

INTERNATIONAL SCIENTIFIC JOURNAL



SCIENCE . BUSINESS . SOCIETY

YEAR 2, ISSUE 3/2017

ISSN PRINT 2367-8380

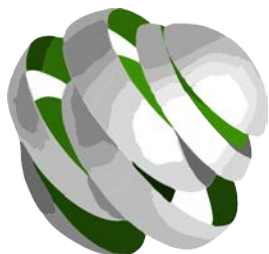
ISSN WEB 2534-8485

PUBLISHERS:

**SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING
"INDUSTRY 4.0"**

108 RAKOVSKI STR., SOFIA 1000, BULGARIA

NATIONAL SOCIETY "INDUSTRIAL & NATIONAL SECURITY"



INTERNATIONAL SCIENTIFIC JOURNAL **SCIENCE. BUSINESS. SOCIETY**

PUBLISHERS:

**SCIENTIFIC TECHNICAL UNION OF MECHANICAL ENGINEERING
“INDUSTRY 4.0”
NATIONAL SOCIETY “INDUSTRIAL & NATIONAL SECURITY”**

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

**ISSN: PRINT 2367-8380
ISSN WEB 2534-8485
YEAR II, ISSUE 3 / 2017**

EDITORIAL BOARD

CHIEF EDITOR

Prof. Dimitar Yonchev, Bulgaria

RESPONSIBLE SECRETARY:

Assoc. Prof. Hristo Karamishev, Bulgaria

MEMBERS:

Prof. Detlef Redlich, Germany	Prof. Sabina Sestic, Bosnia and Herzegovina
Prof. Ernest Nazarian, Armenia	Prof. Senol Yelmaz, Turkey
Prof. Garo Mardirosian, Bulgaria	Prof. Shaban Buza, Kosovo
Prof. Georgi Bahchevanov, Bulgaria	Assoc. Prof. Shuhrat Fayzimatov, Uzbekistan
Assoc. Prof. Georgi Pandev, Bulgaria	Prof. Sveto Cvetkovski, Macedonia
Prof. Iurii Bazhal, Ukraine	Prof. Teymuraz Kochadze, Georgia
Prof. Lyubomir Lazov, Latvia	Assoc. Prof. Veselin Bosakov, Bulgaria
Prof. Ognyan Andreev, Bulgaria	Prof. Vladimir Semenov, Russia
Prof. Olga Kuznetsova, Russia	Prof. Yuriy Kuznetsov, Ukraine
Assoc. Prof. Pencho Stoychev, Bulgaria	Prof. Zhaken Kuanyshbaev, Kazakhstan

CONTENTS

SCIENCE

NUMERICAL ASPECTS FOR OBTAINING TWO-SIDED BOUNDS OF EIGENVALUES

Assoc. Prof Racheva M. Dsc., Prof. Andreev A. Dsc. 104

FORMATION OF PROJECT AND RESEARCH SKILLS OF STUDENTS IN CALCULATION OF LIMITS

Prof. Dr. Kalimbetov B., PhD. Omarova I. 108

SIMULATION AND SOFTWARE DEVELOPMENT FOR SOLVING INTERNAL BALLISTICS PROBLEMS

PhD. Stelia O., PhD. Potapenko L., eng. Sirenko I. 111

INCREASING POTENTIAL OF ROBUST STABILITY OF SYSTEM BY ONE PARAMETER IN A CLASS OF FOUR-PARAMETER STRUCTURALLY STABLE MAPPINGS

PhD student Zakarina A., PhD student Bulatbayeva Yu. 115

MAIN CHARACTERISTICS OF THE RADIATION FROM DOMESTIC EARTH

Ass. eng. Dolchinkov N. T., Prof., Doctor of chemical sciences, eng. Haralampiev M. S. 118

BUSINESS

THE ASSESSMENT ANTHROPOGENIC IMPACT OF INDUSTRIAL OBJECT FOR ECOLOGICAL SYSTEM BASED ON INTEGRATED CRITERION

Ph.D., Abramova A. 121

INTEGRATED PERFORMANCE MEASUREMENT SYSTEM

M.Sc. Ahmed O. 125

RISK FACTORS INDUCED BY INSULATED MINE SELF-RESCUERS ON CHEMICALLY RELATED OXYGEN AFFECTING ON RESPIRATORY COMFORT

Prof. Gryzunov V.V. PhD., student Dzhemilev E.R., student Chipura S.I. 129

COMPARATIVE STUDY OF NOISE MEASUREMENT IN WORK ENVIRONMENT WITH FREQUENCY WEIGHTINGS

Doc. Ing. Michaela Balážiková, PhD., Ing. Martina Dulebová 132

SOCIETY

EXPERIENCE APPLICATION OF THE DUPLICATING WAY "WSEM-PC" FOR THE NOTIFICATION OF PEOPLE AT FIRE IN OFFICE BUILDINGS OF JSC RUSSIAN RAILWAYS

Sharkhun S., Doctor of Engineering Sirina N. 136

CROWDSOURCING LANGUAGE RESOURCES FOR SPEECH RECOGNITION

Ing. Daniel Hládek PhD., Ing. Ján Staš PhD., prof. Jozef Juhár CSc. 139

SYMPTOMS OF VERBAL DYSPRAXIA IN CHILDREN DIAGNOSED WITH SPECIFIC LANGUAGE IMPAIRMENT (SLI)

Denitsa Krusteva 143

ISLAM, THE BALKANS, IDENTITY

Assoc. Prof. Dr Veselin Bosakov 147

NUMERICAL ASPECTS FOR OBTAINING TWO-SIDED BOUNDS OF EIGENVALUES

Assoc. Prof. Racheva M. Dsc.¹, Prof. Andreev A. Dsc.^{1,2},
 Technical University of Gabrovo, Bulgaria¹
 Institute of Information and Communication Technologies – BAS, Bulgaria²
 milena@tugab.bg

Abstract: In this paper a new algorithm and numerical approach which gives two-sided approximations of eigenvalues for second-order problem is presented. Conforming finite element methods are used in combination with an appropriate nonconforming interpolation. Numerical Aspects are discussed and also experiments which demonstrate the proposed algorithm are given.

Keywords: CONFORMING/NONCONFORMING FINITE ELEMENTS, EIGENVALUE PROBLEM, TWO-SIDED BOUNDS OF EIGENVALUES

2000 subject classification: 65N25; 65N30

1. Introduction and Preliminaries

Let Ω be a bounded polygonal domain in R^2 with boundary $\Gamma = \partial\Omega$. Let also $H^m(\Omega)$ be the usual m -th order ($m \geq 0$) Sobolev space on Ω with a norm $\|\cdot\|_{m,\Omega}$ and $(\cdot, \cdot)$ denote the $L_2(\Omega)$ – inner product.

Consider the following weak form eigenvalue model problem: Find a number $\lambda \in R$ and a function $u \in V \equiv H_0^1(\Omega)$, $\|u\|_{0,\Omega} = 1$ such that

$$a(u, v) = \lambda(u, v), \quad \forall v \in V, \quad (1)$$

where

$$a(u, v) = \iint_{\Omega} \nabla u \cdot \nabla v \, dx \, dy \quad \forall u, v \in V.$$

The problem (1) has a countable sequence of real and positive eigenvalues $0 < \lambda_1 \leq \lambda_2 \leq \dots$ and the corresponding eigenfunctions $u_1, u_2, \dots$ can be assumed to satisfy $(u_i, u_j) = \delta_{ij}$, $i, j \geq 1$.

