1/2017, SOFIA
ISSN PRINT 1314-8907
ISSN WEB 2534-8469

Publishers:

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING
"INDUSTRY 4-0"

NATIONAL SCIENTIFIC TECHNICAL SOCIETY
AUTOMATION IN DISCRETE PRODUCTIONS

INTERNATIONAL SCIENTIFIC JOURNAL

INNOVATIONS

YEAR V, ISSUE 1 / 2017
ISSN (PRINT) 1314-8907
ISSN (WEB) 2534-8469

INTERNATIONAL EDITORIAL BOARD

CHAIRMAN:
Prof. Dr. Dimitar Damianov – chairman, BG

MEMBERS:
Prof. Dr. Ivo Malakov, BG
Prof. Dr. Dimcho Chakarski, BG
Rrof. Dr. Todor Neshkov, BG
Prof. Dr. Lubomir Dimitrov, BG
Prof. Dr. Sc. Hristo Shehtov, BG
Prof. Dr. Sc. Kiril Angelov, BG
Prof. Dr. Diana Antonova, BG
Prof. Dr. Vassil Kostadinov, BG
Prof. Dr. Stefan Kartunov, BG
Prof. Dr. Ivan Dimitrov, BG
Prof. D.Sc. Vesko Panov, BG
Prof. Ph.D. Kakha Demetrashvili, GE
Prof. Ph.D. Silviu Makuca, RO
Prof. Ph.D. Predrag Dasic, RS
Prof. Ph.D. Ivan Lashin, RU
Prof. Ph.D. Uwe Fuessel, DE
Prof. Dr. Pancho Tomov, BG

Publishers:

SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING "INDUSTRY-4.0"

NATIONAL SCIENTIFIC TECHNICAL SOCIETY AUTOMATION IN DISCRETE PRODUCTIONS

108, Rakovski Str., 1000 Sofia, Bulgaria
tel. (+359 2) 987 72 90, tel./fax (+359 2) 986 22 40,
office@stumejournals.com
www.stumejournals.com

C O N T E N T S

INNOVATIVE SOLUTIONS

INNOVATIVE METHOD FOR STRESS STATE ANALYSIS IN THE DEFORMATION ZONE OF FORMED SPECIMEN
Assist. Prof. dr. Leo Gusel 3

THE NATURAL FREQUENCIES AND MODE SHAPES OF AN EULER-BERNOULLI BEAM WITH A RECTANGULAR CROSS- SECTION WHICH HAS A SURFACE CRACK
L.Emir Sakman, Aşkın Mutlu 6

DRY JIGGING OF COALS
Ulziisaikhan Purevsuren, Namnan Tumurpurev, Enkhbat Dombon 10

INNOVATION APPROACHES TO OPTIMIZE THE DRILLING PROCESS
Mitev, G.V. 14

CONTROL OF ACTIVE ORTHOSIS BY EMG SIGNALS
Eng. Rõbak D., M.Sc., Prof. Musalimov V., D.Sc., Ass. Prof. Penkov I., Ph.D. 18

DEVICE FOR FOG DENSITY CONTROL
Gonevski N., Assoc. Prof. Ivanov O., M.Sc. Todorov P., Pulis V., Prof. Pérez-Díaz J. L. 21

INNOVATION POLICY AND INNOVATION MANAGEMENT

INNOVATION POLICIES OF POLISH INDUSTRIAL ENTERPRISES BASED ON INNOVATION CUBE MODEL. RESEARCH RESULTS
Author: PhD. Paweł Mielcarek, Assistant Professor 25

ECONOMIC ASPECTS OF SPACE INFORMATION TECHNOLOGIES FOR THE RATIONAL USE OF LAND RESOURCES
Doctor of Economic Sciences, Professor, Zhavoronkova G., PhD (Economics), Associate Professor, Zhavoronkov V., PhD (Economics), Associate Professor Melnyk L. 42

THEORETICAL PROBLEMS IN INNOVATIONS

CREATIVE LEARNING IN ICT-PROFESSORS' TRAINING PROGRAM
Prof. Dr. ped. Zakirova F., Dotc. Cand. tech. Migranova E. 46

THE DIFFUSION OF INNOVATION AS A PART OF THE PROCESS OF CREATING INNOVATIVE PRODUCTS
Assoc. Prof. Petrova, Elitsa, PhD 49

INNOVATIVE METHOD FOR STRESS STATE ANALYSIS IN THE DEFORMATION ZONE OF FORMED SPECIMEN

Assist. Prof. dr. Leo Gusel
University of Maribor, Faculty of Mechanical Engineering
Maribor, Slovenia

leo.gusel@um.si

Abstract: *By using visioplasticity method the velocity field can be determined experimentally, and then the stresses can he obtained analytically from these experimental measurements. That means, strain rates and strains are calculated directly from the velocity field while the stress distribution is calculated from an analytical solution of the equilibrium equations and the constitutive equation relating the stress and strain for the material. This method can also provide detailed data of the pressure distribution on the die surface, which is important in the design of the die profile. In the paper cold forward extrusion through a conical die is illustrated by extruding copper alloy specimens with inscribed grid lines. Stress state distribution in plastic deformation region was analyzed using the visioplasticity method. From the flow lines of each element, the velocity and the strain rates are obtained. Finally, the stress components are calculated from the equilibrium and plasticity equations.*

Keywords: VISIOPLASTICITY, METAL FORMING, PLASTIC DEFORMATION, STRESS, STRAIN, COLD FORWARD EXTRUSION.

1. Introduction

The traditional visioplasticity method, which was introduced by Thomsen, is used to find the complete stress distribution in the deformation zone, according to the deformation of grid lines marked on the surface of the specimen [1]. Although there are some difficulties for this method: for example, the flow lines obtained from experimental data are not smooth, the velocity field calculated from these flow lines may not satisfy the condition of continuity etc., the visioplasticity method gives the most realistic solution to various forming problems.

Furthermore, this method can be used as a means of examining the approximations of other solutions [2, 3]. When the finite flow-line regions are produced, the velocity and strain-rate field can be obtained for each region and then stress distribution can be calculated by considering the equilibrium and plasticity equations.

In the extrusion practice of steel and alloys the die geometric shape may influence the technological process development, and together with technological parameters (tool speed, die angle, lubrication, etc.) contribute to the products proper quality [4]. A large number of the publications dealing with the influence of the metal flow pattern on the mechanical properties of extruded products has been published [5, 6]. In the paper, stress state in forward extruded specimens of copper alloy is analyzed by using the visioplasticity method.

2. Visioplasticity method for obtaining the stress distribution

By using visioplasticity method, better approximations can be obtained of forming processes using theory of plasticity than is possible with the pure theory. The specimen is subdivided in a symmetry plane, and a line mesh is applied to the joint. The velocity field can be approximated by means of the grid distortion arising during the forming process [7]. Mostly square grids composed of line nets are used on longitudinally cut sections in bulk forming. The grid can be inscribed on the specimen by mechanical means of etching, by photographic methods or pressing. The selected grid must be fine enough to make an interpolation of radial and axial velocities on lines r = const. and z = const. possible with sufficient precision.

The deformation can also be approximated from the deformation rates by integrating the deformation rates that a particle experiences on its way along a flow line [7]. For steady-state flow problems in which the flow field does not vary with respect to time, the velocity field can be expressed by the flow function θ (r, z) as follows [8]:

$$v_z = \frac{1}{r}\cdot\frac{\partial\theta}{\partial r} \quad ; \quad v_r = -\frac{1}{r}\cdot\frac{\partial\theta}{\partial z} \tag{2. 1}$$

where v_z and v_r are the velocity components in axial (z) and radial (r) direction.

When the velocity components are known at all points in the deformation zone, the strain rate components in radial ($\dot{\varepsilon}_r$), tangential ($\dot{\varepsilon}_\vartheta$), axial ($\dot{\varepsilon}_z$) direction and shear strain rate ($\dot{\varepsilon}_{rz}$) can be obtained according to [8]:

$$\dot{\varepsilon}_r = \frac{\partial v_r}{\partial r} \quad ; \quad \dot{\varepsilon}_\vartheta = \frac{v_r}{r} \quad ; \quad \dot{\varepsilon}_z = \frac{\partial v_z}{\partial z}$$

$$\dot{\varepsilon}_{rz} = \frac{1}{2}\cdot\left(\frac{\partial v_r}{\partial z} + \frac{\partial v_z}{\partial r}\right) \tag{2. 2}$$

The effective strain rate ($\dot{\varphi}_e$) is then calculated from its definition:

$$\dot{\varphi}_e = \sqrt{\frac{2}{3}\left(\dot{\varepsilon}_r^2 + \dot{\varepsilon}_\vartheta^2 + \dot{\varepsilon}_z^2 + 2\dot{\varepsilon}_{rz}^2\right)} \tag{2. 3}$$

The total effective strain (φ_e) can be evaluated by numerical integration of effective strain rate along a flow line with respect to time:

$$\varphi_e = \int_0^{t1} \dot{\varphi}_e \cdot dt \tag{2. 4}$$

where t_1 is the time required for a point to be displaced along a flow line. When the effective strain is calculated, the yield stress can be obtained from the flow curve and thereby calculate the approximate values for the deviator components of the state of stress as a function of the coordinates. Strain rate components in –r, -z, -υ directions and shear strain rate ($\dot{\varepsilon}_{rz}$) are [8]:

$$\dot{\varepsilon}_r = \lambda \cdot (\sigma_r - \sigma_m)$$

$$\dot{\varepsilon}_z = \lambda \cdot (\sigma_z - \sigma_m)$$

$$\dot{\varepsilon}_\vartheta = \lambda \cdot (\sigma_\vartheta - \sigma_m)$$

$$\dot{\varepsilon}_{rz} = \lambda \cdot \tau_{rz} \qquad (2.\ 5)$$

where σ_m is medium stress and λ is coefficient of proportionality.

From these equations, equations of equilibrium, plasticity and material properties, the stress field in the deformation region for axi-symmetrical process can be calculated from [10]:

$$\sigma_r = \int_{z0}^{z1} \left[\frac{\partial}{\partial z}\left(\frac{\dot{\varepsilon}_r - \dot{\varepsilon}_z}{\lambda}\right) - \frac{\partial}{\partial r}\left(\frac{\dot{\varepsilon}_{rz}}{\lambda}\right) - \frac{\dot{\varepsilon}_r}{\lambda \cdot r} \right] \cdot dz \qquad (2.\ 6)$$

$$\sigma_z = \sigma_r - \frac{\dot{\varepsilon}r - \dot{\varepsilon}z}{\lambda} \quad ; \quad \sigma\vartheta = \sigma_r - \frac{\dot{\varepsilon}r - \dot{\varepsilon}\vartheta}{\lambda} \quad ; \quad \tau_{rz} = \frac{\dot{\varepsilon}rz}{\lambda} \qquad (2.\ 7)$$

3. Experimental work

In the experimental investigation rods of special copper alloy CuCrZr were used. The grid nets commonly used in practice are composed of circles or squares. Evaluation is simpler in the case of circular grids, as the forming process distorts them into ellipses, the principle axes of which indicate both the size and direction of the principal deformations [7].

On the other hand, square grids are usually distorted into rhombi that are more difficult to evaluate but are more popular for use in bulk forming. We decided to inscribe 1 mm square grids on the meridian plane of one-half of a split specimen. In order to obtain deformation accurately, the grid must survive the deformation of the specimen without damage. The grid lines must be thin and sharp and the grid mesh should not split off, which would make the measurements difficult. The material flow can be determined by comparing non-deformed and deformed grids.

Specimen with inscribed grid was then cold extruded trough a conical die having a 22,5° half-cone angle. Two different lubricants were used with different coefficient of friction (m=0,05 and 0,11). Coefficient of friction for both lubricants were obtained in the ring test with great number of experiments. The cold forward extrusion was carried out at a tool speed of 12 mm/s and the extrusion process was stopped when a sufficient length of specimen was extruded to ensure the establishment of a steady-state motion.

4. Obtained stress distribution

The position of every node of the deformed grid after forward extrusion was obtained by measuring microscope. The measuring microscope allows us to measure very small distortions very accurate. These values were put in the special computer program for visioplasticity, as well as every node of initial grid, distance between initial grid nodes, flow curve of the material to be formed and the tool speed. By measuring the difference between initial grid nodes and nodes on the deformed grid it is possible to calculate velocity of every point in r- and z- direction.

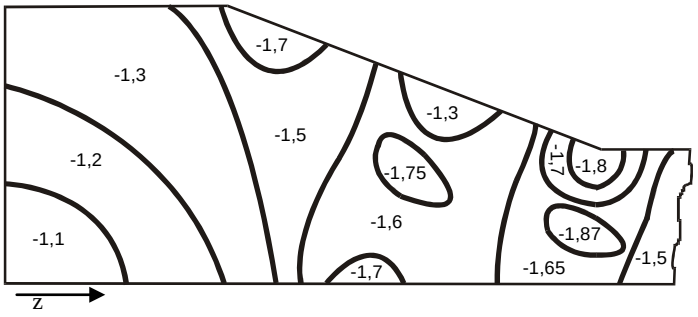
The strain rates and stress field can be obtained from equations (2. 2), (2. 6) and (2. 7).

The results of the distribution stress state components in the deforming region of the specimens are presented in diagrams in Fig. 1, 2 and 3, where s_{f0} is the flow stress of unformed material (s_{f0}= 409 N/mm^2). By using the lubricant with a lower coefficient of friction for the forward extrusion of copper alloy, lower stress components values were reached over the whole extruded specimen, but especially at the end of the deforming zone.

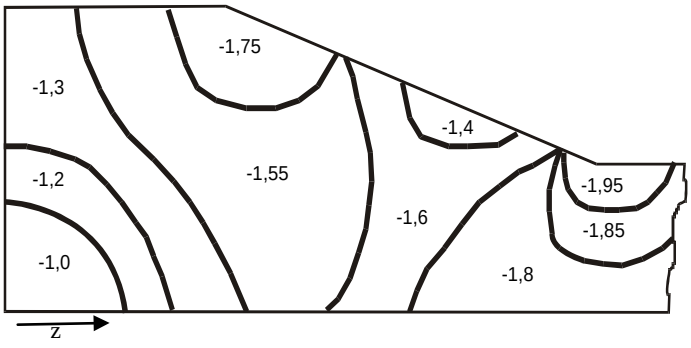
The distribution of radial stress in extruded specimen is presented in Fig. 1. The largest values of the radial stress can be found near the exit of the plastic region. The highest values of (s_r /s_{f0}) were reached on the edge of the exit cone and in the middle of the exit cone. Those are the plastic deformed region with the greatest values of strain, strain rate and therefor also the greatest values of stress components. The influence of the lubricant friction factor is relatively small, but some differences especially at the exit of the plastic region can be found. The difference between the highest value for radial stress in extruded specimen with m = 0,05 and in the extruded specimen with m = 0,11 was 5%. The highest value was reached when lubricator with higher coefficient of friction was used.

Fig. 2 shows the distribution of axial stress in extruded material. The highest values for (s_z/s_{f0}) were reached in the zone before entering the plastic zone. In the plastic zone the axial stress decreases toward the exit of the plastic zone where the lowest value for axial stress is reached. The difference between the highest value for axial stress in extruded specimen with m=0,05 and in the extruded specimen with m=0,11 was about 6%. The influence of coefficient of friction on the axial stress distribution is not that significant, although with better lubricant lower values for axial stress were reached. It is also important to know local stresses in plastic zone because we can obtain (or calculate) the influence of the die wear during cold forward extrusion process of copper alloy.

Fig. 3 shows the shear stress field. It is interesting to note that the shear stresses along the axis line are near zero for both cases. The largest values for shear stress is to be found near tool profile and this value is greater in the specimen where lubricant with higher coefficient of friction (m = 0,11) was used. This means that lubricant can effect on the surface quality of the extruded specimen.

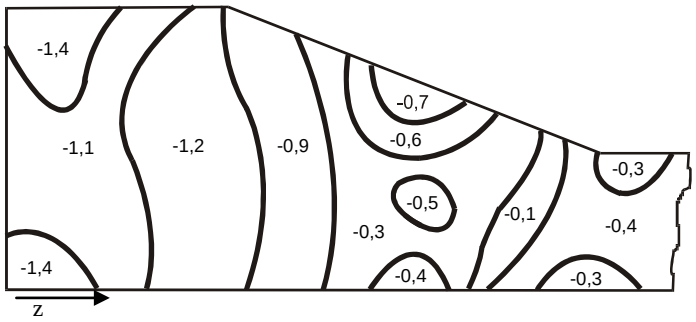


a)

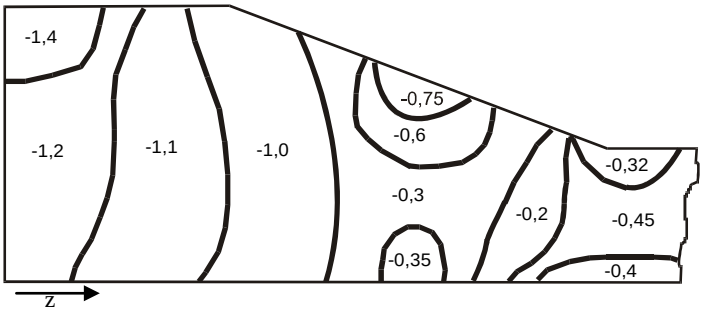


b)

Fig. 1: *The contours of radial stress s_r /s_{f0} for:*
a) *coefficient of friction m = 0,05,*
b) *coefficient of friction μ = 0,11.*

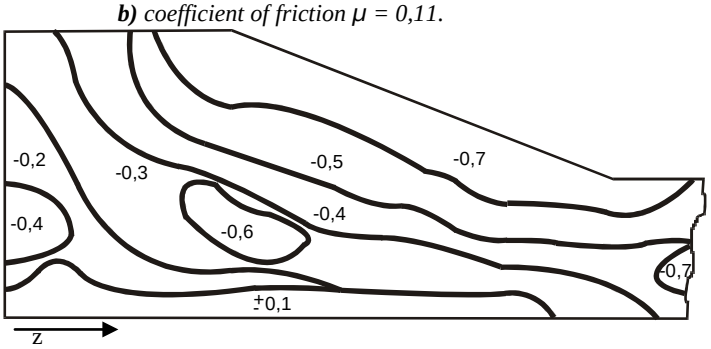


a)

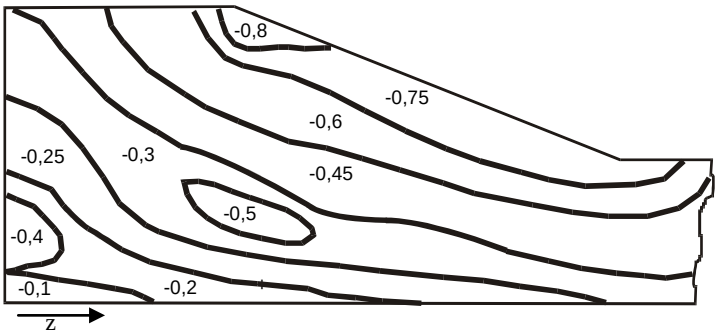


b)

Fig. 2: *The contours of axial stress s_z / s_{f0} for:*
a) *coefficient of friction m = 0,05,*
b) *coefficient of friction μ = 0,11.*



a)



b)

Fig. 3: *The contours of shear stress t_{rz} / s_{f0}) for:*
a) *coefficient of friction m = 0,05*
b) *coefficient of friction μ = 0,11.*

5. Conclusion

Visioplasticity method is very useful in providing a detailed analysis of the distribution of the major field variables such as effective strain, strain rates and stress in any section within the plastically deforming region. The stress distribution must be known at least approximately in three directions inside the deformation zone of the formed material so the deformation limits can be predicted. Knowing the values of stresses in plastic region of the material is very important for prediction of specimen quality and also for obtaining possible die wear during and after forming processes.

Advanced plasticity theory can be used to determine the stresses in the deformation zone from the local strains obtained from material movement. Such method is experimental-analitical visioplasticity method, which is very useful in providing a detailed analysis of the distribution of the major field variables such as effective strain, strain rates and stress in any section within the plastically deforming region. By using visioplasticity method, better approximations can be obtained of forming processes using theory of plasticity than is possible with the pure theory. The material flow is mainly influenced by the strain distribution, strain hardening effects, the geometry of the tooling and the friction conditions between specimen and tool.

The experiments and obtained results, presented in this paper, have showed the influence of the coefficient of friction of the lubricant, used for forward extrusion process, on the radial, axial and shear stress distribution.

Some significant differences were obtained only in plastic regions at the exit of the deformed zone. In those regions higher values of stress components could be expected when using a lubricant with a higher coefficient of friction. The diagrams of stress state distribution in formed material extruded with different lubricator were not very different, although it could be said that greater values of radial, axial and shear stress component could be expected when using lubricator with higher coefficient of friction.

6. References

1. Wang, J. P.; A new approach to visioplasticity in plane-strain extrusion, Journal of Materials Processing Technology, Volume 79, 1998, 144 - 145
2. Nagarajan D., Chakkinga U., Venugopal P., Influence of cold extrusion on the microstructure and mechanical properties of an aluminium alloy previously subjected to equal channel angular pressing, Journal of Materials Processing Technology 182, 2007, 363 – 368.
3. Wongsa-Ngam J., Kawasaki M., Langdon T.G., A comparison of microstructures and mechanical properties in a Cu–Zr alloy processed using different SPD techniques, Journal of Materials Science, July 2013, Volume 48, Issue 13, 2013, 4653–4660.
4. Wang, J. P., Tsai Y. H. Wang, J. J.; The dynamic analysis of visioplasticity for the plane upsetting process by the flow function elemental technique, Journal of Materials Processing Technology 63, 1997, 738-743.
5. Solomon N., Solomon I.; Effect of die shape on the metal flow pattern during direct extrusion process, Revista de Metalurgia, Volume 46 (5), 2010, 396 – 404.
6. Gusel L., Anzel I., Brezocnik M, Effect of lubrication on the stress distribution in an extruded material, International Journal of Advanced ManufacturingTechn., Vol. 25, 2005, 288 – 291.
7. Klocke F.; Manufacturing Processes 4 – Forming, Lehrstuhl fuer Technologie der Fertigungsverfahren Aachen, Springer Verlag, Berlin - Heidelberg 2013, 39–41.
8. Lange K., (2003), Handbook of metal forming, McGraw – Hill Book Company, New York, 2003.
9. Spur G., Stoeferle T.; Handbuch der Fertigungstechnik, Band 2/2-Umformen, Carl Hanser Verlag, München, 2002.
10. Grote K. H., Antonsson E. K.; Handbook of mechanical Engineering, Springer Science LLC New York, 2009.
11. Vijay Sekar K. S., Pradeep Kumar M.; Optimising Flow Stress Input for Machining Simulations Using Taguchi Methodology. International Journal of Simulation Modelling, Vol. 11, No. 1, 2012, p. 17-28.

THE NATURAL FREQUENCIES AND MODE SHAPES OF AN EULER-BERNOULLI BEAM WITH A RECTANGULAR CROSS- SECTION WHICH HAS A SURFACE CRACK

L.Emir Sakman [1], Aşkın Mutlu [1]
Faculty of Engineering – Department of Mechanical Engineering, Istanbul University, Turkey[1]
sakman@istanbul.edu.tr, askin@istanbul.edu.tr

Abstract: *The natural frequencies and mode shapes of an Euler-Bernoulli beam with a rectangular cross- section, which has a surface crack, is investigated. The crack is modeled as a change (sudden or gradual) in the cross-section of the beam, and the perturbation approach is used assuming that the crack is much smaller than the beam cross section. Computations of natural frequencies and mode shapes were carried out for four different crack shapes with rectangular, triangular and parabolic profiles when viewed through the side of the beam. The results are listed in non-dimensional form for various values of the parameters characterizing the crack.*

Keywords: EULER BERNOULLI, BEAM, CRACK

1. Introduction

Identification and characterization of cracks in engineering structures is an important problem both theoretically and technically. One type of problem deals with determination of vibration characteristics of the structure with a crack. Another problem might be the characterization of the crack from measured vibration characteristics of the structure; this is usually called an inverse problem. The practical solution of the inverse problem normally involves solving the forward problem for a wide range of crack types. Therefore, the ability to solve the vibration characteristics of a cracked structure is very important.

Most studies dealing with cracked structures in the literature models the crack as a change in the elastic characteristics of the structure, and utilize some type of numerical method. The present study aims to model the detailed geometry of the crack therefore shedding light on the solution of the inverse problem. Furthermore the perturbation theory approach will be used making the solution analytical.

One of the earlier studies, Adams et al. [1], demonstrated a vibration method for non-destructive testing of structures. Shen and Pier [2] studied the convergence of Galerkin approach for beams with symmetric cracks. Papaeconomou and Dimarogonas [3] describe a transfer matrix model for a cracked prismatic bar. Chondros and Dimarogonas [4] used a variational formulation to analyze lumped and continuous cracks. Khiem and Toan [5] used a modification of the Rayleigh quotient method for detection of an unknown number of multiple cracks on beams. Saez et al. [6] performed damage detection by solving the inverse problem. Chaudhari and Maiti [7] used a rotational spring to represent the crack and worked on solving the inverse problem based on the measurement of natural frequencies. He and Lin [8] uses an acoustic system for contact-type cracks. Nejad et al. [9] worked on analytical estimation of natural frequencies and mode shapes of a beam having two cracks. Mazanoglu et al. [10] modified the energy-based method presented by Yang et al. [11], to solve the vibration of non-uniform Euler–Bernoulli beams with multiple cracks by defining the crack as a spring. Open edge cracks were investigated by Aydin [12] again modeling the crack as a spring. Caddemi and Morassi [13] proposed a justification of the rotational elastic spring model of an open crack in a beam. Finite element method is very popular for investigation of free vibration analysis of cracked beams [14-17]. Cracks in reinforced concrete structures is another popular research topic [18,19] using Euler-Bernoulli Beam theory. Timoshenko Beam model was also used [20, 21].