It is well-known that for second-order self-adjoint elliptic operator the eigenvalues computed using standard conforming finite element method (FEM) are always above the exact ones. This fact comes from minimum-maximum characterization of the eigenvalues (see for example [1]). Therefore, it is an important and interesting problem to find methods giving lower bounds of the eigenvalues.

Our contribution here is to obtain two-sided bounds of eigenvalues by using appropriate finite element spaces.

So, let $V_h \subset V$ be a conforming finite element space. The type of V_h will be specified later on. Then, the corresponding approximation of (1) is: Find a number $\lambda_h \in R$ and a function $u_h \in V_h$, $\|u_h\|_{0,\Omega} = 1$ such that

$$a(u_h, v_h) = \lambda_h(u_h, v_h), \quad \forall v_h \in V_h. \quad (2)$$

We suppose that τ_h is a triangulation of Ω which satisfies the usual regularity conditions (see [2]), i.e. there exists a constant $\sigma > 0$ such that $h_K / \rho_K \leq \sigma$, where h_K is the diameter of the element $K \in \tau_h$ (K is a rectangle or triangle) and ρ_K being the

diameter of the largest circle contained in K . Then we denote $h = \max_{K \in \tau_h} h_K$.

Let us introduce non-conforming finite element spaces $\tilde{V}_h$ related to the partitions τ_h . For this purpose we define mesh-dependent bilinear form

$$a_h(u, v) = \sum_{K \in \tau_h} a_K(u, v), \quad u, v \in V,$$

where

$$a_K(u, v) = \iint_K \nabla u \cdot \nabla v \, dx \, dy.$$

Obviously, in case of conforming FEM, $a(\cdot, \cdot)$ and $a_h(\cdot, \cdot)$ coincide.

Our algorithm applies so-called “nonconforming interpolation operator” $\tilde{I}_h: V \rightarrow \tilde{V}_h$ such that

$$a_h(v - \tilde{I}_h v, \tilde{v}_h) = 0, \quad \forall v \in V, \tilde{v}_h \in \tilde{V}_h. \quad (3)$$

Integral type finite elements in V_h and $\tilde{V}_h$ use integral values on their edges or/and on the elements itself as degrees of freedom. Thus, the obtained finite element space is integrally continuous at the common edges between any two adjacent elements. This feature enables us to construct smoothing and convergence accelerating a-posteriori procedures (see [3,4]). Here, we use integral type finite elements for purpose to obtain asymptotically lower bounds for eigenvalues. In recent years, there are some results in this direction (see e.g. [5] and references therein). But most of them use nonconforming finite element solutions. Obviously, it is valuable to find an interval as small as possible where the exact eigenvalue belongs to. But, it would be undesirably expensive to compute twice the eigenvalues – once using conforming FEM and second time by means of an appropriate nonconforming FEM.

Here, we propose a new procedure for determining bilateral finite element estimates. Namely, it is just sufficient to interpolate appropriately the already obtained finite element function.

2. Main Algorithm

Our method is based on determining pair of finite element spaces $(V_h, \tilde{V}_h)$ which we will precise below.

The crucial point, on one hand, is to verify the condition (3) and to ensure that the degrees of freedom of $\tilde{V}_h$ are a subset of the degrees of freedom of V_h , on the other.

So, distinctive feature of the proposed algorithm is its simplicity and applicability for a variety of integral type finite element spaces $(V_h, \tilde{V}_h)$.

Algorithm

1. Find (λ_h, u_h) from (2) by means of conforming finite element space V_h ;
2. Construct nonconforming space $\tilde{V}_h$ from V_h by eliminating some degrees in such a way that after obtaining of $\tilde{i}_h u_h \in \tilde{V}_h$ the condition (3) to be fulfilled;
3. Calculate the number $\tilde{\lambda}_h = a_h(\tilde{i}_h u_h, \tilde{i}_h u_h)$ which approximates the exact eigenvalues λ asymptotically from below.

As a result of the proposed algorithm implementation, two-sided bounds of eigenvalues λ are obtained:

$$\tilde{\lambda}_h \leq \lambda \leq \lambda_h. \quad (4)$$

Here we present some couple of elements which could be used for the algorithm implementation.

I. Triangular meshes

I.1. Six-point conforming finite element (degrees of freedom are the values at the vertices and the integral values on the edges of the triangle) and Crouzeix-Raviart (C-R) nonconforming element (degrees of freedom are the integral values at the edges of the triangle).

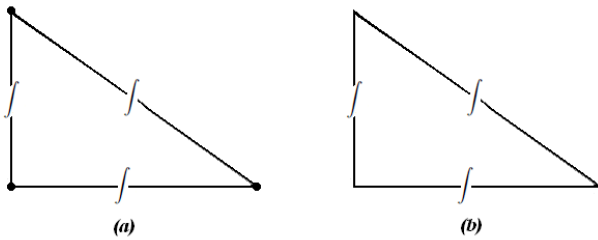


Fig. 1 (a) 6-point conforming triangle; (b) Crouzeix-Raviart nonconforming triangular finite element

I.2. Seven-point conforming triangle (degrees of freedom are the values at the vertices, the integral values on the edges of the triangle and the integral value over the triangle) and extended Crouzeix-Raviart (EC-R) nonconforming element (degrees of

freedom are the integral values at the edges of the triangle and the integral value over the triangle).

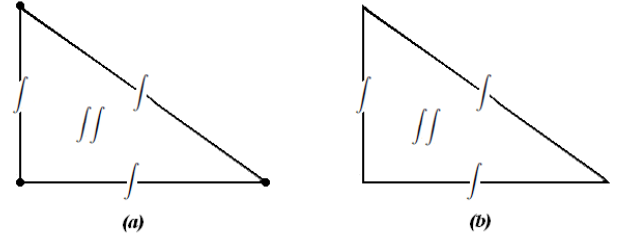


Fig. 2 (a) 7-point conforming triangle; (b) Extended Crouzeix-Raviart nonconforming triangular finite element

II. Rectangular meshes

II.1. Eight-point serendipity conforming finite element (degrees of freedom are the values at the vertices and the integral values on the edges of the rectangle) and Rannacher-Tourek (rotated bilinear element; Q_1^{rot}) nonconforming element (degrees of freedom are the integral values at the edges of the rectangle).

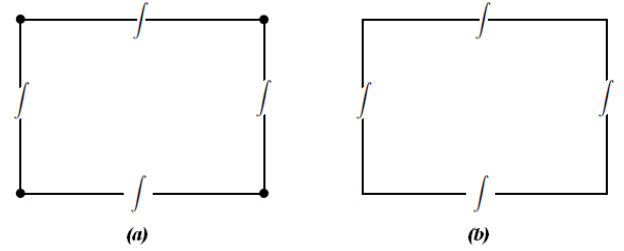


Fig. 3 (a) 8-point serendipity conforming rectangle; (b) Rannacher-Tourek (Q_1^{rot}) nonconforming finite element

II.2. Nine-point conforming rectangular element (degrees of freedom are the values at the vertices, the integral values on the edges of the rectangle and the integral value over the rectangle) and extended Rannacher-Tourek (extended rotated bilinear element; EQ_1^{rot}) nonconforming element (degrees of freedom are the integral values at the edges of the rectangle and the integral value over the rectangle).

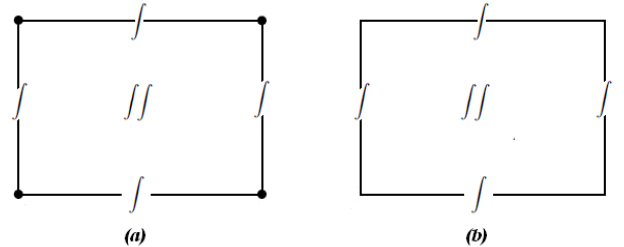


Fig. 4 (a) 9-point conforming rectangle; (b) Extended Rannacher-Tourek (EQ_1^{rot}) nonconforming finite element

Remark. For both cases (triangular or rectangular meshes)

$$\lambda_h - \lambda \leq C \|u - u_h\|_{1,\Omega}^2 = O(h^4)$$

and we suppose for $v \in V$ that

$$(a_h(\tilde{i}_h v - v, \tilde{i}_h v - v))^{1/2} \geq C h^{2-\delta},$$

where δ is small positive number.

3. Numerical Results

The results from numerical experiments given in this section serve as a verification and a confirmation that the proposed algorithm is valid, reliable and effective.

We will demonstrate the proposed method for problem (1) solving on square domain $\Omega = [0, \pi] \times [0, \pi]$.

The reason for this choice is that the exact eigenvalues are known. They are equal to

$$s_1^2 + s_2^3, s_1, s_2 = 1, 2, 3, \dots$$

First, we will use rectangular meshes, so that we divide the domain Ω into N^2 squares, $N = 4; 8; 12; 16; 20$. Thus the mesh parameter h is equal to $\frac{\pi\sqrt{2}}{N}$.

We solve the variational discrete problem (2) using conforming quadratic rectangular (9-point) finite elements for V_h (see Fig. 4(a)). As a result, we obtain the approximate eigenvalues λ_h , which give upper bounds for the corresponding exact eigenvalues and the approximate eigenfunctions u_h which we interpolate. Interpolation is done by means of EQ_1^{rot} -nonconforming finite element space (Fig. 4(b)). Obtaining the interpolants $\tilde{i}_h u_h \in \tilde{V}_h$ and calculating the numbers $\tilde{\lambda}_h = a_h(\tilde{i}_h u_h, \tilde{i}_h u_h)$ we get lower bounds for the exact eigenvalues. The results (4) from our numerical experiment for the first three eigenvalues are give in Table 1 and Table 2, respectively.

Table 1: Approximations of the exact eigenvalues obtained after finite element implementation by means of conforming rectangular quadratic finite elements

	$\lambda_{1,h}$	$\lambda_{2,h}$	$\lambda_{3,h}$
$N = 4$	2.001024281	5.030616274	5.032574099
$N = 8$	2.000065532	5.002110541	5.004469411
$N = 12$	2.000013002	5.000450150	5.002890554
$N = 16$	2.000004120	5.000165987	5.0026355170
$N = 20$	2.000001689	5.000087946	5.002571064
Exact eigenvalues	2	5	5

Table 2: Approximations of the exact eigenvalues obtained after nonconforming finite element interpolation

	$\tilde{\lambda}_{1,h}$	$\tilde{\lambda}_{2,h}$	$\tilde{\lambda}_{3,h}$
$N = 4$	1.902219920	4.655142682	4.656420455
$N = 8$	1.974624003	4.901823878	4.903948840
$N = 12$	1.988641719	4.955268267	4.957598338
$N = 16$	1.993595054	4.974626877	4.977033035
$N = 20$	1.995896103	4.983705600	4.986147765
Exact eigenvalues	2	5	5

Next, for the same model problem we demonstrate the efficiency of the proposed algorithm for triangular meshes. We divide the domain Ω into $2N^2$ isosceles triangles, $N = 4; 8; 12; 16; 20$, so that the mesh parameter h is equal to $\frac{\pi\sqrt{2}}{N}$.

We solve the variational discrete problem (2) using conforming quadratic triangular (6-point) finite elements for V_h (Fig. 1(a)). Thus we obtain the approximate eigenvalues λ_h , which give upper bounds for the corresponding exact eigenvalues and the approximate eigenfunctions u_h which we interpolate. Interpolation is done by means of CR-nonconforming finite element space (Fig. 1(b)). Obtaining the interpolants $\tilde{i}_h u_h \in \tilde{V}_h$ and calculating the numbers $\tilde{\lambda}_h = a_h(\tilde{i}_h u_h, \tilde{i}_h u_h)$ we get lower bounds for the exact eigenvalues. The results from our numerical experiment for the first three eigenvalues are give in Table 3 and Table 4, respectively.

Table 4: Approximations of the exact eigenvalues obtained after finite element implementation by means of conforming rectangular quadratic finite elements

	$\lambda_{1,h}$	$\lambda_{2,h}$	$\lambda_{3,h}$
$N = 4$	2.006678062	5.054137112	5.104918114
$N = 8$	2.000449550	5.004048686	5.007461785
$N = 12$	2.000090174	5.000832398	5.001526627
$N = 16$	2.000028690	5.000269489	5.000494590
$N = 20$	2.000011782	5.000113244	5.000209144
Exact eigenvalues	2	5	5

Table 4: Approximations of the exact eigenvalues obtained after nonconforming finite element interpolation

	$\tilde{\lambda}_{1,h}$	$\tilde{\lambda}_{2,h}$	$\tilde{\lambda}_{3,h}$
$N = 4$	1.881513965	4.418101457	4.288383144
$N = 8$	1.967022311	4.828857313	4.776079375
$N = 12$	1.985029796	4.921083851	4.895512927
$N = 16$	1.991516027	4.955005149	4.940188442
$N = 20$	1.994551051	4.971000836	4.961425791
Exact eigenvalues	2	5	5

As it is expected, the approximate values in Table 1 and Table 3 are greater than the exact ones and the sequences $\{\lambda_{j,h}\}, j=1,2,3$ obtained when the mesh parameter h decreases are decreasing, because of the fact that conforming finite element methods are used.

On the part of the nonconforming interpolation implementation, from the results given in Table 2 and Table 4, respectively, it is clear that the resulting approximation of the exact eigenvalues is from below. When the mesh parameter h decreases, the sequences $\{\tilde{\lambda}_{j,h}\}, j=1,2,3$ are increasing and go to the corresponding exact eigenvalue.

Let us also mention that the proposed algorithm works not only for simple eigenvalues, but also in case of multiple eigenvalues (see Table 2 and Table 4).

Concerning the implementation using triangular elements, it is to be observed here one more interesting phenomenon. In spite of the fact that the conforming approximation $\lambda_{2,h}$ of the exact eigenvalue $\lambda_2 = \lambda_3$ is more accurate than $\lambda_{3,h}$ (as usual for conforming finite element implementation), for the approximations $\tilde{\lambda}_{2,h}$ and $\tilde{\lambda}_{3,h}$ (see Table 4) the situation is rather the opposite.

6. Conclusions

The eigenvalue problems are important and appear in many fields, such as quantum mechanics, fluid mechanics, stochastic process, etc. Thus, a fundamental question is to find the eigenvalues of partial differential equations.