The studies mentioned above do not consider the shape of the crack, but model it as a spring or a change in the local elastic properties. In this study the crack is expressed as a change in the beam cross-section as explained in Section 2. This allows the determination of vibration characteristics depending on the shape of the crack.

2. Perturbation Method and Governing Equations

Considering an Euler-Bernoulli beam of length L and cross-sectional area A(x), the governing equation for the vibrations is

$$-\frac{\partial^2}{\partial x^2}\left(EI(x)\frac{\partial^2 y}{\partial x^2}\right)=m(x)\frac{\partial^2 y}{\partial t^2} \tag{1}$$

where the cross-sectional area of the beam, A(x), varies with coordinate x along the beam. y(x,t) is the displacement, E is the elastic modulus of the beam material, I(x) is the second area-moment of cross section, m(x) is the mass per unit length. The cross section is assumed to be a rectangle with width b(x), and height h(x) changing along the beam; thus

$$A(x)=b(x)h(x) \tag{2a}$$

$$I(x)=\frac{1}{12}b(x)h(x)^3 \tag{2b}$$

$$m(x)=\rho b(x)h(x) \tag{2c}$$

where ρ is the density of the beam material. Both ends of the beam are assumed to be simply-supported,

$$y=\frac{\partial^2 y}{\partial x^2}=0 \text{ at } x=0,L \tag{3}$$

The non-damaged beam has uniform cross section with constant width and height b_0 and h_0 respectively. The crack is modeled as a change in the beam cross-sectional dimensions in the form

$$b(x)=b_0+\varepsilon f(x) \tag{4a}$$

$$h(x)=h_0+\varepsilon g(x) \tag{4b}$$

where ε is a small non-dimensional perturbation parameter and the functions f(x) and g(x) determine the shape of the crack; these are completely general at this point. Substituting (4) into (2) and (1), the vibration equation becomes, ignoring higher order terms,

$$-\frac{\partial^2}{\partial x^2}\left(\frac{E}{12}(b_0h_0^3+\varepsilon(3b_0h_0^2g(x)+h_0^3f(x)))\frac{\partial^2 y}{\partial x^2}\right) \tag{5}$$
$$=\rho(b_0h_0+\varepsilon(b_0g(x)+h_0f(x))\frac{\partial^2 y}{\partial t^2}$$

The governing equation is non-dimensionalized with the following definitions, starred symbols showing non-dimensional variables,

$$x^* = \frac{x}{L} \tag{6a}$$

$$t^* = \frac{t}{\sqrt{\rho \frac{12L^4}{Eh_0^4}}} \tag{6b}$$

$$y^* = \frac{y}{h_0} \tag{6c}$$

$$G^*(x^*) = \frac{g(x)}{h_0} \tag{6d}$$

$$F^*(x^*) = \frac{f(x)}{b_0} \tag{6e}$$

The non-dimensional vibration equation becomes, omitting stars after this point,

$$\frac{\partial^4 y}{\partial x^4} + \frac{\partial^2 y}{\partial t^2} = -\varepsilon \left[\begin{array}{l} \frac{\partial^2}{\partial x^2}\left(\begin{array}{l} (3G(x) \\ +(x)) \frac{\partial^2 y}{\partial x^2} \end{array} \right) \\ +(G(x)+F(x)) \frac{\partial^2 y}{\partial t^2} \end{array} \right] \tag{7}$$

and the boundary conditions

$$y = \frac{\partial^2 y}{\partial x^2} = 0 \text{ at } x = 0,1 \tag{8}$$

Assuming a separated solution of the form

$$y(x,t) = u(x)p(x) \tag{9}$$

leads to

$$\ddot{p} + \lambda^2 p = 0 \tag{10a}$$

$$u'''' - \lambda^2 u + \varepsilon\varphi(u,\lambda) = 0 \tag{10b}$$

Prime and dot denote differentiation with respect to x and t, respectively, and we defined

$$\varphi(u,\lambda) = ((3G(x)+F(x))u'')'' - \lambda^2 u(G(x)+F(x)) \tag{11}$$

Solution of Eq. (10b) is assumed to be in the form of a perturbation series for both the mode shape and the eigenvalue

$$u(x) = u_0(x) + \varepsilon u_1(x) + \ldots \tag{12a}$$

$$\lambda = \lambda_0 + \varepsilon\lambda_1 + \ldots \tag{12b}$$

Substituting, the zero and first order problems become

$$u_0'''' - \lambda_0^2 u_0 = 0 \tag{13a}$$

$$u_0(0) = u_0''(0) = u_0(1) = u_0''(1) = 0 \tag{13b}$$

and

$$u_1'''' - \lambda_0^2 u_1 - 2\lambda_0\lambda_1 u_0 + \varphi(u_0,\lambda_0) = 0 \tag{14a}$$

$$u_1(0) = u_1''(0) = u_1(1) = u_1''(1) = 0 \tag{14b}$$

The solution of the zero order problem is

$$u_0 = \sin n\pi x,\ \lambda_0 = n^2\pi^2,\ n = 1,2,3,\ldots \tag{15}$$

Thus, the first order problem becomes

$$\begin{array}{l} u_1'''' - n^4\pi^4 u_1 = 2n^2\pi^2\lambda_1 \sin n\pi x \\ -\varphi(\sin n\pi x, n^2\pi^2) \end{array} \tag{16}$$

The solution of (16) can be written by variation of constants as

$$\begin{array}{l} u_1 = C_1(x)e^{n\pi x} + C_2(x)e^{-n\pi x} \\ +C_3(x)\cos n\pi x + C_4(x)\sin n\pi x \end{array} \tag{17}$$

Where

$$C_1'(x) = \frac{e^{-n\pi x}(2n^2\pi^2\lambda_1 \sin n\pi x + \varphi(\sin n\pi x, n^2\pi^2))}{4n^3\pi^3} \tag{18a}$$

$$C_2'(x) = \frac{e^{n\pi x}(2n^2\pi^2\lambda_1 \sin n\pi x + \varphi(\sin n\pi x, n^2\pi^2))}{4n^3\pi^3} \tag{18b}$$

$$C_3'(x) = \frac{\sin n\pi x(2n^2\pi^2\lambda_1 \sin n\pi x + \varphi(\sin n\pi x, n^2\pi^2))}{2n^3\pi^3} \tag{18c}$$

$$C_3'(x) = -\frac{\cos n\pi x(2n^2\pi^2\lambda_1 \sin n\pi x + \varphi(\sin n\pi x, n^2\pi^2))}{2n^3\pi^3} \tag{18d}$$

Integrating (18) and substituting in (17) gives the general solution in the form

$$\begin{array}{l} u_1 = K_1 e^{n\pi x} + K_2 e^{-n\pi x} + K_3 \cos n\pi x + K_4 \sin n\pi x \\ +\int_0^x \left[\begin{array}{l} C_1(\xi)e^{n\pi\xi} + C_2(\xi)e^{-n\pi\xi} \\ +C_3(\xi)\cos n\pi\xi + C_4(\xi)\sin n\pi\xi \end{array} \right] \Psi(\xi)d\xi \end{array} \tag{19}$$

where we defined

$$\Psi(x) = n^2\pi^2\lambda_1 \sin n\pi x - \varphi(\sin n\pi x, n^2\pi^2) \tag{20}$$

for brevity. *K*'s are arbitrary constants found by applying the boundary conditions (14b); the result is the system of equations

$$K_1 + K_2 + K_3 = 0 \tag{21a}$$

$$K_1 + K_2 - K_3 + \frac{1}{2n^4\pi^4}\left[(-1)^n - \frac{1}{n\pi} \right] \psi(0) = 0 \tag{21b}$$

$$\begin{array}{l} K_1 e^{n\pi} + K_2 e^{-n\pi} + K_3(-1)^n + \frac{e^{n\pi}}{4n^3\pi^3}\int_0^1 e^{n\pi\xi}\psi(\xi)d\xi \\ -\frac{e^{-n\pi}}{4n^3\pi^3}\int_0^1 e^{n\pi\xi}\psi(\xi)d\xi + \frac{(-1)^n}{2n^3\pi^3}\int_0^1 \sin n\pi\xi\psi(\xi)d\xi = 0 \end{array} \tag{21c}$$

$$\begin{array}{l} K_1 e^{n\pi} + K_2 e^{-n\pi} - K_3(-1)^n + \frac{e^{n\pi}}{4n^3\pi^3}\int_0^1 e^{-n\pi\xi}\psi(\xi)d\xi \\ -\frac{e^{-n\pi}}{4n^3\pi^3}\int_0^1 e^{n\pi\xi}\psi(\xi)d\xi - \frac{(-1)^n}{2n^3\pi^3}\int_0^1 \sin n\pi\xi\psi(\xi)d\xi = 0 \end{array} \tag{21d}$$

Note that K_4 does not show in these equations; this is due to the fact that the term associated with K_4 in the general solution, Eq. (19), is $\sin n\pi x$, and that is the solution of the zero order problem. This part, $K_4 \sin n\pi x$, is therefore discarded and seen as part of the zero order solution. The unknowns in Eqs.(21) are K_1, K_2, K_3 and λ_1 (inside ψ).

In evaluating the terms in Eqs.(21) we come across expressions like $F(0), F'(1), G(1)$, etc. If we assume that the crack is away from the ends ($x = 0$ *and* 1), all these terms become zero.

3. Conclusion

The results are listed in non-dimensional form for various values of the parameters characterizing the crack.

Table1: Crack Shape and λ

Crack Shape	$\lambda_1^{(1)}$	$\lambda_1^{(2)}$	$\lambda_1^{(3)}$	$\lambda_1^{(4)}$	$\lambda_1^{(5)}$	$\lambda_1^{(6)}$	$\lambda_1^{(7)}$	$\lambda_1^{(8)}$	$\lambda_1^{(9)}$	$\lambda_1^{(10)}$
Rectangular Crack	-1.95	-0.25	-16.50	-3.84	-40.38	-17.60	-66.15	-48.39	-88.68	-98.69
Triangle (Isosceles) Crack	-1.94	-0.49	-15.42	-6.74	-34.67	-26.48	-54.90	-59.71	-80.89	-98,69
Triangle (Right) Crack	-1.91	-0.96	-13.36	-12.09	-24.67	-41.07	-37.90	-75.11	-71.63	-98.69
Parabolic Crack	-1.95	-0.34	-16.11	-4.94	-38.10	-21.39	-60.89	-54.45	-83.19	-101.52

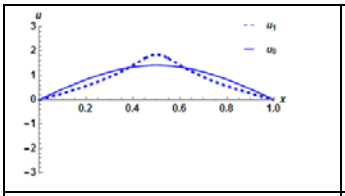


Fig.1 Rectangular crack first mode

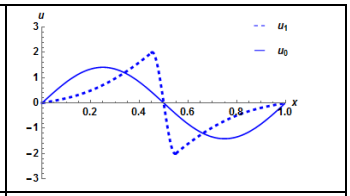


Fig.2 Rectangular crack second mode

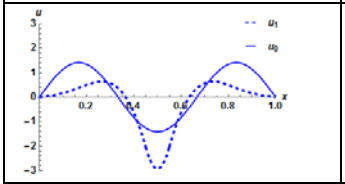


Fig.3 Rectangular crack third mode

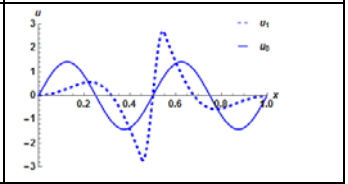


Fig.4 Rectangular crack fourth mode

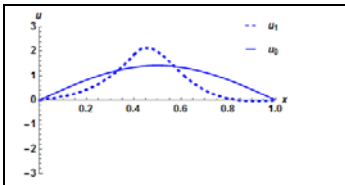


Fig.5 Triangular (right) crack first mode

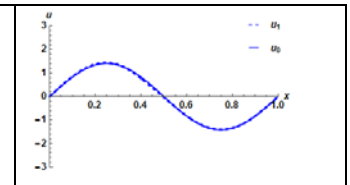


Fig.6 Triangular (right) crack second mode

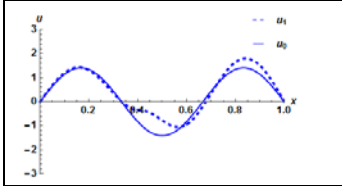


Fig.7 Triangular (right) crack third mode

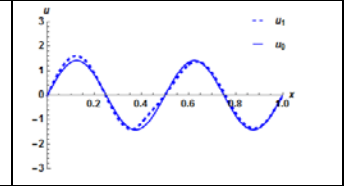


Fig.8 Triangular (right) crack fourth mode

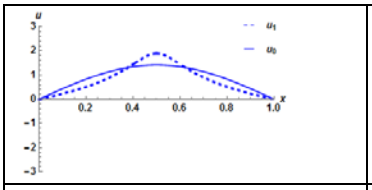


Fig.9 Triangular (isoscales) crack first mode

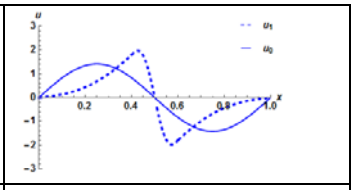


Fig.10 Triangular (isoscales) crack second mode

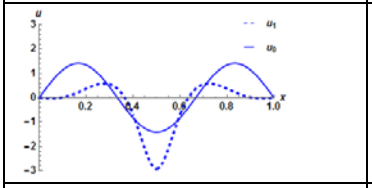


Fig.11 Triangular (isoscales) crack third mode

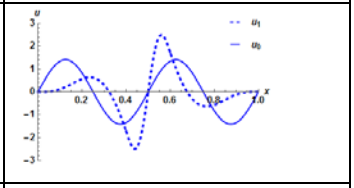


Fig.12 Triangular (isoscales) crack fourth mode

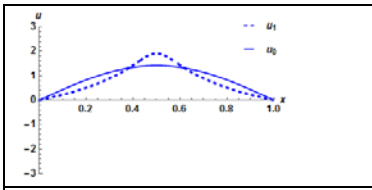


Fig.13 Parabolic crack first mode

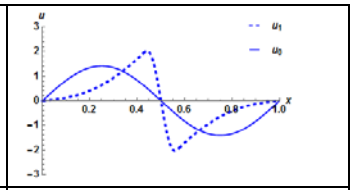


Fig.14 Parabolic crack second mode

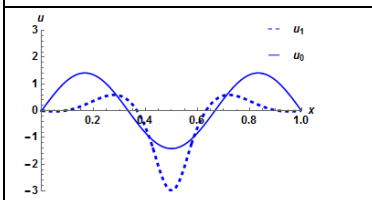


Fig.15 Parabolic crack third mode

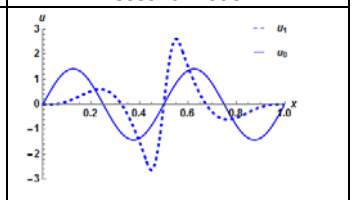


Fig.16 Parabolic crack fourth mode

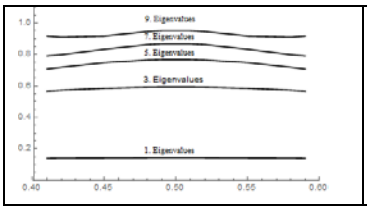


Fig.17 odd eigenvalues

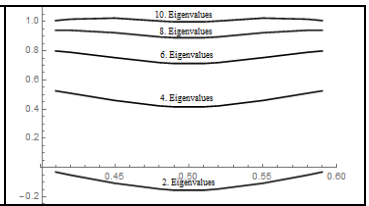


Fig.18 even eigenvalues

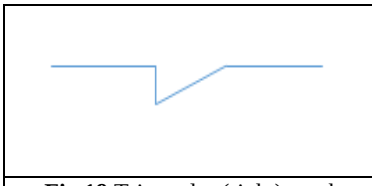


Fig.19 Triangular (right) crack

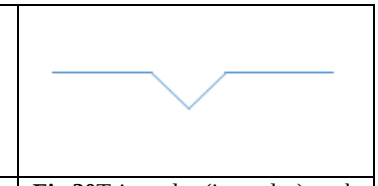


Fig.20 Triangular (isoscales)crack

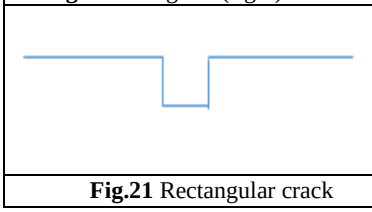


Fig.21 Rectangular crack

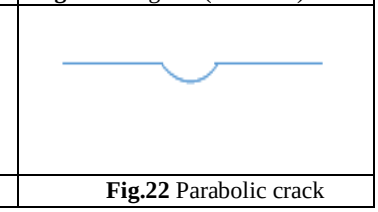


Fig.22 Parabolic crack

Nomenclature

A (x)	area of cross section
b (x), h (x)	width and height of beam cross section
b_0, h_0	width and height of non-cracked beam cross section
I (x)	second area moment
m (x)	mass per unit length
E	modulus of elasticity
ρ	density
L	length of the beam
ε	perturbation parameter
f (x), g (x)	crack shape functions
y (x, t)	vertical displacement
u (x)	mode shape
p (t)	separated time function
λ	eigenvalue
$[\ ]^*$	non-dimensional [ ]

4.References

[1] Adams RD, Cawley P, Pye CJ, Stone BJ. A vibration technique for non-destructively assessing the integrity of structures. J Mech Eng Sci 1978;20**(2)**:93-100.

[2] Shen MHH, Pierre C. Natural modes of Bernoulli-Euler beams withsymmetric cracks.J Sound Vib1990;138**(l)**:115-134.

[3] Papaeconomou N, Dimarogonas A. Vibration of cracked beams. Comput Mech 1989;5:88-94.

[4]Chondros TG,Dimarogonas AD. Vibration of a craclcedcantilever beam. J Vib Acoust1998;120:742-746.

[5] Khiem NT, Toan LK. A novel method for crack detection in beam-like structures by measurements of natural frequencies.J Sound Vib 2014;333:4084-4103

[6] Sáez JF, MorassiA, PressaccoM, RubioL. Unique determination of a single crack in a uniform simply supported beam in bending vibration.J Sound Vib2016;371:94-109.

[7] Chaudhari TD, Maiti SK. Modelling of transverse vibration of beam of linearly variable depth with edge crack.Eng Fract Mech1999;63:425-445.

[8] He Q, Lin Y. Assessing the severity of fatigue crack using acoustics modulated by hysteretic vibration for a cantilever beam.J Sound Vib 2016;370:306-318.

[9] Nejad FB, Khorram A,Rezaeian M. Analytical estimation of natural frequencies and mode shapes of a beam having two cracks Int J Mech Sci2014;78:193-202.

[10] Mazanoglu K, Yesilyurt I, Sabuncu M. Vibration analysis of multiple-cracked non-uniform beams.J Sound Vib 2009;320:977-989.

[11] Yang XF, Swamidas ASJ,Seshadri R. Crack identification in vibrating beams using the energy method.J Sound Vib2001;244**(2)**:339-357.

[12] Kamil Aydin Free vibration of functionally graded beams with arbitrary number ofsurface cracks.Eur J Mech A-Solid2013;42:112-124.

[13] Caddemi S, Morassi A.Multi-cracked Euler–Bernoulli beams: Mathematical modeling and exact solutions. Int J Solids Struct2013;50:944–956.

[14] Kisa M, Brandon J, Topcu M. Free vibration analysis of cracked beams by a combination of finite elements and component mode synthesis methods.Comput Struct1998;67:215-223.

[15] Zheng DY, Kessissoglou NJ. Free vibration analysis of a cracked beam by finite element method.J Sound Vib 2004;273:457-475.

[16] Kisa M, Gurel MA. Free vibration analysis of uniform and stepped cracked beams with circular cross sections.Int J Eng Sci 2007;45:364-380.

[17] Blasques JP, Bitsche RD. An efficient and accurate method for computation of energy release rates in beam structures with longitudinal cracks.Eng Fract Mech2015;133:56-69.

[18] Dundar C, Kara IF.Three dimensional analysis of reinforced concrete frames with cracked beam and column elements. Eng Struct 2007;29:2262-2273.

[19] Xu T, Castel A. Modeling the dynamic stiffness of cracked reinforced concrete beams under low-amplitude vibration loads.J Sound Vib2016;368:135-147.

[20] Heydari M, Ebrahimi A, Behzad M.Forced vibration analysis of a Timoshenko cracked beam using a continuous model for the crack.Eng Sci TechnolInt J2014;17:194-204.

[21] Panigrahi B, Pohit G. Nonlinear modelling and dynamic analysis of cracked Timoshenko functionally graded beams based on neutral surface approach. J Mech Eng Sci2015;0(0):1-12.

DRY JIGGING OF COALS

Ulziisaikhan Purevsuren
Department of Mechanical Science
School of Mechanical Engineering and Transportation
Mongolian University of Science and Technology
Ulaanbaatar, Mongolia
ulziisaikhan_p@must.edu.mn

Namnan Tumurpurev
Director of International High Education Research Center
Mongolian University of Science and Technology
Ulaanbaatar, Mongolia
namnan@must.edu.mn

Enkhbat Dombon
Department of Mining
School of Geology and Mining Engineering
Mongolian University of Science and Technology
Ulaanbaatar, Mongolia
enkhbat@must.edu.mn

Abstract — The coal industry, including coal mining and preparation, coal-fired power generation is one of the most water-intensive industries. Water problem in coal wet processing of South Gobi dessert region of Mongolia is one of serious problem. One of possible methods in arid regions to save water is using dry separation in coal industry. This study investigates the coal particle separation in an air jigging lab device. Tests were conducted with a coal from Mongolian Southgobi dessert region Nariinsukhait mining camp in the size range from 0.5-5 mm.

KEYWORDS — *PARTICLE SEPARATION; AIR JIGGING.*

I. INTRODUCTION

Mongolia is rich with coal. According to preliminary geological estimates, the resource base of the country includes 16 billion mt of coal, which places Mongolia among the top 15 countries in the world with the largest reserves of coal. The coal reserves are distributed uniformly throughout the country. However, the quality of the coal differs in the eastern and western parts of the countries. Lignite is found in East Mongolia, in the Suha Bator district. The Talbulag deposit has a calorific value of 2,400 Kcal/kg. In the western part of the country, there are large deposits of bituminous coking coals. To date, the biggest and most promising proven reserves of coking coal in Mongolia are located in the Tavan Tolgoi deposit of the South Gobi dessert, about 600 km south of Ulan-Bator. The proven reserves of the deposit are 6.4 billion mt, of which more than 40% accounts for high-quality coking coal [1].

There are seven large coal producers in Mongolia, including MMC, South Gobi, MEC, Aspire, Xanadu, Prophecy Coal and SharynGol. The largest customer for coal was China, accounting for over 82% of all exported coal, Fig 1 [2].

Technology of enrichment coal is a prerequisite for improving the quality of values, but also coking coal, coal gasification and liquefaction as the implementation of the country's economy, with a large value to increase the export potential, as well as the development of coal chemical industry.

Wet processing of coal in arid regions of Mongolia is limited by water. Currently, very actual the development of dry separation technology of coal industry in our country.

This study investigates the air jigging coal particle separation of Mongolian Nariin Sukhait deposit of the South Gobi desert, in the coal size range from 0.5-5 mm.

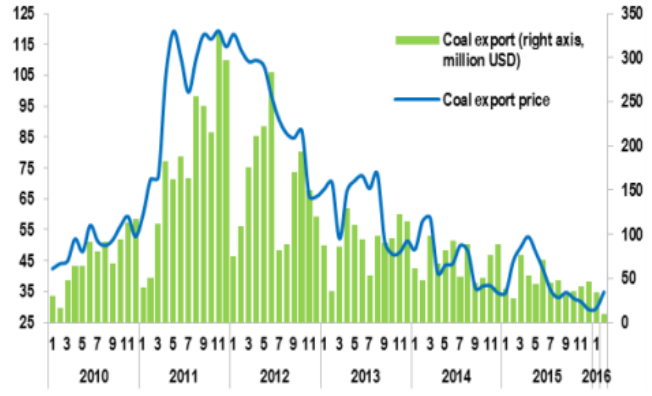


Fig. 1. *Coal export, market price (USD) [12].*

In Mongolian mining industry use different types of dry separation of coal: 1) air dense medium fluidized bed separation with/without external force field; 2) fluidized bed separation based on the difference of settling velocity; 3) compound dry separation; 4) triboelectrostatic separation; 5) magnetic separation. These five categories of technologies have their own advantages respectively in processing certain coal or yielding clean coal product with certain quality. Generally speaking, technologies belong to the categories (1), (4) and (5) usually have high separation efficiency but high operational cost, which are suitable for producing highquality clean coal. In contrast, technologies in categories (2) and (3) don't need additional dense medium or power and usually have larger capacities and low processing cost, but low separation efficiency due to the original limitation of separation mechanism. These technologies are suitable for producing steam coal. Besides, the electrostatic separation technologies and the magnetic separation technologies have high requirements for coal properties and certain degree of dissociation, thus, the handling capacities are limited. Considering these limitation, these two types of beneficiation technologies are only used in very special purpose [3].

II. PREPARATION OF COAL SAMPLE AND AIR JIGGING EXPERIMENTS

In laboratory performed two types of experiments: Coal crushing test and Dry jigging test.

A. Coal crushing test

The Nariin Sukhait deposit coals is high-ash coals with an ash content of 40 %. For air jigging separation use coal with size between 0.5-50 mm. In lab experiments divide this mass in following three categories: separation of 0.5-5 mm coal, separation of 1-5 mm coal and separation of 5-40 mm coal [4].

Coal crushing test for determine mechanical strength and in order to study the quality and wholesale disintegration of execution sample selected in accordance with ASTM D440, Fig 2.

The separation results of 5-40 mm coals with an ash content of 25 % show that a clean coal product with an ash content of 10 % was produced. The detailed separation results are S total 22 %, is shows the this type of coal is soft and easy to aeolian [4].



a) *b)*

Fig. 2. *a) Preparation of 23 kg coal with size 50-75 mm; b) Crushed coals for lab experiments with size 0-50 mm.*

B. Dry jigging test

The dry beneficiation of coal are based on the physical properties of coal and its associated mineral matters. Different types of equipment for dry beneficiation have been developed, based on the exploitation of physical properties such as density, size, shape, magnetic susceptibility, and electrical conductivity [5].