Based on the minimum-maximal principle discovered by Rayleigh, any conforming finite element method gives upper bounds of the eigenvalues (see [7]). Consequently, for purpose to find lower bounds for eigenvalues it comes natural to involve nonconforming finite element methods.

In this paper a new simple and original algorithm for obtaining two-sided bounds for eigenvalues of the Laplace operator is proposed. This algorithm could be extended for more general second-order elliptic operators and could be also applied to fourth-order eigenvalue problems.

The proposed algorithm gives lower and upper bounds of the eigenvalues simultaneously – it is only necessary to solve by conforming FEM the eigenvalue problem once and additionally to apply a nonconforming interpolation to the conforming solution.

In this connection, an another contribution of this paper is that a new manner of usage of nonconforming finite elements is introduced and demonstrated.

Acknowledgements This work was partially supported by the Technical University of Gabrovo under grant D1703E/2017.

References

1. I. Babuška, J. Osborn, Eigenvalue Problems, In Handbook of Numerical Analysis, Vol. II, (Eds. P. G. Lions and Ciarlet P.G.), Finite Element Methods (Part 1) North-Holland, Amsterdam, 641-787, 1991.
2. P.G. Ciarlet, The Finite Element Method for Elliptic Problems. North-Holland, Amsterdam, New York, Oxford, 1978.
3. Q. Lin, N. Yan, A. Zhou: A rectangle test for interpolated finite elements. In: Proceedings of Systems Science & Systems Engineering, 217-229, Culture Publish Co. (1991).
4. A.B. Andreev, M.R. Racheva: Superconvergence of the interpolated quadratic finite elements on triangular meshes, Math. Balkanica, New Series **19**, 3-4, 385-404 (2005).
5. Y.D. Yang, Z.M. Zhang, F.B. Lin: Eigenvalue approximation from below using nonconforming finite elements, Science China, Mathematics (2010), Vol. 53 No. 1, 137-150.
6. A.B. Andreev, M.R. Racheva: A new algorithm for two-sided eigenvalue approximation, Comp. rend. Acad. bulg. Sci., to appear.
7. G. Strang, G.J. Fix, An Analysis of the Finite Element Method, Prentice-Hall, Englewood Cliffs, New Jersey, 1973.

FORMATION OF PROJECT AND RESEARCH SKILLS OF STUDENTS IN CALCULATION OF LIMITS

Prof. Dr. Kalimbetov B., PhD. Omarova I.
H.A.Yasawi International kazakh-turkish university, Turkestan, Kazakhstan
E-mail: bkalimbetov@mail.ru, Omarovai10@mail.ru

Abstract. The paper is devoted to the problem about formation of project and research skills of students of natural sciences direction, using project and research activities on the subject "Mathematical Analysis".

KEYWORDS: PROJECT-RESEARCH ACTIVITY, COMPETENCE, RADICAL EXPRESSION, RATIONALIZATION, INDETERMINACY.

Introduction

Today different goals and objectives are qualitatively assigned to the educational system, which are defined by the dictated social order, by a new model of expert and professional. Consequently, it is necessary to form a personality, which is able to organize his professional career in the ever-changing socio-cultural conditions. Therefore, current priorities of higher education are aimed at development of specialist personality, the leading component of which is the possession of an independent creative and research activities [1].

Recently, the majority of researchers are turning to active teaching methods, such as - project and research. This trend is, firstly, is due to the fact that in recent years there is an increasing need of high school and university students to participate in the project and research activities. Therefore, the process of incorporation schoolchildren and students in cognitive activity is activated. In its turn, analysis of the performed works content allows to make a conclusion that in the most cases activity of executors is not entirely self-sufficient as research activity.

According to the heads of project and research works, the most of students are not able to independently propose and substantiate a hypothesis, plan an activity, formulate a goal, search and analyze necessary information, represent results of research, realize reflection, competently write a report. This is due to the fact that not only the students but also their teachers are not trained to project and research activities [2].

For the future bachelors of mathematics the most interest is the formation of project-research competence of students of natural sciences direction while studying mathematical analysis, as this course has broad opportunities to develop students' key subject competencies. Since the mathematical analysis is the main subject of general mathematical training for specialists, then it is real to form project and research competence exactly while teaching mathematical analysis.

The question is how to organize the learning process, where we not just give knowledge about the studied problems to students and build up their skills to work on the project, as well as research skills, but also solve the deeper problem of formation of project and research competence, the presence of which is necessary to continue mathematical education. The necessity of development these skills and competencies lies in the concept of higher education, since the main objectives of higher mathematical education are: development of creative student's abilities, formation of belief systems, value orientations, cognitive, subject and research skills and competences, ensuring students the readiness to continue professional education.

As an illustration, we present the project and research work "Calculation of limits, using rationalize substitutions", performed by students of H.A. Yasawi IKTU (Turkestan, Kazakhstan).

Results and discussion

As it is known, historically, that the study of rationalize substitutions by students is generally carried out in the course of mathematical analysis in the section "Integration of radical expressions", but in the calculation of limits these substitutions do not find their proper application. The main method of integration of these or other classes of differential expressions is to search the substitution $t = w(x)$, which leads the integrand to a rational form

and gives the opportunity to present the integral in the final form as a function of t .

If the function $w(x)$, which is to be substituted instead of t , is expressed in terms of elementary functions, then the integral is represented in the final form as a function of x . The method of solution, based on the rationalize substitutions, is called the method of rationalization (see., e.g., [3]).

This method, applied to rationalize various irrational and trigonometric expressions, and hence to solve irrational and trigonometric equations and inequalities, to calculate limits, etc., is a generalization of the well-known idea about the use of rationalize integration substitutions [4], where these substitutions are widely used to rationalize the various classes of differential expressions by I. Newton, L. Euler, P. Chebyshev and other mathematicians.

However, experience has shown that the use of rationalization method in the calculation of sequences and functions limits is very effective. Moreover, as rationalize substitutions they can apply or its analogical substitution, rationalizing integrand, or their minor modifications.

Let us consider some examples for calculating limits, using the rationalize substitutions. We denote rational functions of their arguments by $R(z(x), Z(x), \dots)$ and $R^*(t)$; where in the second function is obtained from the first one as a result of rationalize substitution $t = w(x)$. In view of the manifold rationalize substitutions we consider only some of them and give examples for calculating limits of specific functions.

I. Computation of limits, that contain radicals:

$$\lim_{x \rightarrow x_0} R\left(x, \sqrt[l]{\frac{ax+b}{cx+d}}\right),$$

where R is a rational function of two arguments, $l > 1$ – natural number, a, b, c, d – constants.

$$\begin{aligned} \text{Put } t = w(x) = \sqrt[l]{\frac{ax+b}{cx+d}}, \quad t^l = \frac{ax+b}{cx+d}, \\ x = z(t) = \frac{dt^l - b}{a - ct^l}. \end{aligned}$$

The limit transforms to

$$\lim_{t \rightarrow t_0} R(z(t), t);$$

Here the limit has a rational form, since R, z – are rational functions.