Before the laboratory experiments, we are prepared 60 kg of coals and 20 kg associated mineral matters (Pebbles & Gravel) from Nariin Sukhait deposit. For prepare this mass divided in following four categories: with size 15-10 mm, 10-5 mm, 5-1 mm and 1-0.5 mm, Fig 3.

For air jigging experiments use all four size coals, but in our lab equipments more good results of separation is observed in size between 5-1 mm and 1-0.5 mm from Nariin Sukhait deposits.

The tests were performed in a laboratory scale designed air jig model, Fig.4. The cylindrical column of separation with internal diameter is 60 mm and the length 200 mm joined together with air distributor and porous plate. The airflow is produced by the air compressor (P=0.3-0.7 MPa).



Fig. 3. *Prepared coals and mineral matters for air jigging experiments.*

During the tests, the mixed particles are placed into the container and subjected to vibration by one streams of air flow which enter by the bottom plate of the jigging chamber. The active pulsating airflow is produced by solenoid valve. The frequency of the pulsating air can be adjusted with a frequency converter by solenoid valve. One cycle of the pulsating air valve changed from 0.8-1 second by this valve.

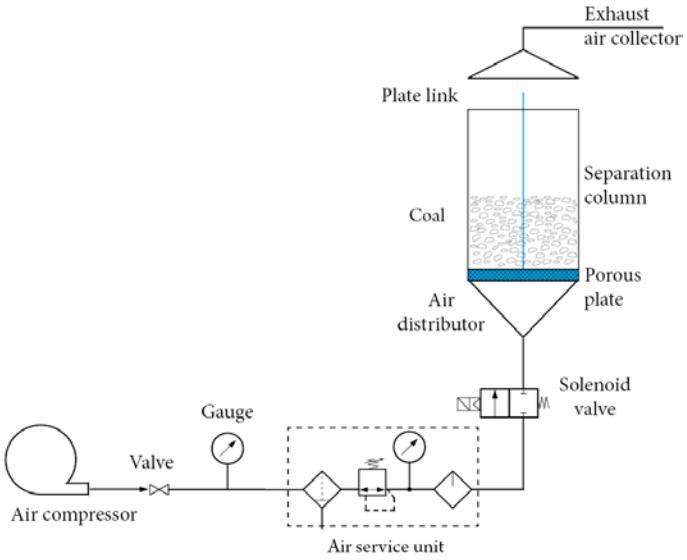


Fig. 4. *Schematics of laboratory air jigging separator.*

Also in experiments for the determine flow effects in separation we are use different types of porous plate with various hole (3 types), Fig 5.



Fig. 5. *Different hole types in porous plate (hole diameter 2-5mm).*

From the experimental results (Fig. 6) observed, these types of plate holes is not very effective for the equal separation by layer. Experiment data shows in Table 1 depending by percentage of coal and gravel, weight, air pressure, duration of the experiments and particle size.

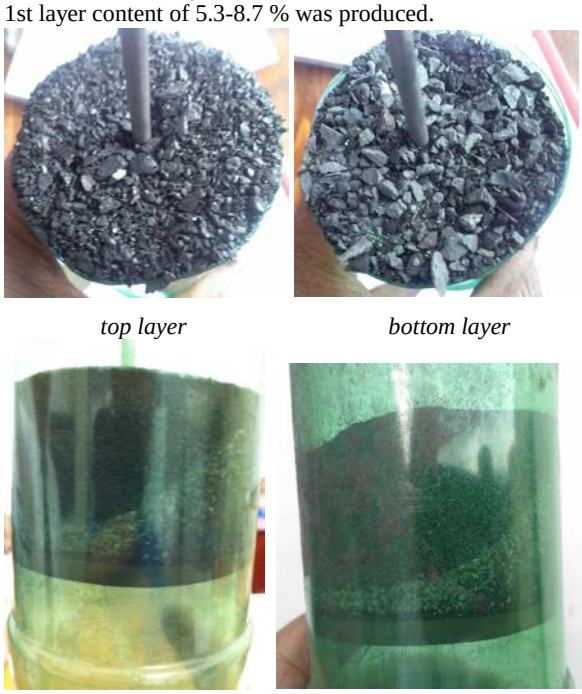
TABLE I. EXPERIMETS DATA

	1st experiment			
	Size, mm	***Weight, g***	***Air pressure, MPa***	***Duration time, min***
Coal	1-0.5	60	0.45	3
Gravel	1-0.5	20		
	2nd experiment			
Coal	1-5	60	0.35	3
Gravel	1-5	20		
	3th experiment			
Coal	1-5	10	0.55	3
Gravel	1-5	8.8		
	4th experiment			
Coal	1-5	50	0.55	3
Gravel	1-5	30		
	5th experiment			
Coal	1-5	60	0.45	3
Gravel	1-5	20		

The experimental results is different. Three layers of particles were produced after the separation process. The top layer consisted of small coal particles, the middle layer contained predominantly mixed products and the bottom layer comprised of higher density coal, stones and gravels.

III. RESULTS AND DISCUSSION

Air jigging separation effects by height in picture (top and bottom layer) shown in Fig 6. The best separation results for 1-5 mm coals with an gravel content of 25 % show that a clean coal in 1st layer content of 5.3-8.7 % was produced.



top layer *bottom layer*

side view of separation layer

Fig. 6. *Results of experiments.*

The three layers were identified visually, removed from the top using dragging slice by move plate, their masses recorded and, each subjected to analysis. This was conducted for all test runs under different operating conditions and is presented in Table 1.

In laboratory experiments after air jigging process the separation layer is not equal in height, that is shows of air flow is not uniform (Fig. 6). Its need to design more air inlet stabilizer for establish this layer effects.

IV. AIR FLOW SIMULATIONS

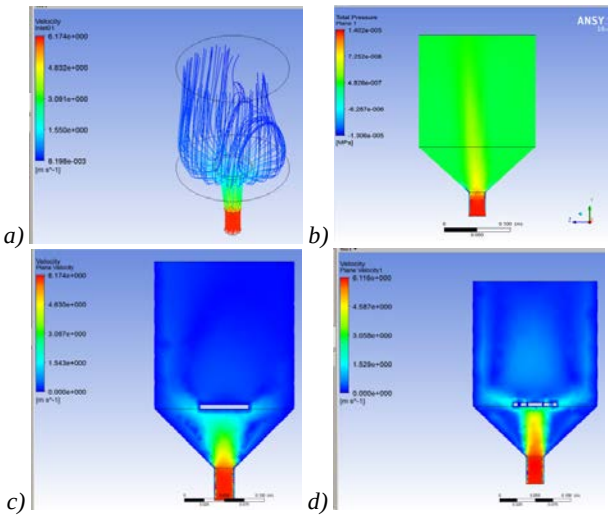
For studying the coal separation in lab fields, simulations were prepared for laboratory experimental tests. It is assumed that the air velocity is symmetrical at the inlet and that the cross air velocity, perpendicular to the direction of inlet airflow, is zero. The boundary condition is no slippage at all sides. In lab experiments airflow is within a low speed range (<100m/ s), the flow of air can be regarded as uncompressed flow. The simulation parameters are shown in Table 2.

TABLE II. PARAMETERS FOR THE AIR FLOW SIMULATION

Parameters	***Values***
Airflow velocity at the inlet	10.0 m/s
Pressure at the exit	0 MPa
Air temperature	20 °C
Air density	1.205 kg/m3
Air viscosity	1.8135×10-5 Pa.s

To study the air flow with and without plate hole in simulation the fluid computation software ANSYS Fluid Flow for air flow pattern analysis was used. Presimulation results in Fig. 7.

But It should be noted that this simulations is without coal particles in separation area, only the flow distribution across the area. Results is to study the air flow with and without plate hole in cylindrical separation area.



a) *b)* *c)* *d)*

Fig. 7. *The air flow simulation results. a) results without plate; b) results with plane plate without hole; c) results with hole plate.*

CONCLUSION

Nariin Sukhait deposit coals of the South Gobi desert has an ash content up to 18.9 % and coal with size between 0.5-50 mm takes all deposit content up to 40 %. Exploration results show that from 310.4 billion tons of coal reserves 53.6% of all deposits are not directly selled, its need to beneficiation [6].

Dry cleaning of coal offers a new alternative approach in coal cleaning in Mongolia. Some of the dry coal-cleaning processes such as air dense-medium fluidized Bed (ADMFB), Air jig AllAir®, and FGX Separators are being using on an industrial scales around the Mongolian coal mining deposits [6]. For Nariin Sukhait deposit coals of the South Gobi desert, the best beneficiation technology is dry separation by pulsating of air flow would seem more appropriate. The separation results of coal with size between 0.5-50 mm in batch pilot-scale air jigging equipments, the clean coal amount 63.9-77.8%, an ash content of 18.9-25 % [6]. This laboratory results show possibility to use dry jigging benefication. For the best results we need to design or use in testing foreign air jigging equipments batch pilot-scale air jig model.

In order to perform pre-experiments in lab designed experimental dry jigging system. Results shown that a layer of fines accumulates in the top of the bed, while a greater proportion of coarse material is observed in the bottom of the bed.

We need to apply the comparison of the computer simulation result and the laboratory separation performance, with the current pulsating. Specifically need to simulate air jigging process with coal particles in separation area, jigging of particulate mixtures of variable size and density. Computing the motion and effect of a large number of small particles of coals in pulsating air flow.

REFERENCES

[1] http://www.coalage.com/. 18 March, 2015.

[2] http://mongolia-mining.org/

[3] Yuemin Zhao, Xuliang Yang, Zhenfu Luo, Chenlong Duan and Shulei Song, "Progress in developments of dry coal beneficiation". 2014.

[4] Ts.Duuren-Ulzii, ”Research work of Mongolian Naryn Sukhait coal mine dry jigging beneficiation technology”, UB., 2016.

[5] R.K.Dwari and K.Hanumantha Rao, "Dry beneficiation of coal-a review" page 177-234, 2007.

[6] Report of Mongolyn Alt Corporation. "Report of Mongolian Naryn Sukhait region coal mine beneficiation of coal with pollution and ash, high sulfur in semi-industrial FGX equipment " UB., May 2016.

[7] Li Zheng, Pan Lingying, Liu Pei and Ma Linwei, "Assessing Water Issues in China’s Coal Industry"

www.cornerstonemag.net/assessing-water-issues-in-chinas-coal-industry/

[8] Philip Hall, "Drv Jigging (University of Nottingham) trial report". May 2009

[9] В.А.Адов, В.В.Морозов, "Разработка и применение критерия формы для оценки обогатимости угля пневматическим способом". 2010

[10] http://www.coalage.com/

[11] http://mongolia-mining.org/

[12] www.mongolbank.mn

[13] M.Kademli and O.Y.Gulsoy, "Investigation of using table type air separators for coal cleaning" Jan., 2014

INNOVATION APPROACHES TO OPTIMIZE THE DRILLING PROCESS

ИНОВАТИВНИ ПОДХОДИ ЗА ОПТИМИЗИРАНЕ НА СЕИТБАТА

Митев Г. В.

Mitev, G.V.

Abstract: *Sowing is the most important of all technological processes and has a serious impact on yields. Failure to observe the basic agro-technical requirements, such as optimum sowing time, proper soil preparation, sowing, sowing depth, etc., leads to irreversible losses. The seed drill, which is a modified version of a factory-made drill for punched wide-row sowing in paired rows. It is part of a machine system used to implement innovative technology in which traditional surface treatment machines are not needed. This requires that a cultivator section be included in its device to prepare the soil at the same time as sowing. Turning the seed drill into a combined machine requires it to check its performance. The inspection was carried out by examining the degree of crushing of the layer, the alignment of the profile of the treated strip and the deviation from the set depth of sowing. Each of these metrics is considered as an optimization parameter involved in three single factor experiments with a single controllable factor in them - machine speed (x).*

Keywords: Sowing, drilling machine, process, cultivation section

Увод

Sowing is the most important technological process and a basic prerequisite for efficient agricultural production [5, 8, 9, 10, 14, 21].

Permanent yields can only be obtained by growing high-productive, benign and resistant to unfavorable external conditions and various diseases and pests [1, 2, 3, 4].

Sowing and sowing seed drilling activities are inextricably linked. Pre-cultivated soil cultivation must comply with the requirements of individual crop types such as:

- for winter crops to reach optimal sizes of soil aggregates, incl. No aggregates larger than 30 mm in the soil, well littered, sufficiently moistened or dry, but not with "colorful" moisture;
- for the spring, the last loosening should be done immediately before sowing and at a depth equal to the seed depth.

Otherwise, in both cases no qualitative sowing can be done, [33, 34, 35, 43, 44, 45].

Timely sowing of agricultural crops is of great importance for the use of soil water both for seed germination and for the rapid development of the root system and the whole plant. It contributes to the proper use of the entire complex of vegetation conditions on which yields depend, [6, 15, 36, 37].

Normally, in early autumn sowing, the plants have enough heat but suffer from water shortages in the soil, and in early spring sowing, on the contrary, the seeds fall on damp, but cold soil and can not rise, [41,42]. Late-sown autumn crops have enough moisture to swell, but often lack the necessary heat to seed germination, and late-spring shoots do not germinate or grow irregularly due to the sharp decrease in soil moisture [37, 38, 39, 40].

Therefore, the best results are the timely sowing, ie the sowing done in such terms, which provide both water and heat and are consistent with the whole complex of vegetation conditions.

Sowing aggregates are complex dynamic systems with a significant number of degrees of freedom [7, 10, 12]. These degrees of freedom meet a number of limitations imposed by the external effects on the seed drill, Z (t), V (t), H (t), Q (t), Y (t). When working in such an environment, seed drills are required to cover certain qualitative and quantitative indicators to be considered as its output streams, Fig. 1. The technology operator is essential and depends on the extent to which the random nature of inputs in the model will be passed on to outgoing flows (ie quantitative and qualitative indicators). This depends, on the one hand, on the capacity of the technology operator (W) on the machine and on the other on on the state of the incoming flows [17, 18, 19].

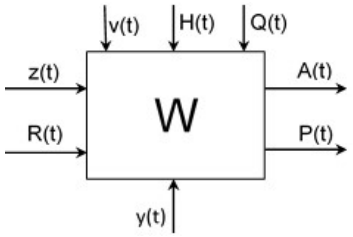


Fig.1. Information model of seeding machine: W - technological operator; z (t), R (t), v (t), H (t) Q (t) and y (t) A (t) - quality indicators; P (t) - quantitative indicators.

Operator W's capabilities are determined by the level of technical solutions and operating principles set in the design engineer. The state of the input streams is predestined by the way they are managed even before they enter the seed drill. In functional terms, the sowing machine can be divided into elementary units, which repeat uniquely to obtain the desired working width (Figure 2), [7, 11, 20, 25, 26]. According to the functional scheme, the operation of the operator W is the result of the transfer of consecutive information flows between the individual units supplemented by internal feedback links. The information interactions between the elementary elements in the functional scheme of the seed drill can be represented in the following dependencies:

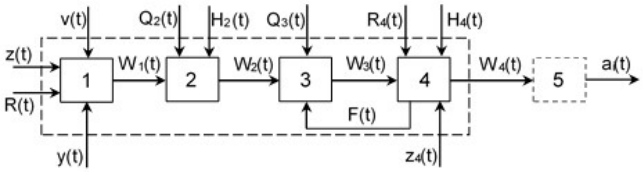


Fig.2. Functional scheme of the seeder:

1-frame; 2 - sowing apparatus; 3 - a conduit; 4 - boot; 5 – soil

$$W_1(t) = \emptyset_1[Z(t), R(t), V(t), y(t)] \quad (1)$$

where $W_1(t)$ is the technological result of the first unit;

Z(t) – the vector characterizing the field profile;

R(t) – the vector characterizing the soil resistance;

V(t) – the vector that characterizes the motion of the seed drill;

y(t) – the vector characterizing the machine / tractor unit (MTA) .

$$W_2(t) = \emptyset_2[Q_1(t), H_2(t), Q_2(t) \quad (2)$$

Where $W_2(t)$ is the technological result of thesecond unit;

$H_2(t)$ – the vector of the adjustment effects on the unit 2;

$Q_2(t)$ – The vector characterizing the external effects of biological objects (plant residues, etc.);

$$W_3(t) = \emptyset_3[Q_2(t), Q_3(t), F(t)]$$

(3)

където $W_3(t)$ is the technological result of the third unit;

$Q_3(t)$ – The vector characterizing external effects of biological nature;

F(t) – The vector characterizing the interfering action of the unit 4 on the unit 3.

$$W_4(t) = \emptyset_4[Q_3(t), R_4(t), Z_4(t), H_4(t)] \quad (4)$$

where $W_4(t)$ is the technological result of the fourth unit;

$H_4(t)$- The vector characterizing the adjustment effects on the unit 4;

$Z_4(t)$- The vector characterizing the field profile on the verge 4.

$P_4(t)$- The vector characterizing the impact of soil resistance on unit 4.

$$a_i(t) = \emptyset_i[Q_4(t)] \quad (5)$$

where $a_i(t)$ is a one-dimensional vector, characterizing a particular technological feature of the sowing machine;

$Q_4(t)$ – The vector that characterizes the external effects of a biological nature.

A characteristic feature of chains with sequential connections is that the denial of one element leads to a denial of the whole system. Also, the significant deviations in the technological result W(t) of one unit cause progressive changes in the technological result of the next units. In some cases, deviations occurring can be compensated by the presence of appropriate feedback links between the units. In other cases, these deviations can bring out the entire system of equilibrium and thus interrupt the normal technological process.

If an association is made and the elementary fluxes flowing out of each unit are treated as electric current, and external impacts are seen as resistances on the unit itself, it can be concluded that the equivalent impact of random external flows will have an additive character. Excessive impact of external flows on a link in a chain may cause a severe drop in the machine and operating circuit diagram and may interrupt indefinitely.

Therefore, the more complex and longer the chain of units, the stronger the influence of random processes on the sowing process.

According to the information model of sowing machines, the improvement of the sowing process should be sought in two other mutually opposite directions [22,23,24]. The first one is aimed at complicating the functional scheme of the machine, which aims at reducing the influence of external influences and building many internal relations between the elementary units. Typical representatives in this area are the combined sowing aggregates.

The second, less popular trend is related to the construction of a short circuit circuit of elementary units. By removing a link or links to the chain, external influences are also eliminated. This reduces the impact of their external impacts, thus weakening the cumulative impact of random processes on the seed drill's technological parameters.

The pursuit of seed drills with similar "simplified" schemes requires the application of principally new functional and technical solutions [22].

Generally, in classical sowing, weed seeds present in the soil have a number of advantages such as: - falling into the soil in large quantities and at a favorable moment for them; - successfully pass the acclimatization stage; - take up enough water; - wait for optimum soil temperature to be reached and germinate in optimal conditions. On average, on 1 m2 of arable land there are about 50000 weed seeds, against 8-10 seeds of cultivated plants, fig. 3.

From the point of view of improving process processes in drought conditions and changing climates, it is important to note that weeds are the main competitors of crop plants for the use of water, nutrients and light [3].

The method for accurate sowing of seed crops by fixing them to biodegradable bands and subsequent laying in the soil is characterized in that the seeds are pre-placed on the biodegradable bands according to the technology of production at a predetermined distance, 21, 22].

Where necessary, nutrients and / or protective equipment may be required for the initial and most critical period of their development. Strips are made in stationary conditions using seed and / or nutrient fixtures. On the periphery of the strips, data on the length, type and variety of the cultivated crop can be displayed, as well as the distance between the seeds inside the line [22, 23, 32].

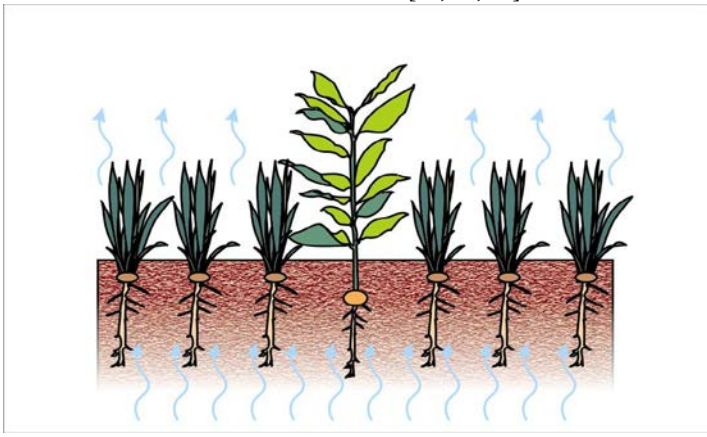


Fig. 3. Principal scheme of distribution of crop and weed seeds in the soil

After the seed has been fixed, the strips are placed in a soil-friendly manner with a length equal to the length of the sowing areas. The laying of strips with pre-fixed seeds is carried out with a simple type of working bodies.

Advantages

The advantages of the method of accurately sowing seed and vegetable crops by applying soil biodegradable tapes to the soil are that the biodegradable seed strips of the seeds are prepared in stationary conditions using seedling and / During the non-annual periods of the year.

As a result of the pre-preparation of the strips and the precise application of the seeds, the maximum quality of the sowing is achieved, as well as the saving of the seeds. The technical solution for tape layout allows sowing of a relatively large length of rows, the bands being able to be joined according to the length of the row.

The device is lightweight, easy to fabricate, and is cheaper than conventional seed drills for precise sowing.

Biodegradable bands can be pre-treated and supplemented with nutrients as well as become hygroscopic when reaching a certain soil temperature in the seed area.
In case of small areas and experimental fields it is possible to completely abandon the need to use the classical seed drills for trenches and vegetable crops.

In classical sowing for the protection of weed plants in the row a number of sprinkler structures are used.

Fig. 4. The evaporation of non-productive water from the soil is high.

When using a biodegradable strip, the water that can evaporate from the soil is at a depth equal to the depth of laying of the strip. The biodegradable tape applied to the soil plays the role of an aperture that stops water from the lower layers of the soil, fig. 5. The weed seeds that are found in this soil layer begin to suffer from a water shortage that reaches the point of withering. Their root system stops their growth and they die, fig. 6.

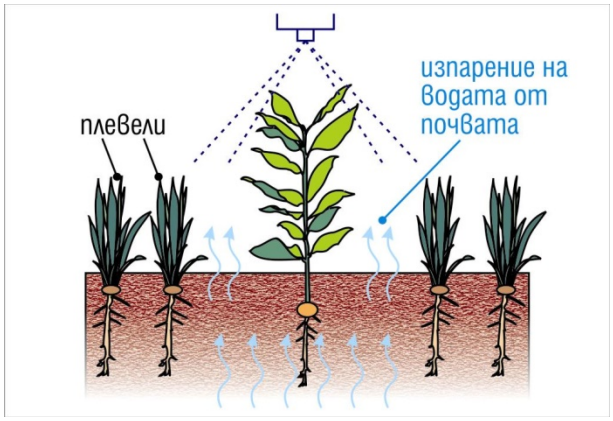


Fig. 4. Destruction of weeds in the order by using herbicides and increasing the rate of evaporation

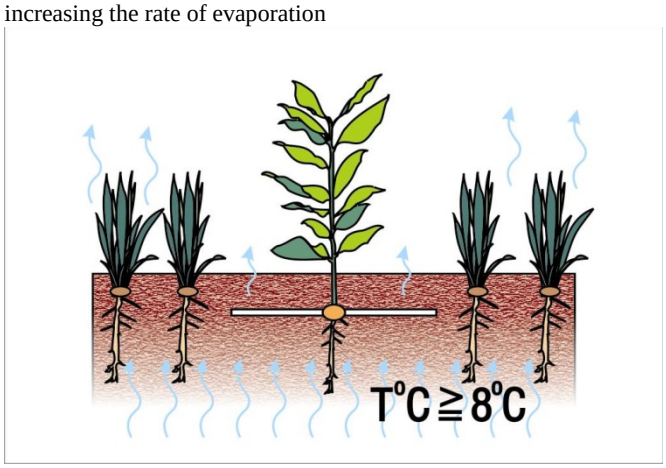


Fig.5. Reducing the evaporation in the row due to limiting the evaporable soil layer

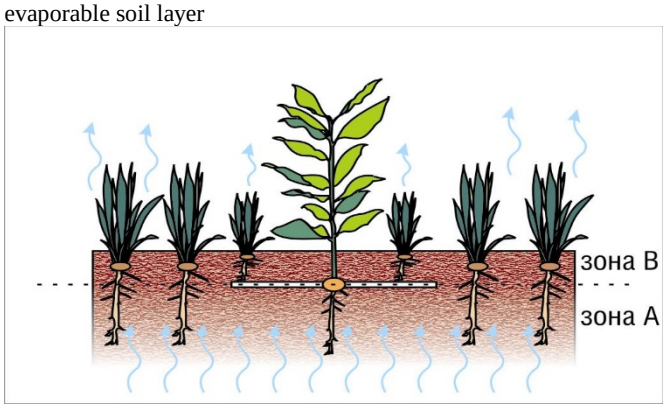


Fig. 6. Biogasable strain placed in the soil stops the growth of weeds within 2 weeks from the time of application

The best seed distribution in the sown area is what gives the emerging plants equal opportunities to use the provided food and climate resources. A prerequisite for this in the first place is to provide the possibility of the root system of plants to develop in a less competitive environment. This is possible if the seeds are placed in rows with spacing equal to $b = r\sqrt{3}$, fig.7. The distance between the rows is equal to $2r$, where r is the radius of the required food zone [9].

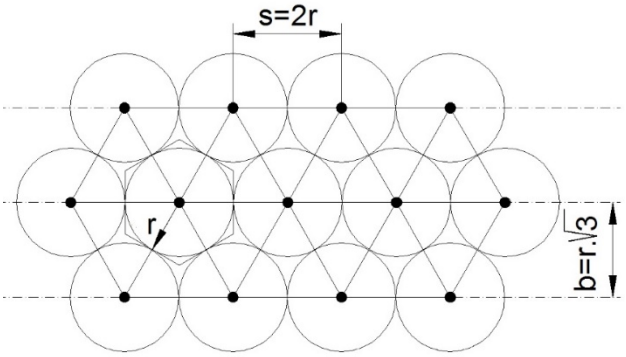


Fig.7. Theoretical distribution of seeds to obtain a level playing field for growth and development

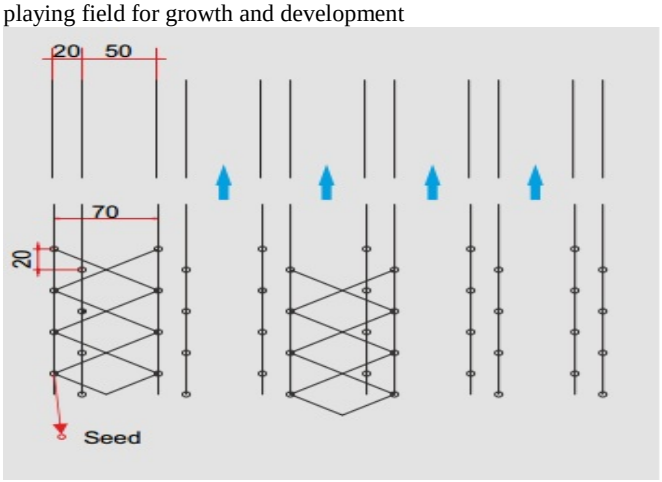


Fig. 8. Scheme of seed application in the soil in paired rows for trenches

The above-described method of sowing is applicable to crops grown on a fused surface. Such are winter cereals and forage crops.

For trenches, this principle is applicable in the following way, fig. 8.

At an intersection distance of 0.70 m, another row is placed, located at 0.20-0.22 m from the main one. Thus, the line spacing remains 0.48-0.50 m. The sowing sections are of a double construction and have the option of stacking the seeds staggered or in parallel. This reduces the distance between plants, hence the competition for light and volume for the development of the root system.

Conclusion

According to the information model of the sowing machines, the improvement of the sowing process must be sought in two other mutually opposite directions. The first one is aimed at complicating the functional scheme of the machine, which aims at reducing the influence of external influences and building many internal relations between the elementary units. Typical representatives in this area are the combined sowing aggregates.

The second, less popular trend is related to the construction of a short circuit circuit of elementary units. By removing a link or links to the chain, external influences are also eliminated. This reduces the impact of their external impacts, thus weakening the cumulative impact of random processes on the seed drill's technological parameters.

The pursuit of seed drills with similar "simplified" schemes requires the application of fundamentally new functional and technical solutions.

Literature

1. Agrostatistic Guide 2000-2014, Ministry of Agriculture and Food.
2. Aleksandrov V., N. Slavov. 1998. Volatility of corn yield depending on meteorological conditions. Plant Growth Sciences, Vol. 35, pp. 11-17. Aleksandrov, C, Vulnerability and Adaptability of Agronomic Systems in Bulgaria, Climate Research, 12 (1) (1999) 161-173.

3. Aleksandrov, V., N. Slavov, Changes in maize yield according to meteorological conditions, Scientific research, 1 (1) (1998) 11-17.
4. Vasilev, K. At. Technology in Agriculture, Rousse, 2012
5. Varlev, I., P. Petkov, Z. Dyankov, 2004. Irrigation - a major factor in reducing drought damage in agriculture. Waterwork 1-2, pp. 22-28.
6. Georgiev I., Fundamentals of simulation and modeling of agricultural machinery. Zemizdat, Sofia, 1973
7. Georgiev I., St. Stanev, St. Shishkov. Agricultural Machines, Sofia, 1975.
8. Daskalov D., J. Demirev and H. Beloev. Agricultural Machinery Guide. Part I, Rousse, 1995
9. Demirev G., K. Bratoev, Agricultural Machines I. Rousse, 2012
10. Demirev G., V. Dobrinov. Investigation of the influence of seed line parameters on the sowing uniformity of accurate sowing of rape. Scientific Works of "A. Kunchev, 2009, vol. 48, pp. 63 - 67.
11. Land-based mechanics. Сборник трудов, XII, Moscow, Машиностроение, 1969
12. Kant. G. 1980. Land without plow, M. Colosse.
13. Kambulov, S.I. Definition of parametric seed drills. Mechanization and Electrification, Rural Housing, No. 7,2007, p. 6-7.
14. Kovada VA, Aridizations of Sushi and Struggle with Nausuchi, M. Science, 1977
15. Kovda, B.A. Незаменимость почвенного покровива в природата. In the book: Земельньйе ресурсьй мира, и употреба и охрана, M. Science, 1978.
16. Kolev, B., Russeva, S., Dimitrov, D. 1992. Assessment of standard soil information for the purposes of modeling and technological design in plant growing. Soil Science, Agrochemistry and Ecology, 27. (2): 15-18.
17. Летошнев, MH Сельскохозяйственные машини, Москва, Колос, 1971.
18. Lissopad, OE, GK Demidov, BD Zonov et al. Селскойзяйственные машини, Москва, Agropromizat, 1986.
19. Loury, A.V., A.A. Grombachevski. Raschet and construction of agricultural machinery, Leningrad, Машиностроение, 1971.
20. Mitev G., H. Hristov and others, Project 2011-FAI-01: Development of a method and means for accurate sowing of trenches and vegetable crops using biodegradable materials. Angel Kanchev University of Rousse, Rousse, 2011
21. Mitev, G.V. And team, 2012. Patent application with ent. No: 111132 / 02.02.2012. Method and device for accurate sowing of seed and vegetable crops by application of biodegradable tapes to the soil. Published in "Queries and Inventions: No: 8/2013.
22. Mitev, GM, Report NSF-2010-AI, unpublished
23. Mitev, GM, Kr. Bratoev, V. Dobrinov, M. Mihaylov, 2015. Complex technological line for soil cultivation without reversing of the layer in the cultivation of trenches. Scientific Work of Rousse University, Volume 54, Series 1.1, 142-148.
24. Mitkov, A. Influence of maize seed fractions on the quality of work of pneumatic sowing machines. / International Agricultural Magazine, №4, p.98 - 103, 1986
25. Mitkov A.L., S. Kardashevski. Statistical methods in agricultural machinery. Sofia, Zemizdat, 1977
26. Mitkov A., D. Minkov. Statistical Methods for Exploration and Optimization of Agricultural Machinery - Part I. Zemizdat, Sofia, 1989
27. Mitkov A., D. Minkov. Statistical Methods for Exploration and Optimization of Agricultural Machinery - Part II. Zemizdat, Sofia, 1989
28. Mitkov, AL, DP Minkov. Mathematical Methods of Engineering Studies. Ruse, 1993
29. Mitkov A. Experiment Theory. Danube Press, Rousse, 2011
30. Митропольский А.К. Техника статистических вычислений. Moscow, Science, 1971
31. Mihailov MD, L. Yordanov, Hr.Hristov Sowing control system for precision sowing machines with biodegradable band. Scientific Works of the University of Rousse - 2011, vol. 50, ser1.1
32. Prospectus Gaspardo
33. Amazon Prospectus
34. Prospectus Pneumovem
35. Raev, I., G. Lee and M. Staneva, Drought in Bulgaria - Modern Analogue of Climate Change, Natural, Economic and Social Dimensions of Drought 1982-1994, pp. 130-143.
36. Slavov N., K. Georgieva. 1998. Winter and summer rainfall in Bulgaria over the past century and their relationship with solar activity. Sat. Fifth Conference "Main Problems of Solar-Earth Impacts".
37. Slavov N., V. Georgiev. 2002. Perennial fluctuations of soil moisture traps in wheat crops and climate change in Bulgaria. Ecology and Future, year 1, vol. 2-4, pp. 77-80.
38. Slavov N., V. Georgieva. 2003. The fluctuations of soil moisture and climate change in our country, Agriculture, 2, 14-15.
39. Slavov, N., E. Ivanova, 1998a. Impact of global climate change on agriculture. Sp.Pedeling Number 6.
40. Slavov N., E. Ivanova. 1998b. Adaptation of Bulgarian agriculture to global climate change

CONTROL OF ACTIVE ORTHOSIS BY EMG SIGNALS

Eng. Rõbak D., M.Sc.[1], Prof. Musalimov V., D.Sc.[2], Ass. Prof. Penkov I., Ph.D[3].
Department of Electrical Power Engineering and Mechatronics – Tallinn University of Technology, Estonia[1]
Department of Mechatronics – National Research University of Information Technology, Mechanics and Optics. Saint-Petersburg, Russia[2].
Department of Mechanical and Industrial Engineering – Tallinn University of Technology, Estonia[3]
dmitririybak@gmail.com, igor.penkov@ttu.ee

Abstract: *The article discusses control of active prosthesis and orthosis by using of EMG (electromyography) signals. It is designed an active orthosis for human lower limb and analyzed kinematic parameters of healthy and injured knee joints. There are considered different types of electrodes and found more optimal design. Also are analyzed electrodes location on human body to obtain more useful results. Problems of active orthosis controlling are also discussed.*

Keywords: EMG SIGNALS, ACTIVE PROSTHESIS AND ORTHOSIS, KNEE JOINT, SURFACE ELECTRODES.

1. Introduction

A long time it is known different types of prosthesis that can be used instead of amputated limbs of human. During rehabilitation period of injured limbs usually are used orthosis.

Presently more useful are not so much cosmetic prosthesis [1, 2] how many controlled bioelectrical active prosthesis and orthosis [3, 4]. At designing of this devices kind take place a lot of technical problems: energy consumption, adaptation to the parameters of the human body, noiselessness, cost etc. But the most difficult task is controlling of prosthesis system provide direct connection between human and prosthesis and also feedback from prosthesis to the human body.

Usually there are three different types of prosthesis controlling [5]:

- use of end EMG signals,
- use of central EEG signals,
- use of intermediate signals (registration from nerve fibers).

The most promising seems to be use of central signals but in this research we consider control of active prosthesis and orthosis by help of EMG signals.

2. Active orthosis

Active orthosis to be considered (Fig. 1) consist of two main parts (lower and upper) and their connecting component (6) simulates a knee joint [6]. The main purpose of this device is to allow movement of an injured knee joint according to trajectories of healthy knee joint. By help of the orthosis it is possible to unload the injured knee joint, partially or fully compensate muscular effort required to bend the lower extremities, and also restoration of the joint moving functions during the rehabilitation period.

The base components of the device are shown in the Figure 1. Rotation of orthosis lower part around axis (6) is made by help of servomotor (4), gears (3), ball screw (2) and stock (1). The resulting device will remove the load provided by the human body on the knee joint during the movement. The linear actuator will fully or partially refund the flexion of the knee joint function. The device autonomy will easily let to use it in daily life, and thanks to the flexibility of settings, it would be easy to adjust it to each individual patient [7].

For correct movement of orthosis parts it is necessary to control carefully velocities and accelerations of system components. For this purpose a set of experiments were made by help of St. Petersburg Institute of Cinema and Television. Each person from experimental group performed several tasks, such as walking in a circle and walk in a straight line. During the experiments a Vicon system with ten cameras Bonita was used. Locations of the markers for optical system are shown in Fig. 2 a, (point 4 is on the back of the leg). Used inertial system consist of three accelerometers gy-61 and the board Arduino Mega [8]. The location of the sensors on the leg is shown in Fig. 2 b.

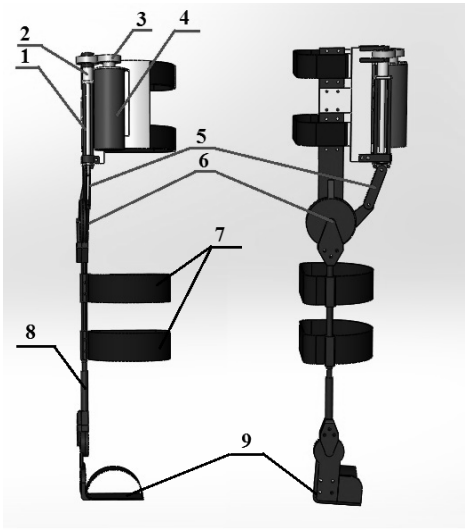


Fig. 1. *Design of the orthosis prototype*
1 – stock, 2 – ball-screw, 3 – gears, 4 – servomotor, 5 – "patella", 6 – flat "knee" joint, 7 – fixing belts with electrodes, 8 – flat "ankle" joint, 9 – "heel-support".

The obtained results were filtered for noise exclusion. Filtration by a Butterworth filter should be implemented first in front direction, then in reverse direction to avoid the phase shift. Results of filtration of data received by sensor 7 (Fig.2) are shown in Fig. 3.

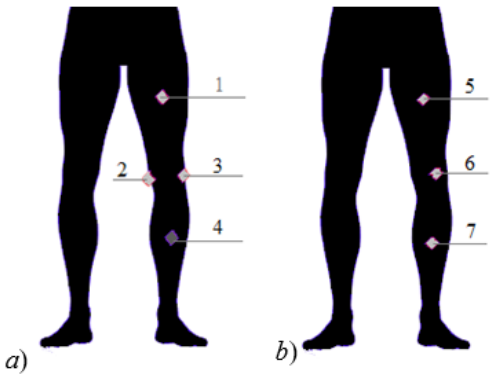


Fig. 2. *Location of the markers and accelerometers*

a - location of the optical system's markers,
b - location of the accelerometers.

Data obtained by inertial system are shown in Fig. 4. Yellow line shows the acceleration obtained during the motion capture, the red and blue lines represent velocity and displacement obtained by integration.

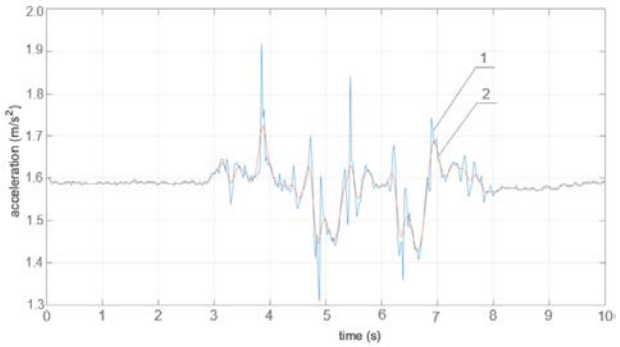


Fig. 3. *Filtering of the data*

1 - data received from the sensor 7,
2 - filtered data.

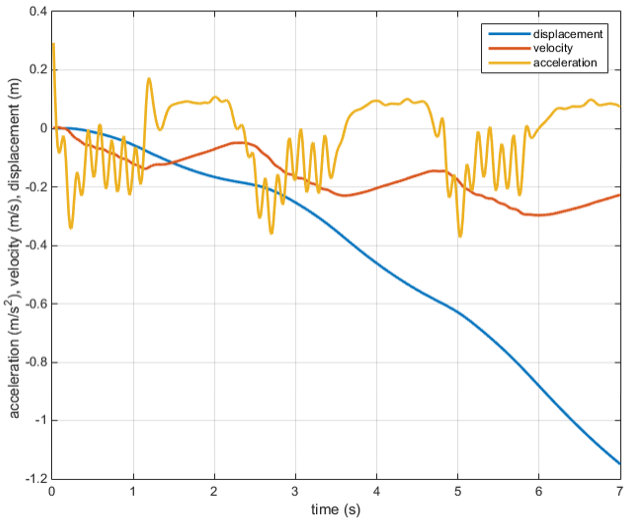


Fig. 4. *Acceleration, velocity and displacement of the point 7 (Fig. 2)*
yellow line – acceleration,
red line – velocity,
blue line – displacement.

On base of obtained results it was developed a model of knee joint and analyzed motion of healthy and injured knees [6].

3. Measurement and filtration

The EMG signals have very small amplitude (20 μV … 2 mV) and the noise amplitude can be much more [9]. Amplitudes of EMG signals are different for different people and signal amplifier should be configurable over wide range.

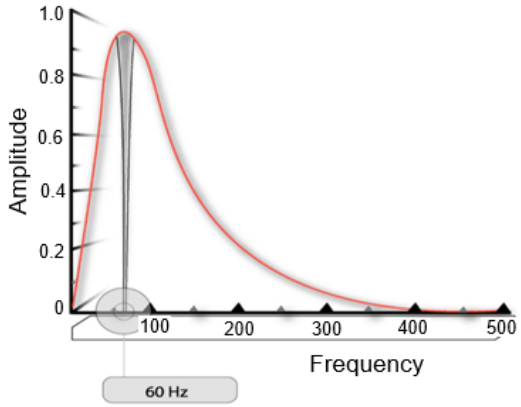


Fig. 5. *Schematic representation of a typical EMG power spectrum [10]*

Frequency of EMG signals are between 10 … 500 Hz. In this case one enough big problem can be power-line (A/C) noise that frequency is between 50 … 60 Hz (Fig. 5). For removing of this noise usually are used a sharp notch filter but the result of this kind filtering is the loss of important EMG signal information [10] and notch filtering should be avoided as a general rule.

The second problem during measurement of EMG signals is influence of other muscles groups. The decreasing of this influence can be obtained by optimal electrode design, distance between electrodes, measurement points etc. Conditions between skin and electrode are also very important for obtaining of signal information. They depend on electrodes polarization effect, electrodes joining, skin conditions, subcutaneous fat etc.

EMG signal amplitude dependence on electrode location on the muscle is shown in the Fig. 6. Correct positioning of the electrode increases important signal information several times.

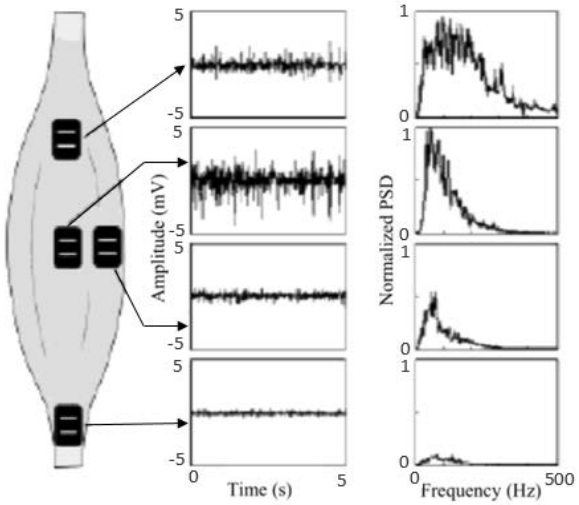


Fig. 6. *Signal amplitude dependence on electrode location [9]*

Signal amplitude is also depend on muscle strength and correct selection of electrode joining points can also increase the signal values significantly. Skeletal muscle cells are formed by the muscle fibers, which constitute the structural contractile units. Each fiber, if excited, has the ability to stretch or contract. The activation of the muscle fiber by nerve endings induces two waves of depolarization that travel at a velocity of 3 to 6 m/s [11]. The internal tissue is electrically conductive. Thus, electrical signals related to depolarization of the fiber can be recorded by electrodes on the skin or muscle. Fig. 7 shows how the different portions of quadriceps acting on the knee extension. F_{pl} is the patellar tendon force, F_q is the resultant quadriceps force, F_{pf} is the tibiofemoral contact force, VM – vastus medialis, VL – vastus lateralis, RF – rectus femoris.

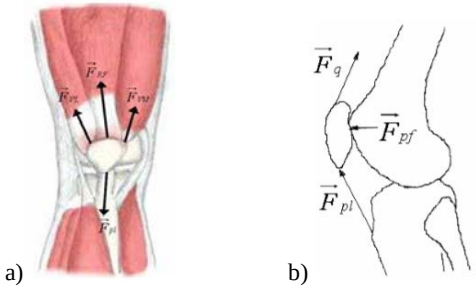


Fig. 7. *Quadriceps forces during contraction [11]*

a) schematic representation of the forces involved in quadriceps action,
b) forces acting on the patella.

4. Surface electrodes

One very important part in correct EMG signals measurement is electrode type. There are two categories of surface electrode: passive and active. Passive electrode consists of conductive detection surface that senses the current on the skin through electrode interface. Active electrodes contain a high input impedance electronics amplifier in the same housing as the detection surfaces [12].

One problem at electrode joining on the skin can be usage of paste or gels. These components are widely use in practice for obtaining of stabile contact between electrode and skin. But in this case electrode can slide on the contact surfaces and measurement conditions will change in the time. The solution can be found by special design of electrode [9] where instead of flat surface (Fig. 6 a, upper design) will be used more complicated surface (Fig. 6 a, lower design).

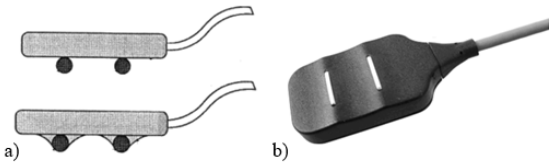


Fig. 8. *Examples of active surface electrodes*

Figure 8 b shows an industrial active electrode in bipolar configurations from Delsys Inc [12]. The spacing between the bars is 10 mm, the length of the bars is 10 mm and the thickness is 1 mm. These electrodes do not require any skin preparation or conductive paste or gels.

5. Control system

Control of active orthosis can be provided by help of dynamic human body system (DHBS) or by direct force control (DFC). In both systems, a hierarchy of two control loops exists. The high-level control loop evaluates EMG signals and the current state of the human body and the orthosis. The output of this loop is the desired motion expressed, as either the desired knee angle or torque. The low-level loop controls the actuator with a PID controller [13].

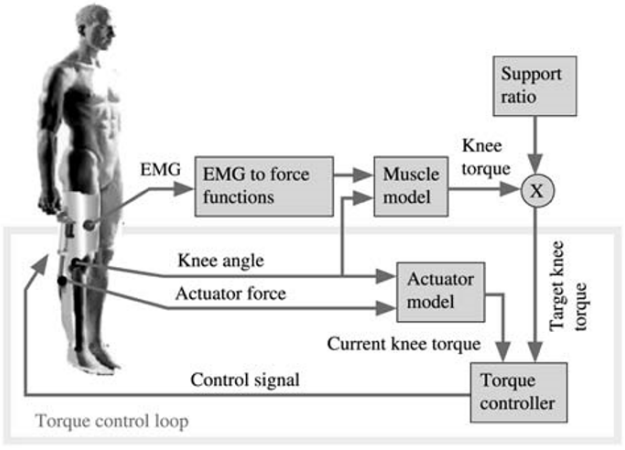


Fig. 9. *Orthosis with the direct force control system [13]*

In the first case (DHBS) the recorded EMG signals are converted into muscle forces and used as an input to the body model together with the joint angles and floor contact information. The model outputs the desired knee angle of the operator, which is passed to the low level control loop as the target value.

In the second case (DFC) the resulting knee torque from the muscle activation is calculated in the high-level control loop from the EMG signals (Fig. 9). The supporting torque is calculated by multiplying torque and by the amplification factor, which can be chosen according to the support required.

Conclusions

Necessary parameters of healthy knee joint were obtained by help of Vicon system. On base of this date a model of the knee joint were developed and movement of healthy and injured knee joints were analyzed. Design and components of an active orthosis are presented. EMG signals measurement system was considered and parameters influencing on measurement results are analyzed.

Acknowledgments

This research work has been supported by School of Engineering (TTÜ) and by Estonian Archimedes Foundation (project „Doctoral School of Energy and Geotechnology“).

References

1. http://www.medicalexpo.com. 04. 2017.
2. http://www.ottobockus.com. 04. 2017.
3. M. R. Tucker, J. Olivier, A. Pagel, H. Bleuler, M. Bouri, O. Lambercy, J. del R. Millán, R. Riener, H. Vallery, R. Gassert. Control strategies for active lower extremity prosthetics and orthotics: a review. Journal of NeuroEngineering and Rehabilitation, 12 (1), 2015.
4. M. Windrich, M. Grimmer, O. Christ, S. Rinderknecht, P. Beckerle. Active lower limb prosthetics: a systematic review of design issues and solutions. BioMedical Engineering OnLine, 15 (3), 2016.
5. T. Shukin. Problem of bioprosthesis control and its possible solution. Proceedings of conference “Non-linear dynamics in cognitive research”. 2011.
6. V. Musalimov, Y. Monahov, M. Tamre, D. Rõbak, A. Sivitski, G. Aryassov, I. Penkov. Modeling of the human lower-limb motion, design and control of knee joint orthosis. International Review on Modelling and Simulations. In Press.
7. N. Turchinovich. Design of knee joint support system. MSc. dissertation, Tallinn University of Technology, Tallinn, Estonia, 2016.
8. N. Krokhaleva. Orthosis supported human lower limb motion model. MSc. dissertation, Tallinn University of Technology, Tallinn, Estonia, 2016.
9. D. Safin., I. Pilshikov, M. Urakseyev, G. Gusev. Evaluation of the efficiency of electrodes design and biosignals amplifiers in prosthetic control systems. Proceedings of Higher Educational Institutions, 2 (10), pp. 88 – 101, 2009.
10. S. Day. Important Factors in Surface EMG Measurement. Bortec Biomedical Ltd, www.bortec.ca, 04.2017.
11. H. U. Kuriki, F. M. de Azevedo, L. S. Takahashi, E. M. Mello, R. Filho, N. Alves. The relationship between electromyography and muscle force. Chapter from the book: EMG methods for evaluating muscle and nerve function. www.intechopen.com, 04.2017.
12. C. J. De Luca. Electromyography. Encyclopedia of medical devices and instrumentation. John Wiley Publisher, pp. 98 – 109, 2006.
13. C. Fleischer, A. Wege, K. Kondak, G. Hommel. Application of EMG signals for controlling exoskeleton robots. Biomed Tech, 51, pp. 314 – 319, 2006.