Example 1. Compute the limit:

$$\lim_{x \rightarrow 0} \frac{\sqrt[m]{2x+1} - \sqrt[n]{2x+1}}{x},$$

where m, n – are integers,

Solution. A direct calculation leads to indeterminacy of the type $\left(\frac{0}{0}\right)$. Use the substitution $t = \sqrt[l]{ax+1}$, i.e.

$$\begin{aligned} \sqrt[m]{2x+1} = t, \quad 2x+1 = t^m, \quad \sqrt[n]{2x+1} = t, \quad 2x+1 = t^n, \\ x = t^{mn} - 1. \end{aligned}$$

Then

$$\lim_{x \rightarrow 0} \frac{\sqrt[m]{2x+1} - \sqrt[n]{2x+1}}{x} = \left| \begin{array}{l} t = \sqrt[n]{ax+1}, \\ x \rightarrow 0, \\ t \rightarrow 1 \end{array} \right| =$$

$$= \frac{1}{2} \lim_{t \rightarrow 1} \frac{t^m - t^n}{t^{mn} - 1} = \frac{1}{2} \left(\frac{1}{m} - \frac{1}{n} \right).$$

II. Computation of limits, that contain trigonometric functions:

$$\lim_{x \rightarrow x_0} R(\cos x, \sin x).$$

Limits of this kind always can be rationalized by the substitution $t = tg \frac{x}{2}$ ($-\pi < x < \pi$).

$$\sin x = \frac{2tg \frac{x}{2}}{1 + tg^2 \frac{x}{2}} = \frac{2t}{1 + t^2},$$

Indeed, thus,

$$\cos x = \frac{1 - tg^2 \frac{x}{2}}{1 + tg^2 \frac{x}{2}} = \frac{1 - t^2}{1 + t^2}, \quad x = 2 \arctg t,$$

$$\lim_{x \rightarrow x_0} R(\cos x, \sin x) = \lim_{t \rightarrow t_0} R^*(t),$$

Therefore, limits of the type

$$\lim_{x \rightarrow x_0} R(\cos x, \sin x)$$

is always calculated in the final form; to express them, except for the functions occurring in the calculation of rational expressions, it is necessary only trigonometric functions.

Mentioned substitution, which is a universal for limit, contained trigonometric functions, leads sometimes to complex calculations. The goal can be achieved by simple substitutions in the following cases:

a) $t = \cos x, \quad t_0 = \lim_{x \rightarrow x_0} \cos x,$ if

$$R(\cos x, -\sin x) = R(\cos x, \sin x);$$

б) $t = \sin x, \quad t_0 = \lim_{x \rightarrow x_0} \sin x,$ if

$$R(-\cos x, \sin x) = R(\cos x, \sin x);$$

в) $t = tg x, \quad t_0 = \lim_{x \rightarrow x_0} tg x,$ if

$$R(-\cos x, -\sin x) = R(\cos x, \sin x).$$

Example 2. Compute the limit:

$$\lim_{x \rightarrow \frac{\pi}{6}} \frac{\cos^2 3x}{ctg^2 3x + \sin 6x}.$$

Solution. It is also indeterminacy of the type $\left(\frac{0}{0} \right)$. We use the

substitution $t = tg 3x$. As $x \rightarrow \frac{\pi}{6}$, $t \rightarrow \infty$. We make appropriate transformations:

$$\cos^2 3x = \frac{1}{1 + tg^2 3x} = \frac{1}{1 + t^2}, \quad ctg^2 3x = \frac{1}{tg^2 3x} = \frac{1}{t^2},$$

$$\sin 6x = \frac{2tg 3x}{1 + tg^2 3x} = \frac{2t}{1 + t^2}.$$

Then

$$\lim_{x \rightarrow \frac{\pi}{6}} \frac{\cos^2 3x}{ctg^2 3x + \sin 6x} = \left| \begin{array}{l} t = tg 3x, \\ x \rightarrow \frac{\pi}{6}, \\ t \rightarrow \infty \end{array} \right| =$$

$$= \lim_{t \rightarrow \infty} \frac{\frac{1}{1+t^2}}{\frac{1}{t^2} + \frac{2t}{1+t^2}} = \lim_{t \rightarrow \infty} \frac{\frac{1}{1+t^2}}{\frac{1+t^2+2t^3}{t^2(1+t^2)}} =$$

$$= \lim_{t \rightarrow \infty} \frac{t^2}{2t^3 + t^2 + 1} =$$

$$= \lim_{t \rightarrow \infty} \frac{\frac{1}{t}}{2 + \frac{1}{t} + \frac{1}{t^3}} = \frac{0}{2} = 0.$$

Example 3. Compute the limit:

$$\lim_{x \rightarrow \frac{\pi}{4}} \frac{\sin 4x - \cos 2x}{tg 4x}.$$

Solution. It is also indeterminacy of the type $\left(\frac{0}{0} \right)$. Use the

substitution $t = tg x$. Due to that $x \rightarrow \frac{\pi}{4}$, then $t \rightarrow 1$. We make appropriate transformations:

$$\sin 4x = 2 \sin 2x \cos 2x = \frac{4t}{1+t^2} \cdot \frac{1-t^2}{1+t^2} =$$

$$= \frac{4t(1-t^2)}{(1+t^2)^2}, \quad \cos 2x = \frac{1-t^2}{1+t^2},$$

$$tg 4x = \frac{2tg 2x}{1-tg^2 2x} = \frac{\frac{tg 2x}{1-tg^2 x}}{1 - \left(\frac{2tg x}{1-tg^2 2x} \right)^2} =$$

$$= \frac{\frac{4t}{1-t^2}}{(1-t^2)^2 - 4t^2} = \frac{4t(1-t^2)}{(1-t^2)^2 - 4t^2}.$$

Then

$$\lim_{x \rightarrow \frac{\pi}{4}} \frac{\sin 4x - \cos 2x}{tg 4x} = \left| \begin{array}{l} t = tg x, \\ x \rightarrow \frac{\pi}{4}, \\ t \rightarrow 1 \end{array} \right| =$$

$$= \lim_{t \rightarrow 1} \frac{\frac{4t(1-t^2)}{(1+t^2)^2} - \frac{1-t^2}{1+t^2}}{\frac{4t(1-t^2)}{(1-t^2)^2 - 4t^2}} =$$

$$= \lim_{t \rightarrow 1} \frac{\frac{4t(1-t^2) - (1-t^2)(1+t^2)}{(1+t^2)^2}}{\frac{4t(1-t^2)}{(1-t^2)^2 - 4t^2}} =$$

$$\begin{aligned}
& \frac{(1-t^2)(4t-1-t^2)}{(1+t^2)^2} = \\
& = \lim_{t \rightarrow 1} \frac{4t(1-t^2)}{(1-t^2)^2 - 4t^2} = \\
& = \lim_{t \rightarrow 1} \frac{(4t-1-t^2)[(1-t^2)^2 - 4t^2]}{4t(1+t^2)^2} = \\
& = \frac{(4-1-1)[(1-1)^2 - 4]}{4(1+1)^2} = -\frac{1}{2}.
\end{aligned}$$

Thus, familiarizing students to project and research activities, and development their respective intellectual and spiritual - moral qualities can be a solution of many problems of modern mathematical education, and provide the most natural way out of the designated position.

References

1. E.B. Pavlova, *Bulletin of BSU*, Ulan-Ude, **15**, 59-63 (2011).
2. T.V. Alnikova, *Autoabstract. ... cand. ped. sciences*, Tomsk, (2007).
3. G.M. Fikhtengol'ts, *Course of differential and integral calculus*, M.: Nauka, (1969).
4. B.P. Demidovich, *Collection problems and exercises in mathematical analysis*, M.: Nauka, (1969).