DEVICE FOR FOG DENSITY CONTROL

Gonevski N. [1], Assoc. Prof. Ivanov O. [1], M.Sc. Todorov P. [1], Pulis V. [1], Prof. Pérez-Díaz J. L. [2]
Institute of Solid State Physics – Bulgarian Academy of Sciences[1]
Escuela Politécnica Superior, Universidad de Alcalá, Alcalá de Henares, Spain[2]

ogi124@yahoo.com

Abstract: A relatively inexpensive instrument (for fog density control), which works in the visible specter, is presented. Its purpose will be to alert the occurrence of fog or visible pollution in the air. It can also detect, if the cleaning fog has reached all areas. This equipment can be used to assess the density of fog. The device is designed for continuous monitoring of the atmospheric air and detection of dispersed agents in the form of aerosols. The total concentration of aerosols is measured and if it exceeds the pre-set threshold, an indication is given via a LED and the information can be exported to external systems. The principle of operation of the device is based on the spectrophotometric method. A beam of monochromatic light is passed through the investigated environment and its intensity is attenuated by the presence of pollutants. The hardware of the device is described, as well as its construction, software and the measuring procedure.

Keywords: FOG, DENSITY, CONTAMINATION, RADIATION, SPECTROPHOTOMETRIC METHOD

1. Introduction

Various sensors for detection of fog exist. They usually operate by evaluating the permittivity of the medium. One way is to estimate the visibility in the air and a common solution is to use cameras [1], [2], [3]. When fog or pollutants are present in the air, this decreases the visibility. Another possibility, which is more widely spread, is to use a light source (emitting from ultraviolet to infrared light) and a detector, placed at a certain distance ahead. The light intensity from the source decreases, when particles or droplets are present in the air, because of light scattering. It is also convenient to use LIDARs to survey the environment [4]. Sometimes humidity sensors are used to help fog presence detection. For fog density evaluation, radars can be successfully implemented [5].

The ideal device for continuous monitoring of atmospheric air and detection of dispersed agents in the form of aerosols should be small, inexpensive, with simple construction and stable in various conditions. It should be operated easily, even by a non-specialist, and should have the option to conduct on-line control. It should also be portable and easy to mount, without requiring special maintenance, with the ability to control small as well as large areas. High sensitivity and the ability to assess a large number of parameters are also required. It should be kept in mind that the fog is difficult to control object as it is ever changing – there are no two instances in which it has the same properties.

We have planned our work, in accordance with the abovementioned goals. Initially, suitable systems for experimental work were developed, investigations were carried out, which lead to the development of laboratory models of different sensors and finally, the device prototypes, each composed of the following components: detector, mechanical, optical and electronic part. Some systems have components for automation that control the transfer of fluids in a pre-defined cyclic manner, in order to ensure a correct measurement and sensor flushing.

The device, which we have designed, Fog Detector 4 (FD-4) measures the total concentration of aerosols and, if it exceeds a certain pre-set threshold, an indication is given, via a LED. This signal can also be exported to external systems. On Fig. 1 the general setup of the device is shown.



Fig. 1 *General setup of the device (1 – measuring device; 2 – aerosol generator; 3 – receiver; 4 – monochromatic filter 650 nm (optional); 5 – laser emitter)*

2. Principle of operation

The principle of operation is based on the spectrophotometric method. A beam of monochromatic light with a specific wavelength is passed through the investigated environment and its intensity is attenuated by the presence of pollutants. This attenuation depends on the size distribution of dispersed particles and their number concentration. The device measures two physical quantities. One of them is the permeability of the environment. It is defined as the ratio of the intensity of traversed light to the intensity of the emitted light. It is inversely proportional to the absorption coefficient. The other quantity is optical density (extinction). It bears information, regarding the aerosol concentration. When the distance for measuring the optical density of the aerosol is known in advance, the calculation of these two quantities is a simple task for modern microprocessor systems.

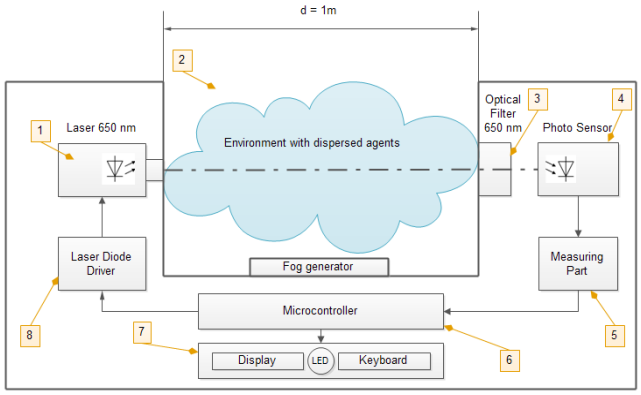


Fig. 2 *A diagram of the experimental setup for investigating environments with dispersed agents*

The general block diagram of the device is shown in Fig. 2. It consists of a light source (1), which is a laser emitting at

wavelength 650 nm, an aerosol generator (2), optional monochromatic filter for the 650 nm wavelength (3), a photo sensor (4), an amplifier (5), a microcontroller (6), user interface (7) and a laser control block (8).

Measurements are conducted in the following manner: the initial intensity of the light beam is measured by passing it through an aerosol-free environment. In order to avoid interference from external sources, the sensing element of the device can be fitted with a monochromatic filter. The signal received by the photo sensor is converted into a digital one and is stored in the microprocessor memory by pressing a button. This measurement is done only once and the value is stored.

When conducting measurements in an environment contaminated with aerosols, the device registers the reduced intensity of the laser beam, which is proportional to the aerosol concentration.

The microprocessor component analyses the values of the stored and the received signals determines the loss of optical power and visualizes the value on the screen in relative units.

The degree of absorption is indicated via a coloured LED. Five percentage intervals have been defined, which differ for the various environments. For each investigated environment (along with the agents dispersed in it) a scheme is selected in advance (Table 1), which takes into account its permeability coefficient.

Table 1 *FD-4 percentage thresholds of the colour indication*

Scheme number	Scheme (r1-r2-r3-r4)
1	2% – 4% – 7% –11%
2	3% – 6% – 10% –15%
3	4% – 7% – 11% –18%
4	5% – 8% – 16% –25%
5	6% – 10% – 18% –35%
6	8% – 15% – 30% – 50%

The percentage intervals given in the table are established experimentally by using different concentrations of aerosol particles and different dispersed agents. The relation between the colour indication and the absorption degree is as follows:

- High – red colour
- Medium – violet colour
- Moderate – blue colour
- Low – green colour
- Below the lowest threshold, there is no indication.

If the signal fluctuates and cannot settle in a narrow interval, an indication is given via a blinking yellow light. When such a situation arises, a new measurement of the incident laser beam intensity must be made in an aerosol-free environment and its new value is stored as a reference.

3. Hardware

The electronic components of the device hardware are shown in Fig. 3.

It consists of three modules – main measurement module, laser emitter and a photo sensor. The emitter and the photosensor are mounted on stands, one of which can be moved onto a support rail.

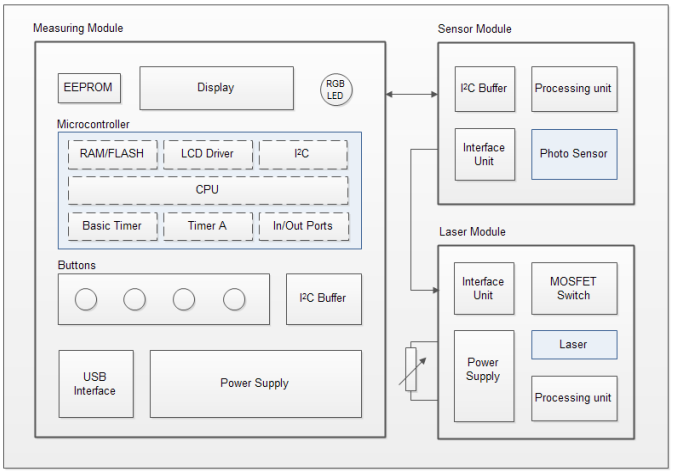


Fig. 3 *Structural diagram of the electronic hardware part*

- **Main measurement module**

The main measurement module of the device is based on the MSP430F microcontroller by Texas Instruments. It is connected to an LCD display, which is controlled directly by the LCD driver embedded in the microcontroller.

Depending on the intensity of the laser emitter and the optical permeability coefficient of the studied environment, the device can operate in four measurement ranges. The chosen range is shown on the display.

A Neo-Pixel RGB LED, controlled via a WS2811 driver is used to visualize the degree of absorption. It is controlled using three 8-bit sequences, transmitted via a one-wire interface.

The operating regime is set via buttons and from the menus shown on the display.

The connection to the sensor module is realized via a buffered I^2C interface.

A USB interface is also provided for connecting the device to other measurement systems.

- **Photo sensor module**

The photo sensor in the device is based on the TSL2561 device. It is a complete, intelligent receiver, which can be configured to operate in different regimes. Its detection range is 0.1 – 40000 Lux. The measured signal is converted into a digital code, which is delivered to the user via an I^2C interface. TSL2561 operates in a wide spectral range and covers the visible and near infrared ranges. Its block diagram and spectral characteristics are presented in Fig. 4 and Fig. 5, respectively.

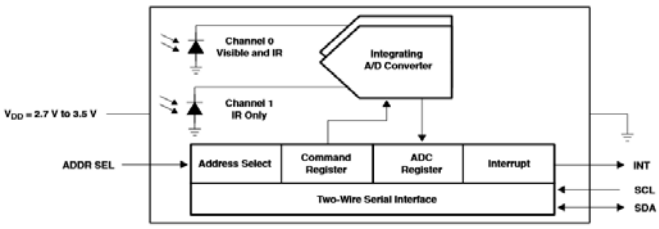


Fig. 4 *Block diagram of optical sensor TSL2561*

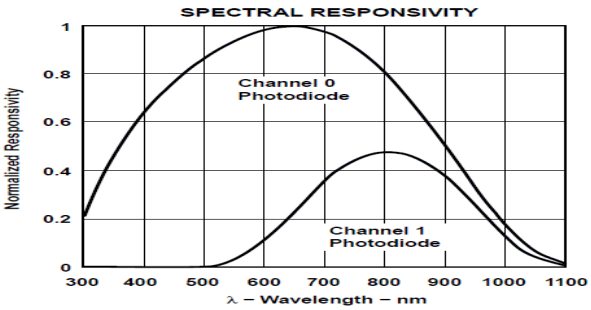


Fig. 5 *Spectral characteristics of optical sensor TSL2561*

- **Laser module**

A Laserfuchs LFD650-1-12 laser diode (wavelength – 650 nm, power – 1 mW) is used as the emitter in the device, for registering dispersed agents. Its intensity can be adjusted manually. The laser diode is powered by a power supply block, which provides stable voltage in the range 2 – 12V and currents up to 500 mA. The main characteristics of the laser emitter are given in Table 2 and Table 3.

Table 2 *Main parameters of the LFD650-1-12 laser diode*

Main Parameters	Min.	Typical	Max	Unit
Wavelength		650		nm
Optical Diode Power	0.5	0.75	1	mW
Operating Voltage	3	3	12	V DC
Operating Current	15	25	30	mA
Operating Temperature	-20		40	°C
Storage Temperature	-40		80	°C

Table 3 *Optical parameters of LFD650-1-12*

Optical Parameters	
Beam Shape	Dot
Laser Class	2
Divergence	1 mrad
Beam Diameter	3 mm
Size of Laser Dot	< 3÷4 mm (at 5m)
Operating Distance	10 m
Optics	acrylic lens
Laser technology	Diode
Focus	fixed (5000 mm)

The laser emitter has the following three operational regimes:

- Off
- Continuous
- Pulsed

When working in pulsed mode, the laser diode can be modulated at one of the following frequencies: 500, 1000, 2000 or 5000 Hz. If needed, the hardware resources of the device allow the generation of chosen modulation frequencies in the range 1÷50 kHz, with an arbitrary duty cycle.

The operating regime of the laser is shown on the display as a bar graph.

- **Monochromatic filter**

In the case of unstable background light of the studied environment, it is advised to use the E361415 monochromatic filter, in order to obtain maximum sensitivity only to the emitter wavelength – 650 nm. The characteristics of the monochromatic filter are given in Table 4.

Table 4 *Parameters of E361415 monochromatic filter*

Parameter	Value
Size	Ø50 mm
λ	650 nm
λ_{max}	646 nm
T_{max}	39,0 %
FWHM	7,5 nm

4. Software

The structural diagram of the device's software is shown in Fig. 6 and Fig. 7. When power is supplied, the software begins system initialization, during which the peripheral devices and default parameters are configured. The control is then transferred to the main program cycle. When a button is pressed, the software performs the function, which is related to it.

The photo sensor data is transferred for processing via the I^2C interface after an intermission has been received by it. Mathematical processing of data is performed by the software - normalization, numerical filtration, percentages calculation and conversion to a form, which is suitable for visualization. The information on the display can be refreshed every second.

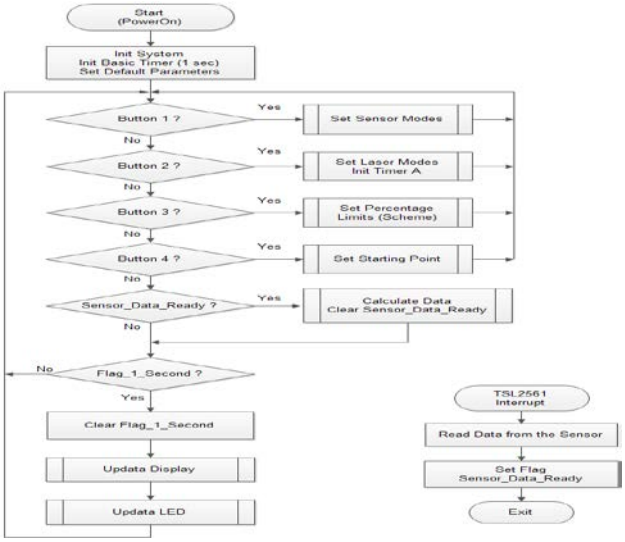


Fig. 6 *– Block diagram of the control algorithm of the measurement system*

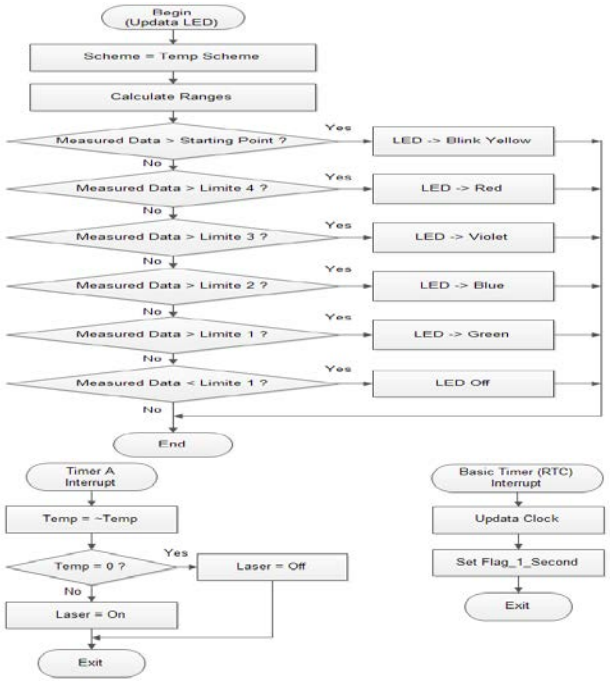


Fig. 7 *– Block diagrams of the sub-programs serving the main algorithm*

5. Construction

The device for registering dispersed agents has a 1-meter long rail as its base. Two stands are placed on it – a fixed one and a mobile one. Their elements are identical and interchangeable. The overall construction resembles a U-shape. Two mechanical

elements are provided for fitting the monochromatic filter (Ø50mm) on the receiver. Two additional stands are also provided for mounting fans that blow at the protective glasses of the emitter and receiver, if condensation appears or in case water droplets form on them. These are powered with 5V by an external DC converter. The main measurement block is powered via a network adapter (9V/0.6A). The total weight of the system does not exceed 5 kg. In order to ensure easier movement of the mobile stand, a ball bearing slide rail with gradually adjustable length in the range 0.5÷1 meter is included as a spare one for replacement. This rail requires one of its ends to be mounted on a base for stability.

6. Conclusion

We have presented the measuring device, which we have developed - Fog Detector 4. It is intended for measurements of optical transparency of environments of different nature - aerosol mists, smokes, dust and other. We have achieved the main goals of this work - our device is lightweight, portable, easily operated, and relatively low-cost. The principle of operation of the device was described, as well as its main components, construction and software.

Acknowledgements

This work has been funded by EU FP7 Security program under contract 312804.

References

[1] Hautière, N., Tarel, J. P., Lavenant, J., Aubert, D. Automatic fog detection and estimation of visibility distance through use of an onboard camera. Mach. Vis. Appl., 17(1):8–20, 2006.

[2] Hautière, N., Labayrade, R., Aubert, D. Estimation of the visibility distance by stereovision: A generic approach. IEICE Transactions on information and systems, 89(7):2084–2091, 2006.

[3] Kuwon, T. Atmospheric visibility measurements using video cameras: relative visibility. Center for transportation studies of Minnesota, no. CTS 04-03, July 2004.

[4] Dannheim, C., Icking, C., Maeder, M., Sallis, P., Fischer, V. Air pollution and fog detection through vehicular sensors. Modelling Symposium (AMS), 8th, 2014. DOI: 10.1109/AMS.2014.43.

[5] Mori, K., Kato, T., Takahashi, T., Ide, I., Murase, H., Miyahara, T., Tamatsu, Y. Visibility estimation in foggy conditions by in-vehicle camera and radar. Proc. International Conference on Innovative Computing, Information and Control, Vol. 2, pp. 548-552, Aug. 2006.

INNOVATION POLICIES OF POLISH INDUSTRIAL ENTERPRISES BASED ON INNOVATION CUBE MODEL. RESEARCH RESULTS[1].

Author: PhD. Paweł Mielcarek, Assistant Professor
Poznan University of Economics and Business,
Department of Organization and Management Theory,
al. Niepodleglosci 10, 61-875, Poznan, Poland
Conference registration number: 31.

Many theoretical concepts of studying innovation strategies concentrate on selected aspects and determinants of this phenomenon and dissemble cohesive and wider perspective. In result there is lack of comprehensive researches concerning innovation policies, especially covering long term, repetitive studies based on the same methodology. The main purpose of this article is to assess innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – *innovation cube.* Those dimensions are: place of creating, continuity of activity and way of innovation utilization. In result of imposition above criteria these model presents eight different variations of innovation policies. The most common innovation policy utilized in Polish industrial enterprises is individual innovator. This means that innovations were created in continuous manner, based on own resources and for own use.

The test sample covered years 2007-2009 and 2012-2014. Surveys were conducted on group of medium and large Polish enterprises belonging to low-, medium- and high-tech industries. Each phase of research was based on the same methodology. From first stage 80 responses were obtained and from the second one 92.

Keywords*:* innovation, strategy, innovation policy, industry, company

1. Introduction

Innovation is one of the key dimensions of functioning and development of the organization (Kaplan, Norton 1993:67-70). It can be perceive as decisive dilemma of company`s success due to its dual role. On the one hand innovation can be seen as a source of

[1] This text is based on the grant financed from the National Science Center, Poland (UMO-2016/21 / D / HS4 / 00696: "*Improvement Of Open Innovation Process In Developing Corporate Strategic Renewal*". Project manager: PhD Paweł Mielcarek.

change that can reshape company`s competitive potential. On the other hand this requires investments and reconfiguration of key resources which raises uncertainty and is highly risky activity (Tidd et al. 2005:111). Therefore, innovation strategy must cope with both of these perspectives. Short term plan focused on orchestrating resource synergy and efficiency. However, long term perspective creates capacity and growth potential of organization. Moreover innovation strategy should also enable cohesion of wide scope of company`s activities depending of current level of its competitiveness, development of technology and market conditions.

In general view, the key goal of the innovation strategy is to assure a long-term survival of the company and growth of its competitiveness by creating revenue streams based on delivery value to customers. On a tactic level innovation strategy should designate goals, create boundaries conditions and key assumptions for innovation process. Embeddedness of and consistency of innovation process within innovation strategy and both of them in organization`s competitive strategy is crucial for achieving success in a longer perspective. These dependencies determine efficiency of innovation strategy based on achieving synergies from positive feedback between the subsystem of innovation and other subsystems of organization (Mielcarek 2016:29). Complex and multidimensional nature of this phenomenon is result of being conditioned on both, external and internal factors, as well as a need of coping operational activity with long term development.

There are many studies that emphasize one specific aspect or research perspective of innovation strategy. For instance in literature of last decades in reference to business environment and external conditions, there can be distinguished m. al.: managing relations (Ahuja et al. 2008), innovation network (Perri et al. 2006), innovation ecosystem (Iansiti, Levien 2004), business model and open innovation (Chesbrough 2006). Also in regards to organizational factors there are many concepts and research frameworks. For instance K. Zduńczyk and J. Blenkinsopp adapted idea developed by E. Martins and F. Terblanche (2003) consisting of four dimensions – strategy, structure, support mechanisms and behavior, to examine their influence on innovation (2007:25-40). In other research, to group of organizational factors researchers include financial expenditure, innovation culture, leadership, organizational structure and interorganizational relations (Assimakopoulos et al. 2011).

There are several studies and attempts of meta-analysis comparing relations of numerous factors in the context of innovation strategy (Damanpour 1991:555-590; Kimberly, Evanisko 1981:689-713). However most of those analyses are based on different scope and

are focused on different level of complexity. Thus still exist a cognitive gap and need of analysis of this phenomenon that is up-to-date and based on complex research framework.

Above mentioned discourse allows to formulate main purpose of this article which is assess of innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – *innovation cube*. In specific those three dimensions are: place of creating innovation (in-house / outside), continuity of activity (continuous / occasional activity) and utilization of innovation (own usage / commercialization). In result of imposition above criteria these model presents eight different variations of innovation policies. Adoption of main goal and presented model allows derivation following research questions assuming Polish industrial enterprises:

1) in terms of diagnosis of innovation strategies:
    a. What is the distribution of each of abovementioned dimensions in cube model in both surveyed periods?
    b. What is the distribution of eight variants of innovation policies in both surveyed periods?
2) in terms of innovation strategies effects assessment:
    a. What type of innovation (according to Oslo methodology) was dominant in both surveyed periods?
    b. How innovation importance phenomenon presents in both surveyed periods?
    c. What other effects were obtained by applying innovation policies in both surveyed periods?

2. Innovation strategy - theoretical starting points

In general main goal of business activity is creating added value for its customers in order to make profit. That is why planners must cope with several functions of strategy, extending on corresponding dimensions of company`s activity (Grant 2012). First of all strategy is way to achieve goals and ensure development of organization. Therefore it reflects to future actions and intended position that company wants to acquire. To put this vison into reality, strategy should also motivate and inspire organization members. Second dimension of strategy is to ensure cohesion of organization`s decisions, which is essential for managers acting within limited rationality. In this sense strategy reduces risk and scope of possible paths of development into a satisfactory solution that meets accepted criteria. Third one is function of coordination and communication. Strategy enables cooperation of different units and individuals within organization. Process of strategic planning leads to exchange of views of

involved parties and in result, to achieve consensus about how organization should proceed and control its actions (Grant 2012).

Literature brings many different views and perspective of defining innovation strategy (see Table 1). Despite wide scope of analysis, it is worth to notice that below list isn`t exhaustive (more criteria and variants can be proposed). At the same time presented variants describing innovation strategies aren`t alternative choices. This means that innovation strategy can be characterized by a combination of different variants, i.e. *global, offensive, imitating, marketing, production and technological*.

Table 1. Criteria of defining innovation strategy

Scope	Criterion	Authors	Strategy variants	Main concern of
Decision makers	Development approach	H. I. Ansoff, E. J. McDonnell, 1988; H. Mintzberg 1987	Formal plan / Emerging plan	Level of complexity and detail in preparing development paths according to future environment fluctuation and potential organization`s response.
Innovation character	Creating value	H. R. Greve 2007	Exploration / Exploitation	Acquisition and developing relations with entities in order to create or discount innovation.
	Level of technological change	C. Christensen, M.E. Raynor 2003	Incremental / Breakthrough	Defining technology capabilities and capacities. Providing market acceptance of innovation.
	Source of innovation	Rothwell R., Gardiner P., 1983; Rothwell R., Zegveld W. 1985	Technology push / Market pull / Coupled	Initiating and driving of innovation activity depending on the relationship between technology developments and fulfilling market needs.
	Type of innovation	P. Doyle, S. Bridgewater 1998; Oslo Manual 2005	Organizational / Market	Organizational innovations: modification of internal elements of company in coherent way, i.e. structure, processes, culture. Market innovation: delivery of value for customers via products and distribution.
Organization	Competiton apporach	C. Freeman, L. Soete 1997; R. G Cooper 1984	Offensive / Defensive	Balancing cost and revenue structure. Competition and risk assessment.
	Company`s function	J. Tidd, J. Bessant, K. Pavitt 2005	Technology / Marketing / Production /	Enabling cohesion and synergy effect between company`s function.

			Human Resources / Financial	
	Value chain position	P. Drucker 2006	Pioneer / Imitating / Niche	Balancing cost and revenue streams in perspective of market needs and competition activity.

Source: own preparation.

First criterion presented in the table, perhaps most general, is decision makers approach to organization development, allowing divisions of rationalist and incremental types of innovation strategy (Whittington 1994). Rationalist approach, represented by H. I. Ansoff, is based on a formal and planned path of development that must cope, with complexity of interdependencies, in the long term perspective. It is crucial to ensure company`s capacity to endure changes and provide coherence in goals with corresponding organization`s procedures and routines. In second perspective - called incremental approach, represented by H. Mintzberg, innovation strategy comes to continuous and evolutionary adaptation to environment fluctuations based on exploring different development paths and create readiness to change strategy whenever new circumstance appears.

Different approach presents Peter Drucker, which emphasizes and relates innovation strategy to position of organization within value added chain (2006). In this perspective efficiency of innovation strategy depends on interactions with different entities such as competitors, suppliers and customers which both, directly and indirectly, determine level of expenditures, achieved income and rate of return form innovation activity. In this view expenditures are determined by cost of resources specialization, entry cost to industry, cost of access to technology or market and cost of innovation duplication. Whilst income and return rate are dependent on market scale, competition activity and possibility of achieving innovation rent.