SIMULATION AND SOFTWARE DEVELOPMENT FOR SOLVING INTERNAL BALLISTICS PROBLEMS

МОДЕЛИРОВАНИЕ И ПРОГРАММНОЕ ОБЕСПЕЧЕНИЕ ЗАДАЧ ВНУТРЕННЕЙ БАЛЛИСТИКИ

PhD. Stelia O., PhD. Potapenko L., eng. Sirenko I.,
Faculty of Computer Sciences and Cybernetics, Taras Shevchenko National University of Kyiv, Ukraine.
oleg.stelya@gmail.com, lpotapenko@ukr.net, i.sirenko@gmail.com

Abstract: The problem of internal ballistics is considered, including basic pyrodynamic equation, law charge combustion, gasification law and equations of the projectile motion. A numerical method is used to solve a system of three algebraic and three ordinary differential equations. The software was developed and a number of computational experiments were made to analyze the influence of the charging parameter on the processes occurring during the projectile movement in the barrel channel. The problem of gunpowder burning and a finite-difference method to solve it are considered. The results of this work can be applied to the design of new types of trunks and charges.

KEYWORDS: INTERNAL BALLISTICS, MODEL, NUMERICAL SIMULATION, PYRODYNAMIC CHARACTERISTICS.

1. Introduction

Modern approaches based on ballistic computer models should be used to improve the efficiency of artillery defeat means. These developments are also required to create new artillery systems, shells and charges. Fundamental research in the field of ballistic theory, mathematical and cybernetic methods for solving problems of ballistics, and software development are required for this.

This paper is a continuation of works [1, 2] devoted to the development of mathematical methods, algorithms and software for solving ballistics problems.

Internal ballistics investigates the phenomena occurring in the barrel weapons under powder gases and other processes at a shot in the barrel [3–6]. Solving the problem of internal ballistics allows determining the dependence of the projectile velocity in the barrel on the time and the path which projectile passing in channel under different conditions of charging and calculating the parameters of new artillery systems.

The papers [7–10] are dedicated to using of mathematical models of internal ballistics problems. The work [7] describes a mathematical model of shot for low pressure in space behind the projectile. The paper [8] considers a mathematical model of internal ballistics based on the physical laws of powder combustion, and experimental results obtained by burning powder in the closed vessel. In [9] the mathematical model for the weapon system with additional propelling charges along the barrel to increase muzzle velocity were developed.

Paper [11] analyzes the changing characteristics of ballistic powder charges artillery ammunition of naval artillery systems for small caliber at post-warranty stages of storage on the basis of internal ballistics model. Papers [12–14] describe sophisticated models of artillery shot, using one- and two-dimensional gas dynamic equations of transient multiphase environments. Computer model of internal ballistics is widely used not only for military applications but also for civilians. For example, in [15] internal ballistics model was used to calculate the damper in the safety grooves of the car.

The aim of this work is to develop a numerical algorithm for solving the basic problems of internal ballistics, to develop the software for pyrodynamic processes simulation depending on the charging parameters. The mathematical model of gunpowder combustion is considered too. To implement this model a finite-difference scheme was developed using parabolic spline.

The paper presents the results of calculations for influence of the powder thickness tape on the pyrodynamic characteristics. Unlike analytical methods for solving basic problems of internal ballistics [3], the computer implementation is advantageous because it allows setting parameters of the model not only as a constant, but in the form of functional relationships and considering the increasing number of factors affecting the process shot.

2. Mathematical model of internal ballistics

Mathematical model of internal ballistics consists of six equations: three differential and three algebraic ones. According to [3], the system can be written as

$$(1) \quad \psi = \chi z(1 + \lambda z),$$

$$(2) \quad p = fw \frac{\psi - \frac{\theta \varphi q v^2}{2fw}}{s(l_\psi + l)},$$

$$(3) \quad \varphi q \frac{dv}{dt} = sp,$$

$$(4) \quad \frac{dl}{dt} = v,$$

$$(5) \quad \frac{dz}{dt} = \frac{p}{I_k},$$

$$(6) \quad l_\psi = l_0 \left[1 - \frac{\Delta}{\delta} - (\alpha - \frac{1}{\delta}) \Delta \psi \right].$$

Equation (1) describes the formation of powder gases. Here ψ is the relative mass of burned gunpowder, z is the relative thickness of the burned powder, and χ, λ are the powder grain form factors. These values are connected by the ratio $\lambda = (1 - \chi) / \chi$.

Equation (2) is the pyrodynamic basic equation that describes the process of expanding powder gases.

Here p is the pressure of powder gases, f is the force of powder, w is the mass of powder charge, θ is the expanding powder gases parameter, φ is the fictitious factor, q is the mass of the projectile, v is the projectile velocity, s is the chamber sectional area, l_ψ is the effective length of a chamber free volume, which given by (6), l_0 is the effective length of the chamber, l is the current position of the projectile in the barrel ($0 \leq l \leq L$, where L is the total path of the projectile in the barrel), δ is the powder density, α is the powder gases covolume, Δ is the charge density, I_k is the final pressure impulse powder gases.

The values I_k , Δ , and l_0 are calculated by formulas:

$$I_k = \frac{e_1}{u_1}, \quad \Delta = \frac{w}{W_0}, \quad l_0 = \frac{W_0}{s},$$

where e_1 is the thickness of the powder burning layer, u_1 is the powder burning speed ratio, W_0 is the chamber volume.

This system is closed with initial conditions and used to determine the pyrodynamic parameters at any time moment t .

The initial condition for equation (5) is calculated from equations (1) and (2) at the end of pyrostatic period when some powder burns. This amount of powder is determined by the values ψ_0 and z_0 . We have set forcing pressure p_0 for calculate these values.

So, with (2) we have

$$p_0 = \frac{f\Delta\psi_0}{1 - \frac{\Delta}{\delta} - (\alpha - \frac{1}{\delta})\Delta\psi_0}.$$

Solving this equation with regard to ψ_0 , we get

$$\psi_0 = \frac{\frac{1}{\Delta} - \frac{1}{\delta}}{\frac{f}{p_0} + \alpha - \frac{1}{\delta}}$$

Knowing ψ_0 , we found z_0 from (1):

$$\begin{aligned} \psi_0 &= \chi z_0 (1 + \lambda z_0) \\ z_0 &= \frac{-1 + \sqrt{1 + \frac{4\lambda\psi_0}{\chi}}}{2\lambda} \end{aligned}$$

The projectile motion starts at zero time. The system of equations (1)–(6) is solved with such initial conditions

$$v = 0, \quad l = 0, \quad z = z_0 \quad \text{when } t = 0.$$

3. Mathematical model of stationary gunpowder combustion

Stationary combustion of gunpowder is described of equations [16, 17]

$$(7) \quad D \frac{d^2 T}{dx^2} - V \frac{dT}{dx} = -f, \quad x \in (0, L),$$

$$(8) \quad \frac{dy}{dx} = \Phi(T),$$

here T is the temperature, D is the coefficient of thermal conductivity, $V = u \cdot c \cdot \rho$, u is the speed of the front of combustion, c is the heat capacity, ρ is the density, $f = Q \cdot \Phi(T)$, Q is the heat of reaction,

$\Phi(T) = k_0 \exp(-\frac{E}{RT})$, k_0 is pre-exponential factor, E is the activation energy, R is the universal gas constant, and y is the mass concentration of powder.

The appropriate boundary conditions are set for the equation (7) and initial condition is set for the equation (8).

For solving the boundary problem for the equation (7) we used the finite-difference scheme based on parabolic spline [18]. To use the finite-difference scheme it is necessary to split the interval $(0, L)$. For this purpose, two splitting (Δ_x and Δ_τ) are defined:

$$(9) \quad \Delta_x : 0 = x_0 < x_1 < \dots < x_N = L,$$

$$(10) \quad \Delta_\tau : 0 = \tau_0 < \tau_1 < \dots < \tau_{N-1} = L,$$

where $x_i < \tau_i < x_{i+1}$, $i = \overline{1, N-2}$.

Then the finire-difference scheme is written as

$$(11) \quad \begin{aligned} &\phi_{\tau_{i-1}} \left(\frac{D}{h^2} + \frac{V}{h^2} \mu \right) - \phi_{\tau_i} \left(\frac{2D}{h^2} - \frac{V}{h} \left(1 - \frac{2\mu}{h} \right) \right) + \\ &+ \phi_{\tau_{i+1}} \left(\frac{D}{h^2} - \frac{V}{h} \left(1 - \frac{\mu}{h} \right) \right) = -(f_{x_{i+1}} + f_{x_i})/2, \quad i = \overline{1, N-2}. \end{aligned}$$

where ϕ_{τ_i} is the lattice function that approximates the solution of equation (11) at the grid.

The finite-difference scheme is monotonous and has a unique solution. This follows from the following theorem [19].

Theorem. Let the following conditions be satisfied for the splitting (9)–(10):

$$\tau_{i+1} = \tau_i + h, \quad i = \overline{0, N-2}, \quad h > 0, \quad N = L/h + 1,$$

$$x_1 = x_0 + h - \mu, \quad x_{i+1} = x_i + h, \quad i = \overline{1, N-2},$$

$$x_N = x_{N-1} + \mu, \quad 0 < \mu < h.$$

Then, if $\mu > h - \frac{D}{|V|}$ and $V > 0$ or if $\mu < \frac{D}{|V|}$ and $V > 0$ the

difference maximum principle for (11) is valid.

Since the right-hand side of Equation (7) contains the desired solution, the system of the finite-difference equations is nonlinear. The combined Newton's method and successive upper relaxation method is used for solution of the system [20]. The Kutta-Merson method is used for solving the Cauchy problem for the equation (8).

4. The results of computational experiments

For solving the ordinary differential equations (3)–(5) we use the Kutta-Merson method [21]. The advantage of this method over the "standard" Runge-Kutta 4th order method is an opportunity to evaluate error at each step of calculations without additional computational cost. This allows choosing a necessary step for the series of sample calculations. This method worked well for solving the problem of external ballistics [1]. The software was developed according to the constructed algorithm.

To conduct the computational experiments we should set a significant amount of numerical parameters which are divided into groups such as gunpowder parameters, gun and projectile characteristics, charging conditions.

For these calculations we used data for 100 mm guns from [22]. Computational experiments were conducted for strip of nitroglycerine gunpowder with different thickness of strip (Table 1).

We used the following gunpowder parameters: $\delta = 1600$ kg/m³, $\alpha = 0,001$ m³/kg, $f = 950\,000$ J/kg,

$u_1 = 0,6 \cdot 10^{-9}$ m³/(N·s), $\theta = 0,2$. Charging conditions was

$w = 7,15$ kg. Gun and projectile characteristics were $q = 16$ kg,

$s = 0,0082$ m², $W_0 = 0,011$ m³, $L = 5,53$ m, $\phi = 1,15$,

$l_0 = 1,3415$, $p_0 = 3 \cdot 10^7$ Pa.

Examples of calculating the pyrodynamic characteristics such as dependence the pressure of powder gases in the space behind the projectile and speed of the projectile on the time are shown at Figures 1 and 2 (numbers are corresponding to different rows of Table 1). The dependence of the pressure of powder gases in space behind the projectile and speed of the projectile on the position of the projectile in the barrel is shown in Figure 3.

Using the model, varying the gunpowder strip thickness, we can adjust the rate of gas formation at a shot and get the optimal ratio between maximum pressure in the space behind the projectile and muzzle velocity. The importance of such calculations is due to the fact that the thinner powder gives more gas per unit time and may create a pressure that exceeds its allowable value for the strength of the barrel. On the other hand, the thicker powder may have not time to burn in the barrel.

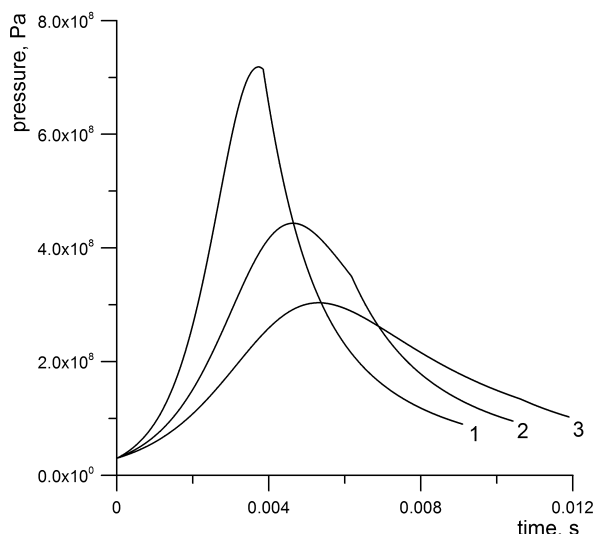


Fig. 1. Dependence of the powder gases pressure in the space behind the projectile on the time at the shot with different powder strip thicknesses

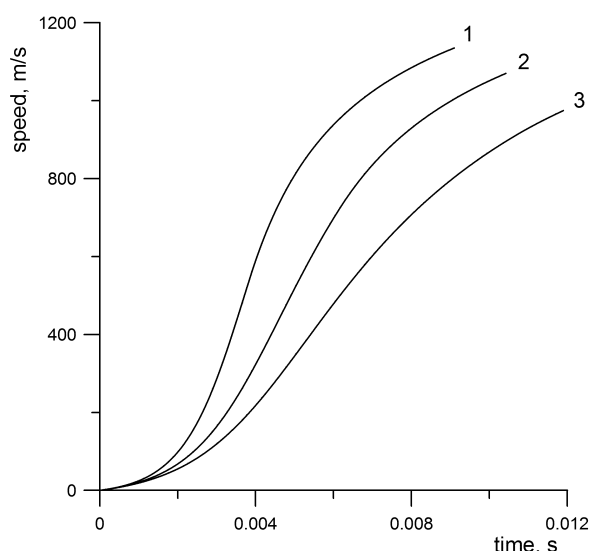


Fig. 2. Dependence of the projectile speed on the time of the shot with different powder strip thicknesses

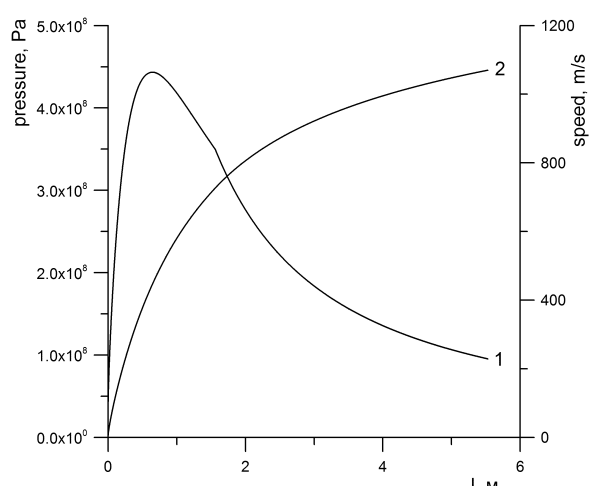


Fig. 3. Dependence of pressure powder gases (1) and the projectile speed (2) on its position in the barrel when fired (l)

Figure 4 shows pyrodynamic curves corresponding to the different thicknesses powder strips. Number of graphs corresponds to the different rows of Table 1.