Another perspective of defining innovation strategy is based on relationship between technology developments and fulfilling market demand. Core concept were laid by R. Rothwell, P. Gardiner and R. Rothwell, W. Zegveld (1983; 1985) that described different model of innovation process according to main source of initiating and driving of innovation activity. Their assumption focus on dominating role one of two factors: technology developments or fulfilling market needs. Later, corresponding to those considerations, C. Christensen and M.E. Raynor focus on phenomena of technological innovation included in their concept of incremental versus breakthrough innovation (2003). In this approach company pursue to deliver proposition corresponding to level of improvements that customers

are able to accept, whilst company has to strive to maximize sales and minimize costs. The acceptance level of novelty differs for each industry. There are some of the most demanding customers whose expectations won`t be satisfy by any of the offered products on the market. On the other hand there is a group of potential customers who would buy the product if company would reduce its price. Nonetheless the pace of technological development usually exceeds the capacity to acquire new products by the average customers. It is also important that companies by developing innovations raise limit of customer`s acceptance for new products (Christensen, Raynor 2003).

Propositions presented in above table do not deplete existing criteria of analysis of innovation strategy. They rather designate complexity and scope of this phenomenon. However, due to fragmentation of listed criteria and concept, raise a need for synthesis aim at presentation of comprehensive and consistent concept describing types of innovation strategies.

3. Variants of innovation strategies – innovation cube model

Presented model covers innovation strategy variants based on several determinants such as: scale and scope of resource base, company`s bargain power and position within its competitive environment and value added chain as well as market scope and demand. The basic assumptions that create foundation and boundaries condition of this model are as follow:

1) Each variant presents general overview of company`s innovation strategy, that predetermine use and efficiency of most of engaged resources and overall of achieved effects. However, at the same time some of innovation projects can be realized outside of selected variant (based on different approach and/or resources usage).
2) The ability to achieve goals of innovation strategy is limited by set of simultaneously affecting boundaries conditions. Most important of them are coping with competitor`s activities and simultaneously delivering value according to customer`s needs. Based on above limitations, company can choose how to realize its innovative policy. In results managers can decide if they need to cooperate or not within innovation process? Is it crucial to run continuous innovative activity or based on solely projects? What is purpose and effect of created innovation?
3) Above assumption favor covering broad variety of different configurations of individual innovative behavior of organization. In results this put pressure to

extend number of variants cover by innovation cube model. At the same time it was crucial to ensure readability of the model that will determine its utility and applicability, so to limit number of variants cover by cube model.

In result of overlapping abovementioned assumptions three dimensions were selected: (1) place of innovations creation (in house or outside), (2) type of activity in terms of its continuity (continuous or occasional activity), (3) utilization of innovation (own usage or commercialization). That allows setting a three-dimensional matrix consisting of eight different variants of innovation strategy: buyers, collectors, individual innovators, occasional innovators, brokers, guerrillas, seller and casual sellers (see Figure 1).

First of dimensions is a place of innovation creation. Companies that build own research and development resource often meet several limitations hindering efficiency of innovation operations. That is why some of organizations build relationships with other entities within innovation process. The main reasons for this is reduction of transaction costs, division of labor and specialization of activities, access to technology, markets and know-how, or sharing the risk in the project (Bae, Chang 2013:968). However collaboration within innovation activity can bring several negative effects, such as knowledge spillovers, strategic drift, unnecessary diversification, raises cost of cooperation and relationship management, lowering efficiency and product quality or creates cultural conflicts (Tidd et al. 2005:292).

Second of dimensions is a type of activity in terms of its continuity of operation. Constant running of innovation activity enables fast and flexible reactions for changes appearing in the environment and within the organization. Moreover continues operation foster control and coordination, as well as favor process of innovation management. In result, it creates the conditions for synergy, which contribute to raising the efficiency of innovation activities. Also potential advantages can be gained by implementing constant improvement of activity due to business process orientation (Harrington 1991:16–21). But the realization of innovative activity in a constant manner is also costly and not always adequate to market demand or given competitive environment.

Third of dimensions is innovation utilisation. Entities that implement innovations for their own use are usually driven by two different causes. First one is aimed at building and securing the leader position in a market. In this approach it is crucial to ensure long enough period of discounting incurred investment due to innovator rent. Second approach is to reduce the distance between the company and the market leader, which usually leads to create imitation of innovation or by providing lower cost of operation, in order to avoid risk carried

out by leader (Tidd et al. 2005:121). In group of companies that aim at sales of innovations,

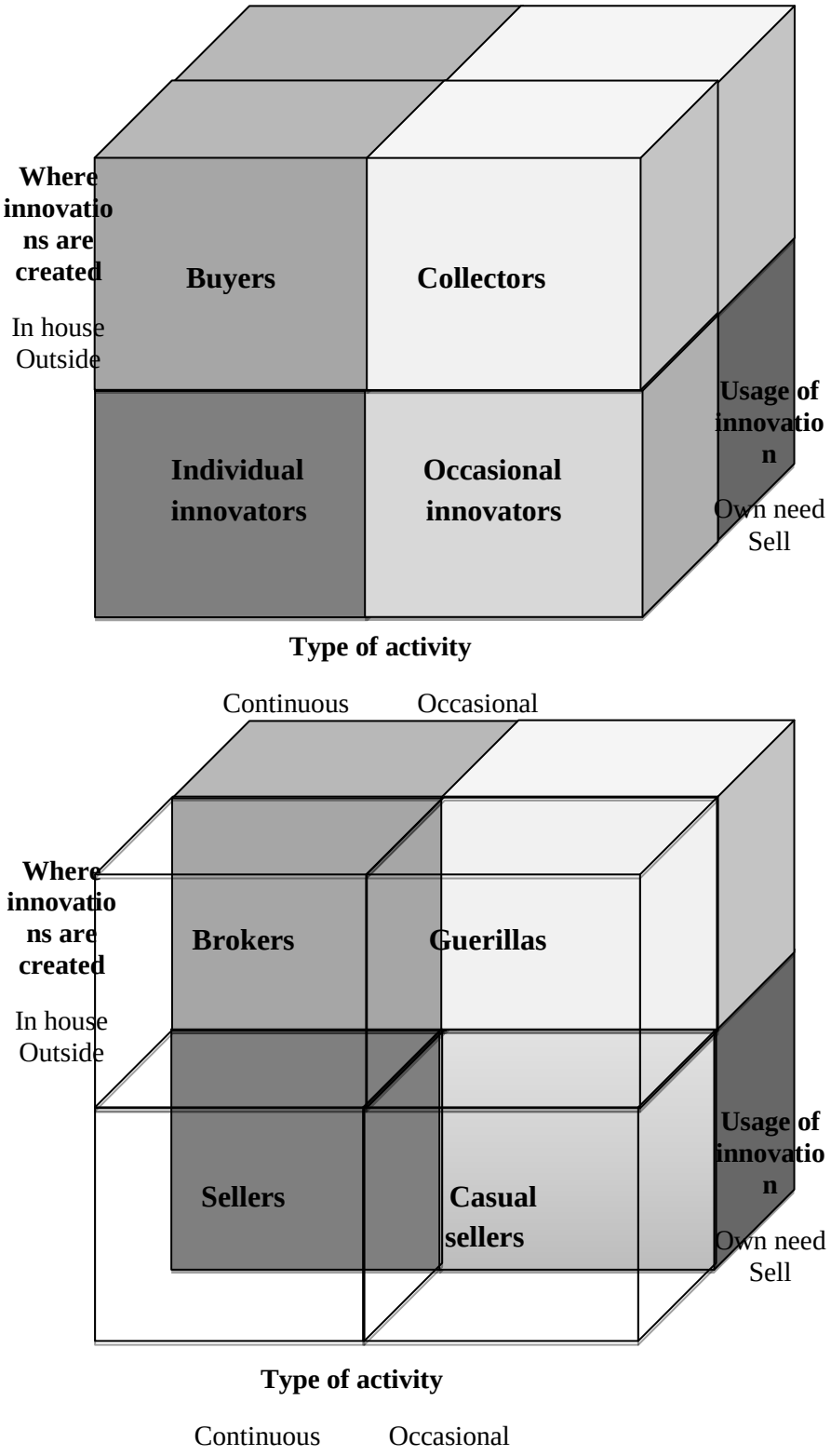


Figure 1. Matrix of innovation strategy

Source: (Cyfert, Mielcarek 2011:22).

it is possible to distinguish few types of approaches. First of them is implemented by large companies while introducing new-generation of innovation. After successful entry to new geographical market they may decide to sell previous innovation to other, less advanced markets (Bennett 1995:273-275). Other approaches based on commercialization as innovation strategy, can aim at achieving advantage in market position due to monopoly or niche occupancy. According to M. Porter`s five forces concept, along with increasing of company specialization, raises the cost of entering to industry, so other companies are forced to buy innovations introduced by more developed or specialized entities.

Above presented variants of innovation strategies correspond to both conditions created by the environment as well as the result of manager's decision and company`s competitive potential and create framework for assessing innovation policies.

4. Effects of innovation strategies in Polish industrial enterprises - research results

Characteristics of the research sample

The analysed data are the result of nonprobability sampling procedure carried out on a group of medium and large Polish industrial companies. In specific, research covered six industries - two of each: low, medium and high technology. The twosteps research procedure was conducted in 2010 (the collected data cover years 2007-2009) and repeated in 2015 (the collected data cover years 2012-2014). Then responses were rejected from entities that do not establish innovation or have provided incomplete questionnaires. Altogether from a first stage of research 80 responses and from second 92 responses were collected.

The methods used in research were survey with a structured questionnaire including 17 closed questions. The questionnaire includes auto check questions in order to ensure the reliability of answers. Half of the responses were gathered via traditional mail questionnaire survey and half were achieved by CATI method (computer-assisted telephone interview). The questionnaires were delivered to managers or specialists involved in innovation activity and R&D within companies.

Research results

First step of **innovation strategies diagnosis** was analysis of the three dimensions characterizing innovation policies of Polish industrial enterprises. In general in both surveyed periods most of responders were creating their innovations in house, based on continuous manner and for own use (see Figure 2). This kind of orientation of innovation policy is typical

for closed innovation model, which seems to be less effective in highly dynamic and competitive environment.

However there can be indicated changes in patterns in both analyzed periods that mark new trends. Including dynamic perspective there tendencies between 2007-09 and 2012-14 were noticed. 1) There was raise of concentration on endogenous potential and own resource base in creating innovation (from 61% to 95% of companies). This change can be interpreted as further closing of company innovation process within organization boundaries. As advantages of this orientation are economics of scale and rise of resource efficiency but at the same time there is strong dependency of current resource base and limitation of stimulus of development. 2) There is decrease of continuity and regularity of innovation activity (drop from 67% to 54% of companies). This can mean that more enterprises turn towards use of project orientation instead of consistent innovation process. So it can reflect raise of dynamic and discontinuity of environment, especially customer's needs. 3) There is also growth of company's percentage that creates innovation for commercialization (raise from 13% to 37%). This also support view of innovation policies focused on customer's needs.

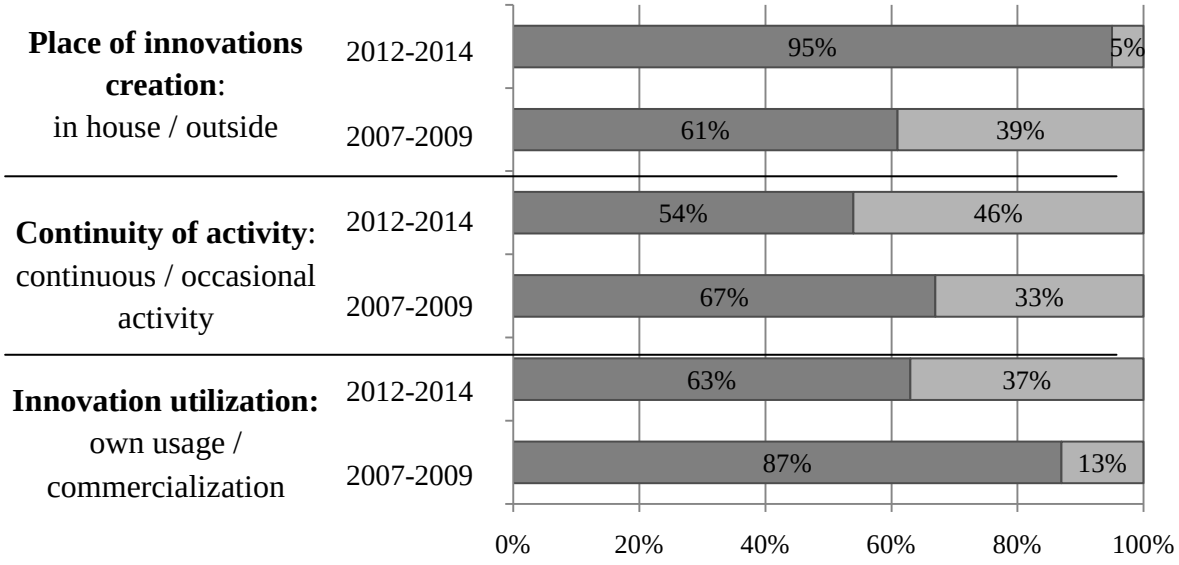


Figure 2. Three dimensions of innovation policies in Polish industrial enterprises
Source: own work.

Despite some changes and observed tendencies in innovation policies, still the most common type of strategy is based on close innovation model. More than one third of surveyed companies were using individual innovator (35%), then seller (28% of respondents),

occasional innovator (18%) and casual seller (14%). Rest four variants represent 5% of company's behavior (see Figure 3). Two variants: individual innovator (creating based on own resource, continuous manner and for own use) and casual innovator (creating based on own resource, in discontinuous manner and for own use) are covering 53% of all innovation policies in Polish industrial enterprises in 2012-2014. This also reflects and confirms domination of close innovation model. Next innovation policies in term of distribution are seller (creating based on own resource, continuous manner and for sell) as well as occasional seller (creating based on own resource, in discontinuous manner and for sell). Both of those variants represent 42% of innovation policies in Polish industrial enterprises. This emphasis importance of marketing orientation in adopted strategies.

According to changes between analyzed periods there is significant growth of market orientation policies (raise about 17% of those two variants) in comparison to decrease in adoption of close innovation policies (drop about 10%).

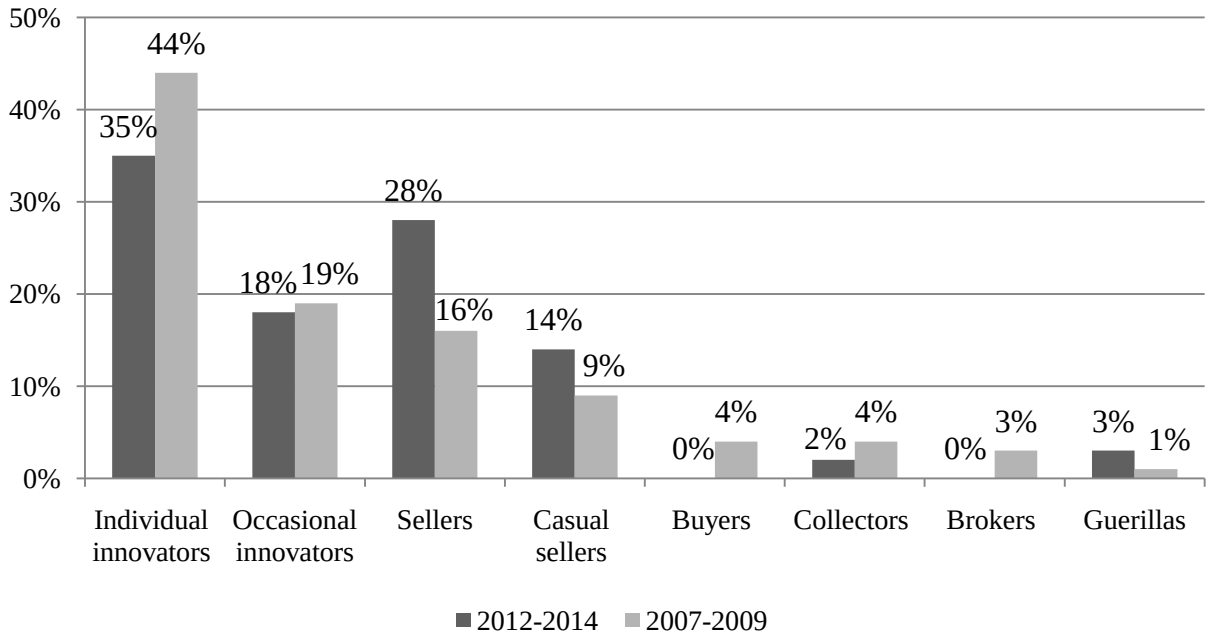


Figure 3. Distribution of variants of innovation policies in Polish industrial enterprises
Source: own work.

Second part of analysis refers to **effects of innovation policies**. In this area there was analyzed innovations activities for each of innovation type (product, process, marketing and organizational) in refer to its geographical scope/importance of created innovation (see Table 2). There was assumption that the wider the geographical scope of created innovation the

greater is it importance and novelty level. Innovation activity was presented as percentage (values shown in below table response number of companies that introduce at least one innovation in given period).

In general most of surveyed companies were creating product innovation, then process innovation, marketing innovation and lastly organizational innovation. In comparison between two analyzed periods more companies were carrying innovation activity in regards to all of four innovation`s types. The average values rise from 29% in 2007-09 to 35% in 2012-14.

In terms of innovation importance most common are in house innovations (implemented within company so can be interpreted as imitations in regards to their competitors) that were created in more than 50% of surveyed companies. On the second place there were innovations with country scope, next innovations with regional scope and lastly with global scope. It is worth to emphasize that innovation characterized with global scope, which are assumed with the highest novelty level, had raise from 12% in 2007-09 to 23% in 2012-14. This almost doubles the amount of companies that created breakthrough innovation. Observed tendencies confirm raise of efficiency of innovation policies in Polish industrial enterprises.

Table 2. Innovation activity of Polish industrial enterprises – breakdown of innovation type

Innovation type	Innovation importance (geographical scope)									
	In house innovation		Innovation with regional influence		Innovation with country influence		Innovation with global influence		Average	
	2007–2009	2012–2014	2007–2009	2012–2014	2007–2009	2012–2014	2007–2009	2012–2014	2007–2009	2012–2014
Product innovation	58%	74%	23%	49%	58%	48%	21%	38%	**40%**	**52%**
Process innovation	63%	44%	15%	28%	25%	32%	13%	21%	29%	31%
Organizational innovation	56%	46%	2%	25%	19%	27%	0%	16%	**19%**	**26%**
Marketing innovation	40%	44%	15%	22%	40%	31%	13%	18%	27%	29%
Average	**54%**	**52%**	14%	31%	36%	35%	**12%**	**23%**	29%	35%

Source: own work.

Besides innovation activity also other effects of innovation policies were analyzed. Respondents could choose any answer out of ten propositions: brand building, cost reduction, gaining competitive advantage, income rise, fulfilling law and polices, new market entry and rise of market share, reduction of environmental hazards, rise of production flexibility rise of production capacity, rise of production flexibility (see Figure 3). In both surveyed periods most common effect of innovation strategies was enter on new market or rise of share on current market (respectively 62% in 2007-09 and 79% in 2012-14). Next there were achieving competitive advantage and rise of production capacity. Less common response from all effects was fulfilling law and polices.

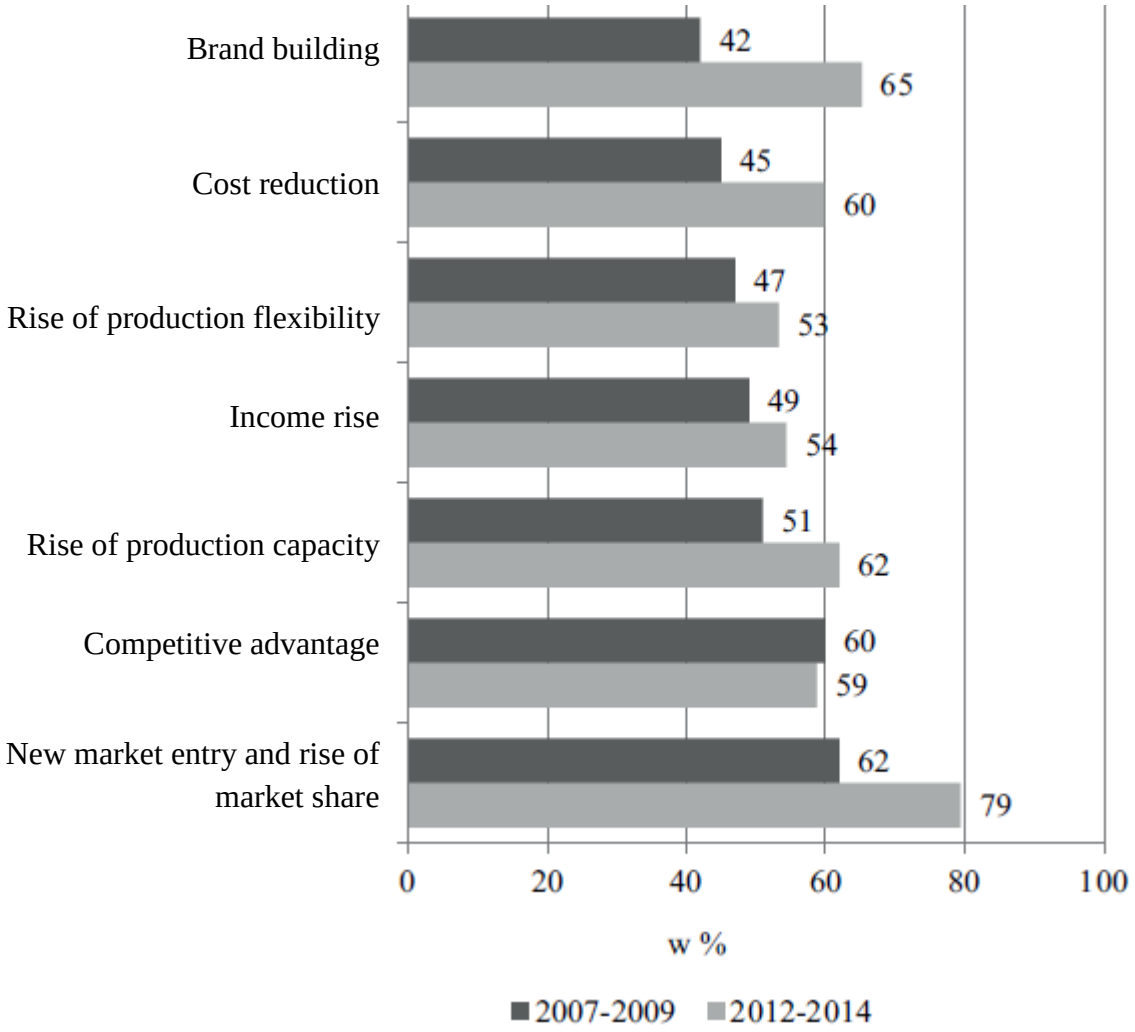


Figure 3. Distribution of effects of innovation policies in Polish industrial enterprises

Source: own work.

5. Conclusions

The main purpose of this article was to assess innovation strategies applied in Polish medium and large industrial enterprises based on three dimensional innovation activity model – *innovation cube.* In refer to the main goal two research fields were indicated: innovation strategies diagnosis and effects assessment.

In terms of diagnosis of Polish industrial enterprises the most common adapted strategy was individual innovator (creating innovation based on own resources, in continuous manner and for own use). Second most popular variant is seller (creating innovation based on own resources, in continuous manner and for sell). Next two are occasional innovator and occasional seller. Those four variants out of eight altogether represent 95% of adopted innovation policies in surveyed companies. It is worth to emphasize, that despite some ongoing changes, still most popular is closed innovation model that designate and create framework of companies behavior as rather self-sufficient and independent entities.

These finding might be surprising especially in contrary to one of key theoretical paradigm and widely comment open innovation model. Partly the reason of this state might be found on macroeconomic level in refer to Poland i.e. low interpersonal trust that transfer on interorganizational trust, complex and illegible law and tax system, underfunded research institution and lack of incentives for business – since cooperation. Those factors hindered building relationships and innovation networks which are one of crucial elements of open innovation strategies.

To gathered full view of innovation strategies, indicted policies were assessed by criterion of achieved effects. Namely distribution of four types of innovation was presented as well as innovation scope in terms of its geographical influence. In general, since first research phase more companies attended to innovation activity (growth from 29% in 2007-09 to 35% in 2102-14). Most of surveyed companies were creating product innovation, then process, marketing and lastly organizational innovation. In comparison between two analyzed periods innovation activity rise in regards to all of four innovation`s types. In terms of innovation importance most common are imitation changes however between two surveyed periods there was significant rise of global innovation that can be identify with breakthrough and highly novelty of introduced solutions.

Obtained view of innovation policies of Polish industrial enterprises is rather complex and hard to explain with a few regularities. One of observed trends is change towards market orientation between both surveyed periods (rise of share of seller and occasional seller as well as enter on new market and increase market share as the effect). Also despites some gaps in

environment embeddedness and innovation networks building (open innovation model) there is consistent rise of innovation activity as well as growth of importance and novelty level of created solutions.

Conducted research also has some limitations. First one is lack of financial results of each of implemented strategy as well as no precise information about profitability of created innovations. This is commonly found obstacle in all of innovation research due to tangible/intangible and complex character of this phenomenon as well as rather long and hard to defined scope of investment return. Second group of limitations is result of sample size and characteristics. It would be preferred to carry out more research based on probability sampling and wider scope of selected industries (services, agriculture e.t.c.) as well as to provide some multinational comparisons for analysis.

References

Ahuja, G., Lampert, C.M., Tandon, V. (2008): *Moving Beyond Schumpeter: Management Research on the Determinants of Technological Innovations*, The Academy of Management Annals, 2, 1, 1-98.

Ansoff H. I., McDonnell, E. J. (1988): *The New Corporate Strategy*. New York: John Wiley & Sons.

Assimakopoulos, D. Xie, X. M. Zeng, S. X. Tam, V. M. (2011): *Can Cooperative Innovation Improve Innovation Performance?* Tallinn: European Academy of Management Conference.

Bae, Y. Chang, H. (2012): *Efficiency and Effectiveness Between Open And Closed Innovation: Empirical Evidence In South Korean Manufacturers*. Technology Analysis & Strategic Management, 24, 10, 967-980.

Bennett, R. (1995): *International Marketing. Strategy, Planning, Market Entry & Implementation*. London: Kogan Page.

Chesbrough, H., (2006): *Open Business Model. How to Thrive in the New Innovation Landscape*. Boston: Harvard Business School Press.

Christensen, C. Raynor, M. E. (2003): *The innovator's solution: Creating and Sustaining Successful Growth.* Boston: Harvard Business School.

Cyfert, S. Mielcarek, P. (2011): *Modele Realizacji Działalności Innowacyjnej Przedsiębiorstwa*. Przegląd Organizacji, 4, 20-23.

Cooper, R. G. (1984): *The Strategy-Performance Link in Product Innovation*. R&D Management, 14, 4, October, 249-257.

Damanpour, F. (1991): *Organizational Innovation: a Meta-Analysis of Effects of Determinants and Moderators*: Academy of Management Journal, 34, 3, 555-590.

Davies, J. (2009): *Rotating Leadership and Symbiotic Organization: Relationship Processes in Collaborative Innovation*. Chicago: American Academy of Management Conference.

Drucker, P. (2006): *Innovation and Entrepreneurship*. New York: Routledge.

Freeman, C. Soete, L. (1997): *The Economic of Industrial Innovation*, New York: Routledge.

Grant, R. M. (2012): *Contemporary Strategy Analysis*, 8th Edition. Chichester: John Wiley & Sons.

Greve, H. R. (2007): *Exploration and exploitation in product innovation*. Industrial and Corporate Change, 16, 5, 945-975.

Harrington, H. J. (1991): *Business Process Improvement. The Breakthrough Strategy for Total Quality, Productivity and Competitiveness.* New York: McGraw-Hill.

Iansiti, M. Levien, R. (2004): *The Keystone Advantage: What the New Dynamics of Business Ecosystems Mean for Strategy, Innovation, and Sustainability*. Boston: Harvard Business School Press.

Kaplan, R. S. Norton, D. P. (1993): *Putting the Balanced Scorecard to Work*. Harvard Business Review, September – October, 134-147.

Kimberly, J. R. Evanisko, M. J. (1981): *Organizational Innovation: The Influence of Individual, Organizational, and Contextual Factors on Hospital Adoption of Technological and Administrative Innovations.* Academy of Management Journal, 35, 1, 689-713.

Mainiero, L., (1994): *Corporate Renewal: Evolutionary Or Leader Driven?* Academy of Management Executive, 8, 1, 83-84.

Martins E. G. Terblanche F. (2003): *Building Organisational Culture that Stimulates Creativity and Innovation*. European Journal of Innovation Management, 6, 1, 64-74.

Miles, R. E. Snow, Ch. C. Meyer, A. D. Coleman, Jr. H. J. (1978): *Organizational Strategy, Structure and Process*. The Academy of Management Review, 3, 3, 546-562.

Mielcarek, P. (2016): *Procesy Zarządzania Innowacjami w Przedsiębiorstwach Przemysłowych.* Warszawa: Difin.

Mintzberg, H. (1987): *The Strategy Concept I: Five Ps For Strategy.* California Management Review, 30, 1, 11-24.

Oslo Manual (2005): *The Measurement of Scientific and Technological Activities. Proposed Guidelines for Collecting and Interpreting Technological Innovation Data,* Organization for Economic Cooperation and Development, Paris.

Perri, P. Goodwin, N., Peck, E., Freeman, T. (2006): *Managing Networks of Twenty-First Century Organisations.* Hampshire: Pelgrave Macmillan.

Razavi, S. H., Attarnezhad, O. (2013): *Management of Organizational Innovation.* International Journal of Business and Social Science, 4, 1, 226-232.

Rothwell, R., Gardiner, P. (1983): *The Role of Design on Product and Process Change.* Design Studies, 3, 161-169.

Rothwell, R., Zegveld, W. (1985): *Reindustrialization and Technology.* London: Longman.

Tidd, J., Bessant, J., Pavitt, K. (2005): *Managing Innovation. Integrating Technological, Market and Organizational Change.* Chichester: John Wiley & Sons.

Whittington, R. (1994): *What is Strategy and does it Matter?* London: Routledge.

Zduńczyk, K., Blenkinsopp, J. (2007): *Do Organisational Factors Support Creativity and Innovation in Polish Firms?* European Journal of Innovation Management, 10.1, 25-40.

ECONOMIC ASPECTS OF SPACE INFORMATION TECHNOLOGIES FOR THE RATIONAL USE OF LAND RESOURCES

Экономические аспекты космических информационных технологий для рационального использования земельных ресурсов

Doctor of Economic Sciences, Professor, Zhavoronkova G., PhD (Economics), Associate Professor, Zhavoronkov V.
National Aviation University, Kyiv,
PhD (Economics), Associate Professor National University of horticulture, Melnyk L., Uman, Ukraine.
zhavor@ukr.net

Abstract: *The use of space information technologies (GIS) will optimize production through sustainable use of natural (land) resources, environmental protection and control of agricultural operations. Space information technologies are the basis for resource saving and ecological organic agriculture. The necessity of environmental monitoring to improve agricultural production using space information technologies of agricultural lands is defined. The values of GIS implementation are calculated. The main advantages provided by them are determined.*

KEYWORDS*: SPACE INFORMATION TECHNOLOGIES, LAND RESOURCES, ELECTRONIC AGROTECHNOLOGICAL MAPS, AEROSPACE PHOTOS, SPACE LAND MONITORING.*

1. Introduction

The transition of world agriculture on an intensive path of development requires that farmers increase the effectiveness while decreasing the cost of production. At present, the only way to control the profitability of agricultural production is the introduction of new technologies that allow maximizing the use of available resources. Among these technologies should be allocated space information technology to improve the efficiency of land use.

The main purpose of land use is ensuring the effective and rational use of lands of the society through regulation of land relations and the application of methods of organization and use of land resources. This commits the government to sustainable development of land use on the modern level with the use of achievements of world science and the latest technology in land management.

Particular urgency of these issues in terms of market transformation, when legislatively fixed different forms of land ownership. For many decades land use in the Ukraine was economically unnatural, sometimes destructive. For exterior lighting this problem, the knowledge of the laws and features of development of land use appropriate to note that absolute state ownership of land resulted in the delimitation of the environmental priorities in land use. It has become obvious that the methods of land management those have developed in the conditions of domination of state ownership of land and are still used to this day, do not meet modern requirements of market economy, do not meet the needs of economic entities on earth.

The efficiency of agricultural enterprises depends on awareness of the condition of crops and the ability to control the effects of operations and activities [1, p. 181]. The use of information technologies will enable the optimization of production through rational use of natural resources, protection of environment and control of agricultural operations. Space and information technologies are the basis of resource-saving and ecological organic agriculture.

Modern information technologies in agricultural production is not only the monitoring of natural and resource potential with a view to its rational use, but also timely adjustment of farming systems using technologies of precision farming. Based on information about the heterogeneity of physical and chemical indicators of soil nutrient content within a field, status, development and yield of crops. The use of such technology allows providing efficiency of the agricultural sector through increasing the economic impact from business activities and through the optimization of anthropogenic load on the natural environment.

2. Retrospective application of remote sensing technology to agricultural land

Information technology sensing of agricultural land started to be applied in the 30-ies of XX century in the United States, when planes were photographing fields to determine the exact acreage of crops and the monitoring of the quality of the soil cover [2, p. 55]. In the 60-ies of the last century began a new stage of development of these technologies, which created the preconditions for the progressive development of space technologies, which is still going on [3]. Since 1978 year, in the United States launched a program space removal – a Foreign Agricultural Service (FAS), whose task is monitoring and forecasting the gross yield of agricultural crops [5, p. 6].

In Europe in 1988, the EU Council of Ministers adopted a 10-year program using data of remote sensing for improving the statistical accounting in agriculture. Now this program acts as the project Monitoring Agriculture by Remote Sensing (MARS). It allows you to determine the area and condition of crops, to predict the yield of different crops within individual countries, administrative territories and farms [6].

In recent time, space and information technologies are increasingly used in the practice of management of the post-Soviet countries. In Kazakhstan the project "the national system of space monitoring of agriculture", which is based on European technology of state monitoring of agricultural production. In Russia, the popularity of satellite monitoring system to obtain timely information on crop areas, control over the timely conduct of agricultural activities, forecasting of losses and productivity.

3. Information technology sensing of agricultural land in Ukraine

In Ukraine, the research of remote monitoring of agrarian resources started since 1980. In the system of the Ministry of agriculture of the former USSR were established all-Union scientific-research center "agricultural resources" and the corresponding branch of the Institute in Ukraine [8].

Institute of Agroecology and environmental management NAAS and SE "Dniprokosmos" State space Agency of Ukraine (SSAU) developed the Concept of scientific-technical program "Monitoring agricultural resources and forecasting their status using remote sensing data" (Agrokomos) and created a lot of scientific-methodical and normative documents for the creation and dissemination of space information technology in the production practice, the domestic agricultural industry. With the support of the

Ministry of agrarian policy and food of Ukraine, State space Agency of Ukraine, institutions of NAS of Ukraine and company RapidEye AG implemented the pilot project "Monitoring agricultural resources using data from the RapidEye satellite system" (AGRO-UA) [8].

NSC "Institute for soil science and Agrochemistry im. A. N. Sokolovskiy", Kharkiv national agrarian University and National University of life and environmental Sciences of Ukraine started monitoring various characteristics of soil, erosion, degradation and methodology of soil survey using remote sensing and practical application of materials in economic activities.

Ukrainian scientific-research Institute of forecasting and testing techniques and technology. L. Pogorely is implementing a project on introduction of the European system of forecasting of productivity of MARS/CGMS developed by the joint research centre of the European Commission.

However, despite the significant volume of scientific studies, their findings remain fragmented, uncoordinated and not brought to the technological system used in industrial activities. According to the materials of the meeting of the Interdepartmental scientific Council of NAS of Ukraine and NAAS on the use of technology ERS APK (01.03.2011), Ukraine still has not developed a unified state system of remote (space) monitoring of agro-resources and information support of management in the agricultural sector [8].

At present, the use of information technologies for monitoring agricultural land in Ukraine is insufficient, although the legal basis of land monitoring provided for by article 191 of the Land code of Ukraine. Monitoring of land vested in the Central Executive body's national, regional and local level, carrying out state policy in the sphere of land relations and environmental protection [4].

In Ukraine adopted a Concept of implement the state policy in the field of space activities for the period up to 2032, in which developed the nation-wide target scientific and technical space program for 2013-2017, the goal of which is to improve the efficiency of use of space potential for solving urgent tasks of socio-economic, environmental, cultural, informational and scientific and educational development of society, ensuring national security and defense, protection of geopolitical interests of the state [7]. However, in this program little attention is paid to technologies of sensing of land for agricultural purposes.

4. Space technology to monitor the status of agricultural lands

The use of space technologies for monitoring agricultural land has a number of advantages, in particular, they provide:

- high accuracy and actuality of data;
- a wide range of the study area;
- a high frequency of new information;
- the possibility of collecting, storage, generalization and standardization of information [9, p.18].

The main sources of information used to monitor the status of agricultural land are aerospace imagery, topographic maps and agrotechnological e-cards.

Satellite images provide information about the change in the optical properties of the surface soils and are characterized by high data visualization. With their help it is possible to draw some conclusions about the nutrient content of the soil, to determine the sensitivity of crops to moisture of soil, the quality of crops within a single field that can be used as inputs to predict their yields.

Regarding space surveys, the main parameters determining the quality of the results of sensing are: the resolution and frequency of removal, spectral resolution and bandwidth scanning [9]. In addition to the space images for monitoring of land use topographic maps, charts, land maps and data agrochemical certification of fields, schema, sequence rotation, a cartogram of agricultural industrial groups of soils, which allow to achieve high accuracy and reliability of the results [10, p.5].

Today the most famous space providers of information technologies are the follows foreign companies: Cropio (USA / Germany), eLeaf (Netherlands), Precision Agriculture (Australia), Astrium-Geo (France), Vega (Russia), and national company MapExpert [11]. Most companies use in their practice accumulated by spacecrafts archive data of different exposure qualities, such as: SPOT 2, SPOT 4, Landsat 4, Landsat5, Landsat 7, IRSP6 LISS-3, ALOS, TerraASTER, IKONOS, QuickBird ObrView-3 , EROS and others. The resolution quality of photos and map scale determine the level of suitability of space photos of these devices (Table 1).

Moreover, such informational data to an archive database over a period of more than 20 years and can be used for analysis of land condition in the past, ensuring the land use of agricultural crops.

Table 1

Quality of space photos used for mapping of agricultural technologies [12]

Spacecraft	Resolution, meters	Map scale
IKONOS	4	1:20000
Landsat 7	30	1:150000
IRS – 1C	23,5	1:117000
IRS – 1C	5,8	1:29000
SPOT 1-4	20	1:100000
SPOT 4	10	1:50000
SPOT 5	5	1:25000
EROS A	2,4	1:12000
EROS B	0,7	1:3500
QuickBird	1,0	1:5000
ObrView-3	4,0	1:20000

Topographic maps are a picture of relief with the ability to determine the level of soil erosion and obtain information about a possible deposit of ground water level and so on. However, the maps present static condition of the land, without showing the real, dynamic migration processes and soil erosion caused by natural processes and anthropogenic activities. In General, the use of satellite images and topographic maps combine to give a complete picture of the field condition and level of development of crops.

Usage of modern electronic agrotechnological maps of fields are also equally effective method of monitoring of agricultural land in which space-time fixed costs of resources for field works are fixed. These maps provide the efficiency of agrotechnological process at the appropriate time, taking into account soil and climatic conditions of certain fields. Under certain technical conditions electronic agrotechnological map allows to:

- provide an opportunity to record and control all agricultural operations based on accurate baseline data for their implementation;
- assist in carrying out of a detailed analysis of the conditions that affect the development and growth of plants on specifically chosen field;
- optimize the production process in order to maximize profits and simultaneous rational use of resources involved in a particular transaction.

5. Economic aspects of agricultural land

One of the main ways to improve the efficiency of land use should be the study of the potential of the land with the help of electronic maps of fields. For this purpose it is necessary to create a system AgroGIS for exploring spatial data of electronic maps of fields. Functional diagram AgroGIS for evaluating the economic efficiency of land use is shown in Fig.1.

However, services of creating an electronic map of the field cannot be called cheaper because now they can be used only by the large agrarian enterprises. The value and duration of the works on creating of the electronic maps is represented in Table 2.

Usually, a high value of introduction of precision farming (37.8 - 43.8 thousand dollars USA), especially the electronic maps of fields, is very costly innovative project. However, those agrarian enterprises, which, nevertheless, dare to use space information technology in their work, will be able to carry out intensive and sustainable agricultural production development in the future.

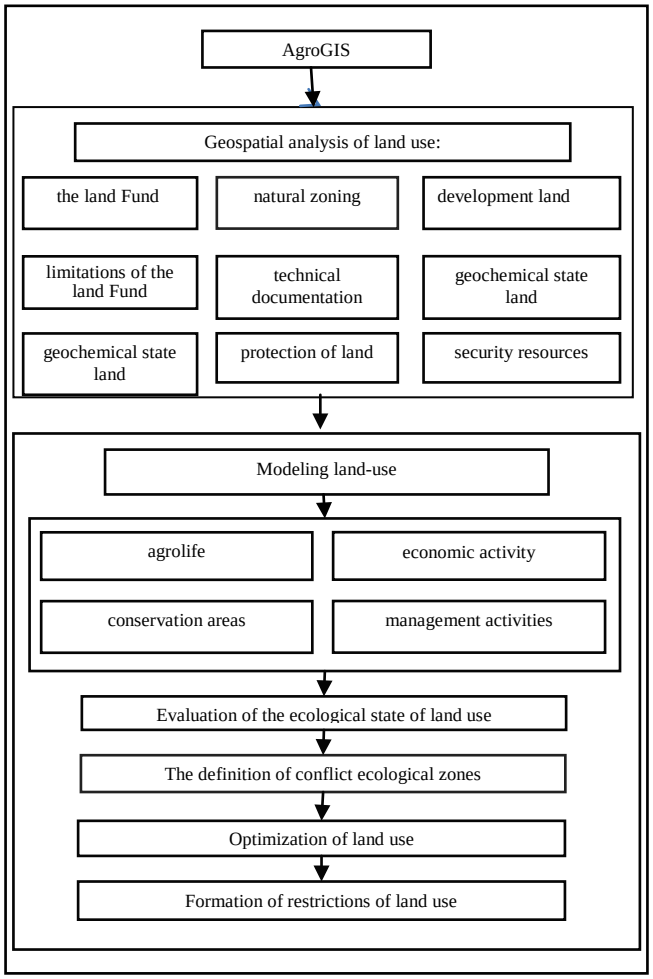


***Fig. 1** Functional diagram the use of geographic information systems to assess the effectiveness of land use*

Taking into account international experience (study of the American Institute of Precision Agriculture) and domestic realities the minimum amount of savings from the introduction of space information technologies has been calculated. According to Table 3 it is over 18 dollars USA per one hectare.

Table 2

The value of creating an electronic map of the field and duration of the works (for the area of 20 thousand hectares) [13]

Name	Value, dollars USA	Duration, days
High resolution space photo	3,200-6,200	over 30
Low resolution space photo	1,000-3,200	over 30
Hardware-software complex "HeoOblikovets"	10,000	60
Detour of field boundaries	10,000	20
Vectorization of field boundaries	2,400	20
Creation of electronic map	11,200	60

Reduction of fuel costs for inspection (detour) and processing fields and for fertilizer, reduction of staff costs will optimize resource costs, reducing the production costs, and thus increase the profitability of the production process.

Given the cost of creating of electronic maps of the field in 20 thousand hectares (37,800 dollars USA) and the possible amount of savings for the same area of agricultural land (36,480 dollars USA), the costs of enterprises for the implementation of space technologies in production can be considered as justified.

These information technologies allow to intensify agricultural production, increase productivity, increase efficiency of use of production assets and circulating assets, to achieve the highest level of productivity due to the dosed application of fertilizers and pesticides and reduce the anthropogenic influence on the ecological situation.

Table 3

Savings in production costs using space information technologies [11]

Cost items	on 1 hectare/year	on 1,000 hectares/year	on 100,000 hectares/year
	dollars USA	dollars USA	dollars USA
Fuel, spent on the detour of field territory	0.15	150	15,000
Wages to employees	0.8	840	84,000
Fertilizers	1.4	1,400	140,000
Control measurements and analyzes	1.28	1,280	128,000
Insurance	0.17	170	17,000
Control of mortgaged crop for the loan	0.2	200	20,000
Costs from too late identifying of weaknesses	8.7	8,700	870,000
Costs of low yields	5.5	5,500	550,000
Total	18.2	18,240	1,824,000

Cost estimation for implementation of space information technologies on the basis of precision agriculture is proof of the need for reorientation of agricultural enterprises on the latest technology of agriculture that will achieve the rationalization of the process of agricultural production and enhance competitiveness of crop production. It is therefore advisable to distinguish several stages of implementation of systems of land monitoring using space technologies, namely:

1. Collection and acquisition of geospatial databases – digitization of the boundaries and contours of the field, build maps, create satellite images.
2. The build routings for rotoorangi, sowing, application of fertilizers and plant protection means.
3. Direct work in the field with the use of auto GPS navigation system.
4. Mapping productivity with the use of satellite images and sensor yield and moisture, which are installed on tractors or combine harvesters.
5. Agronomic, economic and environmental assessment of effectiveness of introduction of new farming technologies. Agronomic and environmental effect is to make the right decisions regarding the amount of fertilizers and means of plant protection that will boost crop yields and reduce negative impacts on soil. The economic effect is to reduce the cost of cultivation of agricultural plants.

6. Conclusions

Implementation of latest achievements in information technologies of land cultivation and crop production is quite problematic for domestic enterprises and pose a threat to the technological security of agricultural sector. The main problems are:

- the lack of clear government policy concerning the space activities in the agricultural sector;
- problems in the creation of effective developments in technologies of remote monitoring of agrarian resources;
- necessity of modernization of machine and tractor fleet;
- significant value of space land monitoring;
- long payback period (5-10 years) of creating of electronic agrotechnical maps of fields;
- low readiness of domestic farmers to change of technical and technological support of agriculture and crop production.

In our view, the removal of these problems is possible only through the development of space activities through interdepartmental coordination of research of the National Academy of Agricultural Sciences, the Ministry of Agrarian Policy and Food

of Ukraine and the National Space Agency. This work will contribute to solving the problems of rational use of agricultural land, revealing weaknesses in agricultural landscapes, defining the status of crops and agricultural ecosystems.

The advantage of such cooperation in that the government by attracting domestic scientific staff promote the development of not only the space industry, and actively develop agriculture, with much lower costs and greater synergistic effect. In addition, such projects may be subject to foreign direct investments that are interested in maintaining ecosystems.

Thus, the use of modern space technologies is an objective requirement for successful agricultural practices, because information technologies:

- provide detailed monitoring of land resources and state of crops;
- help to form reasonable management decisions to the prevention of negative consequences of economic activity;
- can improve the efficiency of the use of land and quality of growing of agricultural plant;
- ensure the increase of productivity and reduce of production costs through rational use of fertilizers, pesticides, fuels and lubricants and so on.

In general, space information technologies ensure compliance with requirements of technological, environmental and economic security of the agricultural sector and the environment.

Among the priority scientific researches in the sphere of land use are: development of legal documents on creation of automated cadastral registration system; preparation of scientific and methodical bases of land-cadastral surveys using GPS; remote sensing of the earth.

The use of space technologies, the transition to automated land cadastre will provide the opportunity of building an effective national land administration system; promote the formation in Ukraine of an effective system of regional geographic information systems. Using them for the management of land resources will allow solving the problems of development of regions.

GIS technology can monitor the environment, intensify agricultural production, increase its productivity, improve efficiency of assets, and achieve higher levels of crop capacity due to dosage applying fertilizers and pesticides, which reduce the human impact on the environment. Considering the minimum amount of savings from the introduction of space information technologies, it can be concluded about the feasibility of their implementation in modern conditions in Ukraine.

7. References

1. Zhavoronkova G.V. Space information technologies in the system of technologic security of agricultural sector / Zhavoronkova G.V., Krachok L.I. // Bulletin of Chernovtsy Trade and Economic Institute. Economic sciences. Vol. 1 (57). – Chernovtsy: CHTEI KNEU, 2015. – P.180-188.

2. Shumakov A. Remote sensing for solving problems of agriculture: the experience of different countries / A. Shumakov // Earth from space – the most effective solutions. – 2011. No. 9. – P. 54-56.

3. Rogana J. Remote sensing technology for mapping and monitoring Land-Cover and Land-Use Change / John Rogana, Dong Mei Chenb [Electronic resource]. – Mode of access: http://gis.geog.queensu.ca/publicationpdfs/2004rsinplanning.pdf.

4. Land Code of Ukraine, adopted 25.10.2001, №2768-III // Vidomosti Verkhovnoyi Rady Ukrayiny (VVR). – 2002. – №3-4. – Art. 27.

5. Tarariko O.G. The use of space technologies in agricultural complex of Ukraine / Tarariko O.G., Syrotenko A.V., Voloshin V.I., Bushuev E.I., Parshina O.I., Grekov O.V. // Bulletin of Agricultural Science. – №7. – 2007. – P. 5-10.

6. Vlasova O. V. Monitoring of agricultural crops with the use of the European system of MARS // scientific Bulletin Tauride.– Kherson : Ailanthus, 2006. – Vol. 45. – P. 45-51.

7. The national target scientific and technical space program of Ukraine for 2013-2017 on September 5, 2013 No. 439-III. – Bulletin of the Verkhovna Rada (BVR). – 2014. – № 20-21. – 725 p.

8. About creation of the state program "Monitoring agricultural resources, forecasting of their condition with the aim of preserving the competitiveness of agribusiness and food security of Ukraine". – [Electronic resource]. – Access mode: http://www.agroua.net/news/news_38624.html?uid=fc58264d094efad6318dd71d7a3401bb.

9. Mikhailov S.I. The use of remote sensing data to solve problems in the field of agricultural production / Mikhailov S.I. // Earth from Space – the Most Effective Solutions. – 2011. – №9. – P. 17-23.

10. Yevsyukov T. Monitoring of especially valuable lands using remote sensing and GIS technologies / Yevsyukov T., Open'ko I. // Bulletin of Lviv National Agrarian University. Series: Economy of AIC. – 2013. – №20 (2). – P. 231-242.

11. Tymoshenko Y. Precision Agriculture and Ukrainian realities / Tymoshenko Y. // Agribusiness [Electronic resource]. – Available from Internet: http://www.agro-business.com.ua/2010-06-11-12-53-22/548-07-07-11-40-56.html.

12. Hrabak N.H. Fundamentals of agriculture and land protection / Hrabak N.H., Topiha I.N., V'yun V.I., Davydenko V.N., Chmyr S.M.: manual. – K.: Professional, 2005. – 796 p.

13. Innovative development of agricultural complex of Ukraine: manual / [R.I.Mala, V.V. Mironova, N.V. Eremeeva]; Donetsk Regional State Administration, Separated subdivision "Donetsk technical school of Lugansk National Agrarian University" – Donetsk, 2012. – 65 p.

CREATIVE LEARNING IN ICT-PROFESSORS' TRAINING PROGRAM

КРЕАТИВНОЕ ОБУЧЕНИЕ В ПРОГРАММе ПОВЫШЕНИЯ КВАЛИФИКАЦИИ иКТ-ПРЕПОДАВАТЕЛЕЙ

Prof. Dr. ped. Zakirova F.,
Dotc. Cand. tech. Migranova E.
Faculty of "Vocational education in the sphere of ICT" – Tashkent University of information technologies, Uzbekistan
f.zakirova@tuit.uz
e.migranova@tuit.uz

Abstract: *The main issues are considered in this article: urgency creative learning in the system for retraining and improving of pedagogical staffs' professional skills in the Republic of Uzbekistan, specificity of ICT-professor's activities, pedagogical conditions and content of ICT-professors' creative learning, pedagogical model and stages of organization classroom for ICT-professors' creative learning.*
KEYWORDS: *CREATIVE LEARNING, INFORMATION and COMMUNICATION TECHNOLOGies, higher education, system for retraining and improving of pedagogical staffs' professional skills, pedagogical model, curriculum, innovative TRAINING technologies.*

"Imagination is more important than knowledge"

A. Einstein

1. Introduction

In modern conditions of innovative education, creativity is considered as one of the main professional qualities of a teacher, since in a dynamically changing world the success of teacher's professional self-realization depends on his ability to find and make effective original decisions in a timely manner, be well orientated in the new context of education.

Effective forms, methods and means, on which possible to develop the creative potential of the teacher, in practically, the teacher of the Higher education (hereafter reoffered to as "a professor") is definition of the problem.

It should be noted that this problem is defined not only as socio-economic and socio-cultural changes in the society, but as well as the methodological problems. With a great interest of researchers to the concept of "the professor's creativity" there is still no clear mechanism for his development.

Each person has creative abilities and this idea is important for pedagogy.

In our opinion, any teacher is creative, moreover, the professor, who works in the field of information and communication technologies (hereafter reoffered to as "ICT-professor") is more creative, due to the innovative nature of information and communication technologies (hereafter reoffered to as "ICT") itself.

The purpose of the article is to examine the content and methods of developing the creativity of ICT-professors in the context of the system for retraining and improving of pedagogical staffs' professional skills in the Republic of Uzbekistan.

2. Preconditions and means for resolving the problem

2.1. Legal basis for the system of professional development of academic staffs in the Republic of Uzbekistan

The Law "On Education" and "On National Training Program", adopted in 1997, became an important factor in creating a national model for the training of personnel in the Republic of Uzbekistan.

In these basic documents, the system for retraining and improving of pedagogical staffs' professional skills is an independent type in the system of lifelong education, it that demonstrates the importance of this field in Uzbekistan.

The advanced training and retraining of pedagogical staff of the Higher educational institutions is carried out by *the Head Scientific and Methodological Center for professional development for academic and executive staff in Higher education*, as well as 16 branch centers for various fields of training programs in Tashkent and regional centers in the regions of our country.

The decree of the First President of the Republic of Uzbekistan No.91 from June 2, 2005 "*On improvement of the system of training in the field of ICT*" [1], *Tashkent University of Information Technologies* has been determined as a responsible university for a preparation of ICTs' specialists. Five branches of the university in the cities Nukus, Karshi, Samarkand, Urgench and Fergana provide training for ICTs' specialists in the regions of the country. In Mart 2017, Tashkent University of Information Technologies was named after Muhammad al-Khorazmi [2].

The decree of the First President of the Republic of Uzbekistan No.4732 from June 12, 2015 "*On measures to further improve the system of retraining and improving of pedagogical staff's professional skills of the Higher education*" [3] sets out the goals and tasks, as well as the structure of this system.

The main task of these branch centers for the system for retraining and improving of pedagogical staffs' professional skills is to disclosure of the creative potential of each academic staff, based on innovative and modern teaching technologies.

Achieving this goal is possible only with the use of adequate, purposeful, content and teaching technologies that involve each person in an active creative information and communication process, allow creating conditions for the awareness and effective application of acquired knowledge.

It is important to understand that techniques and skills of creative activity do not fit the traditional model of teaching and learning.

2.2. ICT-professors' training program

Changing the goal of learning primarily leads to change a content and a curriculum of the system for retraining and improving of pedagogical staffs' professional skills.

The new curriculum was developed for the system for retraining and improving of ICT-professors' professional skills, which includ the following training modules:

1) The legal and regulatory framework for Higher education,
2) Innovative training technologies and creativity,
3) ICT in education,
4) Practical English language,
5) Fundamentals of system analysis and decision making,
6) ICT-subjects,
7) Practice,
8) Attestation.

The percentage of these training modules in the curriculum is shown in the diagram (Fig. 1).

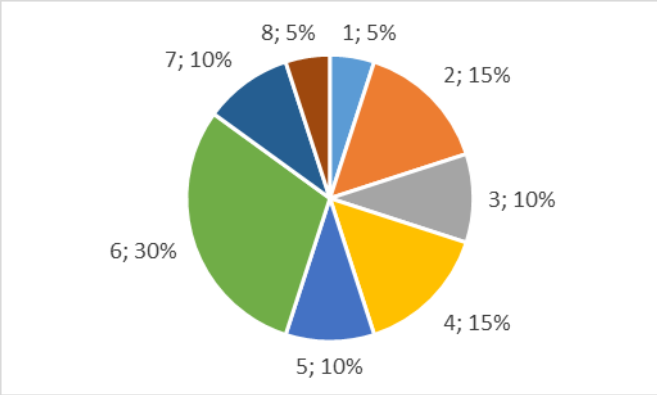


Fig. 1. *The curriculum of ICT-professors' training program*

Creativity has become one of two interrelated components in the program of the system for retraining and improving of ICT-professors' professional skills:

1) an independent training module;

2) a creative learning: "A form of education that develops people's potential for original ideas and actions" [4].

3. Problem-solving

3.1. A creativity as a training module

As an independent educational module, a creativity is presented the theoretical and practical point of view in the program of the system for retraining and improving of ICT-professors' professional skills.

The core of the module "Innovative training technologies and creativity" is consists of a familiarization and practical application with the basic approaches for development of creativity, as a necessary condition for the emergence of a creative personality, ability to go beyond the available knowledge, views, opinions and create a new one.

The module assumes the development of the creative potential of ICT-professors by reducing the share of reproductive activity and increasing the share of productive and creative activity.

In the classroom, ICT-professors solve situational tasks on methodological problems on the basis of methods of creativity development [5]:

- "10 discoveries",
- "Disney's Creative Strategy",
- "Plus. Minus. Interesting",
- "Novelty. Attractiveness. Exercise",
- "Simply. Complicated. Unrealistic", etc.

Additionally practical skills help to disclose the specific of the professional activity of ICT-professors, spastically, to use modern ICTs not only as an object of study, but also by means of innovative forms, methods and tools teaching and learning.

ICT-professors pioneer in introducing in innovative technologies into the educational process – an electronic learning systems, distance learning technologies, interactive electronic boards, 2.0/3.0 web-technologies, SMART-rooms, etc.

On the other hand, modern ICTs make possible to reveal the creative potential of the person [6].

3.2. The model of ICT-professors' creative leaning

The creative teaching is the creative education-research activity where both professors and listeners create the atmosphere where new innovative products are born.

Pedagogical conditions was developed for the effective development of ICT-professors' creativity:

1. Use a motivation of ICT-professors for scientific and innovational pedagogical activity.

2. Orient on a specific product in forms of a new pedagogical ideas, sites, blogs etc.

3. Competent-oriented work with the real pedagogical projects.

4. Use interactive forms, methods and tools for developing ICT-professors' creativity.

5. Use pedagogical innovations and results.

Since we are dealing with practicing ICT-professors, we need to make maximum use of their experience and innovative knowledge in the field of information and educational technologies, for we created the model of ICT-professors' creative leaning for the system for retraining and improving of pedagogical staffs' professional skills (Fig. 2).

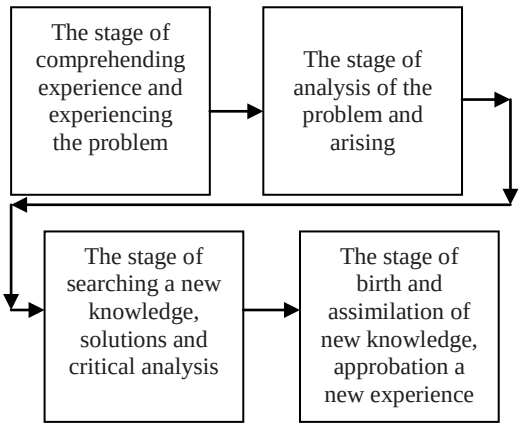


Fig. 2. The m*odel of ICT-professors' creative leaning*

In such creative teaching environment the main place is occupied by a group of interacting ICT-professors who, while discussing issues of interest and participating in discussions, stimulate and activate each other in statements and actions.

In order to implement creative ideas, ICT-professors, working in the group, carry out pedagogical projects, presenting their methodical products in the form of presentations (PowerPoint, Ispring, etc.), mental maps in MindMap, videos, blogs, educational and methodological software products, etc.

4. Results and discussion

The experiment was conducted at the branch Center for retraining and improving of ICT-professors' professional skills of Tashkent University of Information Technologies in November 2016, and also in January 2017.

In total, 103 participants of the system for retraining and improving of ICT-professors' professional skills (Table 1) in the areas:

- "Informatics and Information Technology" (IIT),
- "Computer Engineering" (CE),
- "Software Engineering" (PE).

Table 1. *General data*

№	Category	IIT	KE	PE	TOTAL
1	Without a scientific degree	48	14	22	**84**
2	Candidate of Science	8	3	5	**16**
3	Doctor of Science	2	1	0	**3**
4	Total**:**	**58**	**18**	**27**	**103**
5	Of them: -men; - women.	**40** **18**	**13** **5**	**24** **3**	**77** **26**

At the beginning of the experiment, a survey was conducted to determine the basic concepts of creativity development technologies.

The main questions and answers are reflected in the diagram (Fig. 3).

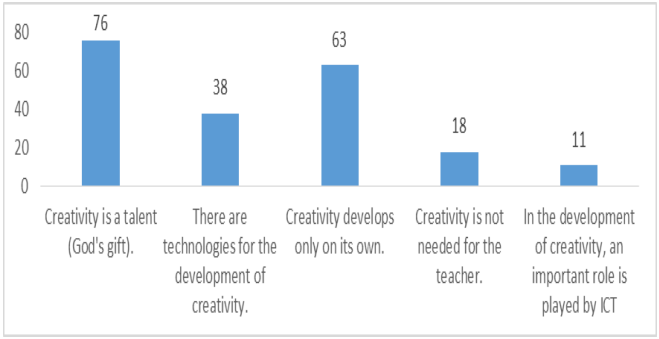


Fig.3. *The scheme of the analysis of the phenomenon of the ICT-professors' creativity*

The data of the questionnaire do not require comments and, in our opinion, reflect the insufficient awareness of the problem in question.

At the beginning of the study module "Innovative training technologies and creativity", testing was conducted to reveal the level of creativity according to the method of E.Torrance [7].

The analysis revealed that (Tabl. 2):

1.The factor of the flexibility is 56%;

2. The factor of the fluency is 31%;

3. The factor of the accuracy is 24%;

4. The factor of the originality is 23%.

Table 2. *Data of Torrance's testing*

№	Category	IIT	KE	PE
1	The factor of the flexibility (%) Of them: -men; - women.	55 54 56	51 49 53	62 61 63
2	The factor of the fluency (%) Of them: -men; - women.	31 29 35	29 26 32	34 33 35
3	The factor of the accuracy (%) Of them: -men; - women.	22 23 21	24 24 24	27 28 26
4	The factor of the originality (%) Of them: -men; - women.	25 27 22	21 22 20	22 25 19

The data of the testing are consistent with the fact that ICT-professors are creative by their nature and by the rapid development of modern ICTs.

It was also noted that female ICT-professors (and about 25% among ICT-professors) have a higher level of fluency and flexibility; however, they possess relatively lower originality; whereas the ICT-professors of the male gender have opposite characteristics.

This is consistent with the fact that women are more plodding and solve problems by existing methods, and men are trying to use non-traditional methods in order to do quickly.

After going through the training courses, ICT-professors noted that the followings were new for them:

- Creative abilities are widely used in pedagogical practice;
- Creativity manifests itself not only in individual activities, but also in collective activity;
- Creativity is developed through practice: participating in the processes of creative production thought: create programs for computer, computer diagrams and figures, sites, and so on;
- New technologies provide new opportunities for creative thinking, as well as new forms of access to ideas, information and people;
- Creative is not the subject of a curriculum; it is the general functions of education.

5. Conclusion

In conclusion, this article reveals the model of ICT-professors' creative leaning in the system for retraining and improving of pedagogical staffs' professional skills and its specificity.

The creative leaning is a main condition for the maximum development of ICT-professor's professional abilities that will enable to see, find, effectively solve and correctly evaluate solutions to creative problems in his activities. The model of ICT-professors' creative leaning consist of the four interrelated stages: comprehending experience and experiencing the problem, analysis of the problem, searching a new knowledge, solutions and critical analysis, birth and assimilation of new knowledge, approbation a new experience. This model corresponds with models of creative leaning by A.Osbrn [8] and K. Rossman [9].

The data of the experiment show that ICT-professor is a creative person, whose professional activity relat to ICT's innovation and ICT-professors' creativity able to be developed.

6. Literature

1. The decree of the First President of the Republic of Uzbekistan No.91 "On improvement of the system of training in the field of ICT"– Tashkent: 2005.
2. The decree of the First President of the Republic of Uzbekistan No.2834 "On measures to further improve the activities of Tashkent University of Information technologies " - Tashkent: 2017.
3. The decree of the First President of the Republic of Uzbekistan No.4732 "On measures to further improve the system of retraining and improving of pedagogical staff's professional skills of the Higher educational institutions" - Tashkent: 2015.
4. Loveless A. Creating spaces in the primary curriculum: ICT in the creative subjects. Curriculum Journal, 14 (1), 2003, 5-21.
5. Ilyin E. Psychology of creativity, creativity, giftedness. - St. Petersburg: Peter, 2009. – 217 p.
6. Polat, E.S. Modern pedagogical and information technologies in the education system: Textbook. Allowance for stud. Supreme. Training. Institutions / E.S. Polat, M.Yu. Bukharkin. - 2 nd ed., Sr. - Moscow: Publishing Center "Academy", 2008. - 368 p.
7. Torrance E. Guiding creative talent [Text] / E.P. Torrance. – Englewood Cliffs, N.J: Prentice-Hall, 1966. – 278 p.
8. Lefrancois G. Applied pedagogical psychology. - St. Petersburg: Prime-UVROZNAK, 2005. - 416 p.
9. Alan J. Creative thinking / Trans. in English. Astrovsky A. - M.: NT Press, 2007. - 176 p.

THE DIFFUSION OF INNOVATION AS A PART OF THE PROCESS OF CREATING INNOVATIVE PRODUCTS

Дифузията на иновации като част от процеса на създаване на новаторски продукти

Assoc. Prof. Petrova, Elitsa, PhD

National Military University, Veliko Tarnovo, Bulgaria,

elitsasd@abv.bg

Abstract: *Without claiming to be exhaustive, this paper aims at analysing the diffusion of innovation as a part of the process of creating innovative products. The essence of the innovation process, some models for developing new products, the stages of the innovation process, the diffusion of innovation and interconnectedness of the different elements in the process of developing new products are presented.*

Keywords*: diffusion, innovation*

1. Introduction

The innovation process is traditionally considered as a sequence of separate stages or activities. This model is indicated as a linear model for creating innovative products. There are two main variations of the linear model of innovation. The first is the technology-driven model, which suggests that the scientists do discoveries, the technologists continue to develop scientific ideas into products, the engineers and designers turn them into prototypes for testing, and finally the Marketing specialists supply the user with the end product. In the 70 years of the 20th century, it was found that the role of the market is fundamental to the innovation process. This fact leads to the creation of a second linear model of innovation that emphasizes the role of marketing as an initiator of new ideas stemming from the close relationship with customers and striving to meet their needs.

The results of the innovation process can be: fundamentally new and not analogous in the world; improvements and modifications that have received public and market recognition; existing products and technologies used in completely new areas. [1]

2. Basic models for creating innovation. Prerequisites for the study and ways to solve the scientific problem

In the 80s of the 20th century the linear model began to be questioned. The recognizing that the innovations become a reality through the interaction of science (controlled by universities and industry), technological development (controlled by industry) and the market needs is a significant step forward. The model of simultaneous binding shows that innovations are a result of connection between knowledge, production and marketing. The interactive model developed this idea by emphasizing that innovations arise as a result from the interaction between market, science and capabilities of the organization, while the network model recognizes that the creation of a new product should be seen as a process of knowledge accumulation over time.

It can be summarized that the basic models for creating innovation are: [2]

- 60s of the 20th century. Technology Driven Model or Model of Technological Pressure - a simple linear model of a sequential procedure where emphasis is placed on research and development and the market is the recipient of their results.
- 70s of the 20th century. Model of Market Pull - a simple linear sequential procedure, with a focus on marketing, where the market is a tool for research and development directing, and has a reactive character.
- 80s of the 20th century. Attachment Model - emphasis is placed on the integration of R&D and marketing.
- 90s of the 20th century. Interactive model - a combination of pull and push models for creating innovation.
- 2000. Networking model - focus is placed on the accumulation of knowledge and establishing cooperation between the organizations.

There are many models for developing new products, including: [3]

- Departmentalisation model. Each department is responsible for solving certain tasks. R&D departments provide interesting technical ideas, engineering departments develop prototypes of potential products, manufacturing departments organize and carry out production of viable product and marketing departments are responsible for introduction the product on the market.
- Engineering. The model aims at facilitating the integration of activities using feedback from customers and focusing on the project as a whole.
- Cross-functional model highlights on creating cross-functional teams of specialists with different skills.
- Response model is focused on the significant role of the user, as an external source of ideas, or on the significant role of the organization which creates new proposals, projects or ideas.

The dynamic changes in the socio-economic environment put contemporary organizations on a number of challenges, in response to which the need for adaptability is highlighted by organizational flexibility increasing [4].

3. Diffusion of innovative products. Solution of the examined scientific problem

The several stages can be distinguished in the innovation process. The creation of an idea for innovation (inventions) can be considered for a start of the innovation process, while the moment of complete exhaustion of opportunities for distribution of the product or technology in other fields or businesses can be defined as an end. Development of new products begins search of ideas for them. The needs and desires of the consumer are a logical starting point in the search for ideas. Among the sources of ideas unless users can be pointed also: employees, suppliers, distributors, participants in the distribution channels, employees in support services of the company's products, advertising agents, consultancies, R&D laboratories, university laboratories, media. They can suggest what the consumers like or do not like and what are the characteristics of the competitors' products or competition.

The main purpose of the selection of ideas is weaker ones to drop out at an early stage of the innovation process. At this stage the organization should answer to the questions such as:

- Does the product meet consumer's needs?
- Can the product be distinguished from alternative products?
- Does the product use the existing resources of the organization and skills of the staff?
- What investment is required for the product's development and its introduction on the market?

- What is the investment return?
- What are the potential benefits?
- What is the impact on the existing products and technologies?

All ideas which do not meet adequately one or more of the questions drop out during the innovation process. The concepts should be developed only for the most attractive ideas.

Once an idea is accepted by the management of the organization it needs confirmation by consumers. The idea testing begins with a description of the product in order to create consumer perceptions. The description gives information about product's strengths and weaknesses and includes the presentation of product's concept to a relevant target audience of users and at the same time tries to capture their reactions. By testing the concept, the company understands whether it differs significantly from other products, what benefits it provides to the consumer, how consumers would like the product to look like, whether they will buy it and at what price.

The next step in the innovation process is the development and testing of the product as a prototype. The prototype is a model of a finished product, which contains the basic properties without some additional elements. The finished prototypes are subjected to functional and user testing. The prototype is subjected to intensive laboratory tests to determine the reliability of its functioning in the laboratory during the functional testing.

The product testing is done by users in three versions:

- **α assay,** in which the product is tested in activity in the business unit from its workers and employees;
- **β assay,** in which the products are tested outside the business unit for a short period of time, attracting users to use the prototype and giving feedback on their experience with it;
- **γ assay,** in which products are tested outside the business unit for a prolonged period of time, in order to identify and eliminate any problems that users encounter in real use of the product.

If the product passes the tests successfully, the marketing department gives it a trade name, and a package and a program for testing in a real market environment are being developed. The finished product can be tested by:

• Introducing on a controlled small market where several retail outlets are agree to sell the new item, and to the creator is being allowed placement control, advertising and price control;

• Purchase simulating, where buyers are invited to watch products advertising, and then receive a certain amount of money that they can spend at the store and to be interviewed for the reasons for their purchase choice;

• Using a trial market where several localities or regions are selected on the national market and the product is being sold with different marketing strategies;

• Using the limited marketing applied only in a city with a specific marketing strategy in a few retail outlets;

• Using exposure to distribution halls;

• Using testing on market fairs.

The testing of the finished product is the last step before taking a decision to produce and sale the new product.

A detailed plan for entering the market is developed at the stage of commercialization. It should describe the core environmental factors, main opportunities and problems, strategy for introducing the product on the market, market segments, key marketing activities related to the product, its development, price, placement and distribution.

The speed of the diffusion process is to achieve a certain degree of dissemination of innovation for a period of time. It can be measured by the cumulative volume of sales or by the achieved percentage of distribution.

The scientific literature describes a market as a heterogeneous set of users. Consequently, it can be differentiated to market segments which are characterized with a variety in the consumer behaviour. The most popular studies on this issue are presented by Bass (1969) and Rogers (1996). [5]

The model for forecasting the diffusion of products by Frank Bass assumes that the behaviour of potential users of an innovation is influenced by two communication channels - mass media and interpersonal communications. Depending on the main source of information which relies on the individuals when deciding to purchase it can be distinguished two groups of consumers - innovators and imitators. The decision to purchase taken by the innovators is determined by information received from external to the social system sources (such as advertising), while the decisions of imitators have internal sources of information (interpersonal communication). The model presents the idea that the social pressure on the non-users becomes greater if more consumers buy a product. [6]

The analytical type of Bass model can be presented by the following equation:

$$n(t) = \underbrace{p(m - N(t))}_{I} + \underbrace{q\frac{N(t)}{m}(m - N(t))}_{II}, \quad (1)$$

where:

n (t) - the number of users who buy a new product in period t;

N (t) - the cumulative number of users who buy at least once a new product to the time t;

m - the potential number of users;

p - coefficient of innovation (coefficient of external influence);

q - coefficient of imitation (coefficient of internal impact);

I- purchases by innovators;

II- purchases by imitators.

Depending on the period of time required to users to decide on the acceptance, respectively rejection of an innovation after its introduction in the market, Rogers differentiates five consumer categories: innovators, fast adopters, early majority, late majority and laggards. Each category has specific socioeconomic and behavioral profile. Traditionally it is assumed that the promoting innovation efforts of enterprises should focus on innovators who subsequently stimulate the uptake of innovation by other users. This would lead to the emergence of snowball effect and acceleration of the diffusion process.

According to Kalyanaram and Urban, the businesses followers have a lower market share than the pioneering in a long-term [7], i.e. the later one marks appear on the market, the stronger is the negative competitive impact on its diffusion. This is explained by the growing resistance of the pioneer brand and early followers. Innovative followers, however, can have a faster diffusion, greater market potential, greater proportion of repeat purchases and even to delay the diffusion of pioneer brand.

4. Some results and discussion

Most authors share the view that an enterprise that first launches a product on the market has a greater chance of achieving a distinct competitive advantage. In a long run, these benefits lead to a greater market share from the pioneer enterprise compared to its predecessors. However, the pioneer company is exposed to a higher risk of failure of the new product. Followers have the opportunity to learn from the foreign experience and to avoid potential mistakes of the pioneer enterprise. They also have the chance to benefit from technological innovations and / or adapt to potential changes in the user preferences, which are significantly more dynamic at the start of the diffusion process.

Therefore, the choice of strategic position can be reduced to a choice between innovation leadership (leadership) and innovative follow-up. From the standpoint of the creating, implementing and spreading innovation an organization can fall into one of the following positions: 1) creator (inventor); 2) innovator (first implementer); 3) successor implementer; 4) non-invasive. The innovative leader is usually the organization that is the creator and implementer of an

innovation. The innovative study should be seen as a strategy where the follow-on organization seeks to avoid the difficulties of first entry and to benefit from the potentially lower costs for adaptation.

5. Conclusion

In conclusion, it can be reminded that the innovation process begins with the emergence of the creative idea and ends with its commercialization. This simple linear pattern is in the minds of most people. Recent studies in this regard, however, prove that the process should be seen as a simultaneous functional interaction between all the elements of innovation creation. Modern innovation management is aimed at reducing the demand cycle, i.e. at shortening the duration of a product's retention on the market.

References

1. Banabakova, V. Marketing. PH NMU, 2014, p. 129.
2. Rothwell, R. Successful Industrial Innovation: Critical Factors for the 1990s, R&D Management. Vol. 22, No. 3, 1992 in Trott, Paul. Innovation Management and New Product Development. 4th edition, Prentice Hall, 2008. Available at: https://books.google.bg/books?id=9hv4GqUq1E0C&printsec=frontcover&dq=Trott,+Paul,+Innovation+Management+and+New+Product+Development,+4th+edition,+Prentice+Hall,+2008
3. Saren, M. A Classification of Review Models of the Intra-firm Innovation Process. R&D Management, Vol. 14, No. 1, 1984, pp.1-24.
4. Dimitrova, S., Nichev, N., N. Stefanov. Development of Outsourcing Services. International Conference on Knowledge-Based Organisations, Volume 21, Issue 1, 2015, pp. 192–197.
5. Rogers, EM. Diffusion of Innovations. 4th edition, Free Press, 1995.
6. Bass, F. A New Product Diffusion Model for Consumer Durables. Management Science, 15 January, 1969, p. 215-227.
7. Kalyanaram, G., G. Urban. Dynamic Effects of the Order of Entry on Market Share, Trial Penetration, and Repeat Purchases for Frequently Purchased Consumer Goods. Marketing Science, Vol. 11, 1992. Available at: http://econpapers.repec.org/article/inmormksc/v_3a11_3ay_3a1992_3ai_3a3_3ap_3a235-250.htm