The curves of Figures 1 and 4 have the points at which the derivative is ruptured. These are the points of the end of the first pyrodynamic period.

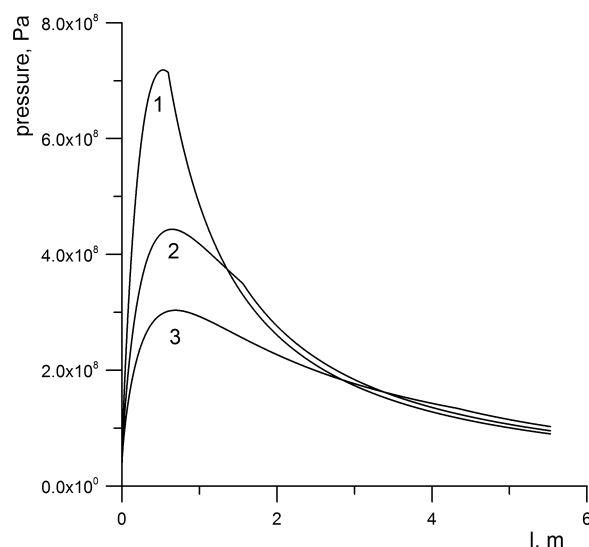


Fig. 4. Dependence of the powder gases pressure in the space behind the projectile on the position of the projectile in the barrel during firing for different powder strip thicknesses

Table 1: Value of pyrodynamic characteristics for different thicknesses of powder strip

№	Strip thicknesses $2e_1$, mm	Maximum pressure, Pa	Muzzle velocity, m/s
1	1,5	$0,71839 \cdot 10^9$	1135,2
2	2,0	$0,44335 \cdot 10^9$	1070,0
3	2,5	$0,30337 \cdot 10^9$	974,6

Literature

- [1] Stelia O.B., Potapenko L.I., Sirenko I.P. Computer simulation of the trajectory of the center of mass of the body thrown at an angle to the horizon. 2014. No 3(117). P. 87–94.
- [2] Buy D., Stelia O., Sirenko I., Potapenko L. Development of computational techniques to solve problems external and internal ballistics. International scientific journal "Science, business, society". 2016. Iss. 4. P. 3–6.
- [3] Serebryakov M. E. Internal ballistics of barrel systems and powdered missiles. Moscow, Oborongiz. 1962. 705 p.
- [4] Zaharenkov V. F. Internal ballistics and automation of design of artillery guns. Sankt-Peterburg., Balt. gos. tehn. un-t, 2010. 276 p.
- [5] Benevol'skiy S. V., Burlov V. V., Kazakovtsev V. P. Ballistics. Penza, PLII, 2005. 510 p.
- [6] Corner J. Theory of the interior ballistics of guns. New York, Wiley. 1950. xiii, 443 p.
- [7] Chankaev S. K., Yakovlev V. Ya. Dynamics of the projectile's motion at low pressures in the trunk. Applied mechanics and technical physics. 2007. Vol. 48, No 6. P. 44–49.
- [8] Vasile T., Safta D., Barbu C. The fundamental problem solving of interior ballistics using the physical law of powder burning. AARMS Mechanics. 2004. Vol. 3, No 3. P. 407–414.
- [9] Hajn. M. Projectile velocity increase by use of separated propellant charge, Advanced in modern mechanical engineering, Proceedings of the 4th International Conference on Fluid Mechanics and Heat & Mass Transfer (FLUIDSHEAT '13) Dubrovnik, Croatia, June 25–27. 2013. P. 128–133.

- [10] Jedlicka L., Komenda J., Beer S. Analysis of Ballistic Characteristics of Pistol Cartridge. *Advances in Military Technology*. 2012. Vol. 7, No 1. P. 32–40.
- [11] Verteletskyi V. F. The task of assessing the state of powder charges artillery ammunitions of small caliber naval nomenclature. *Proceedings of the Academy of of naval forces named P. S. Nakhimova*. 2012. Iss. 1(9). P. 37–44.
- [12] Chankaev S. K., Yakovlev V. Ya. Dynamics of the projectile movement at low pressures in the barrel. *Applied mechanics and technical physics*. 2007, No 3(41), Part 2. P. 173–180.
- [13] Rashad M., Zhang X., Elsadek H. Interior ballistic two-phase flow model of guided-projectile gun system utilizing stick propellant charge, *WSEAS Transactions on Applied and Theoretical Mechanics*. 2014. Vol. 9. P. 124–135.
- [14] Tenenev V. A., Rusyak I. G., Sufiyanov V. G., Ermolaev M. A., Nefedov D. G. Construction of approximate mathematical models on results of numerical experiments. *Bulletin of the South Ural State University, Ser. Mathematical Modelling, Programming & Computer Software*. 2015. Vol. 8, No 1. P. 76–87.
- [15] Kartashova E. D., Muyzemnek A. Yu., Zemskov R. A. Perfection of systems of maintenance of passive safety of cars on the basis of computer modeling of processes of functioning of pyrotechnic elements. *News of higher educational institutions. The Volga region. Technical science*. 2012. No 3. P. 110–119.
- [16] Knyazeva AG, Dyukarev A.E. About modes of solid-phase decomposition of single crystals of initiating explosives. *Physical mesomechanics*. 2000. No 3. P. 97–106
- [17] Merzhanov A. G., Dubovitsky F. I. To the theory of steady burning of gunpowder. *Reports of the USSR Academy of Sciences*. 1959. Vol. 120. No 1. P. 153–156.
- [18] Stelia O. B. About existence of the one parabolic spline. *Journal of Computational and Applied Mathematics*. 1997. No 1(81). P. 124–129.
- [19] Stelia O. B. Solving boundary value problems for ordinary differential equations using parabolic splines. *Journal of Computational and Applied Mathematics*. 2007. 1(94). P. 91–98.
- [20] Ortega J. M., Rheinboldt W. C. Iterative solution of nonlinear equations in several variables. *CIAM*. 2000. xxvi + 572 p.
- [21] Arushanyan O. B., Zaletkin S. F. Numerical solution of ordinary differential equations on Fortran. *Moscow, MGU*, 1990. 336 p.
- [22] *Grounds for the design and construction of guns and ammunition for ground artillery*. Moscow, Military Publishing House of the Ministry of Defense of the USSR. 1976. 460 p.

The positive definiteness of the Lyapunov function (9) will be determined by conditions

[illegible]

From (3) we find the decomposition of the components of the velocity vector into the coordinates of the system

[illegible]

The total time derivative of the Lyapunov vector-valued function is

$$\begin{aligned} \frac{dV}{dt} = & -x_2^2 - x_3^2 - \dots, -x_n^2 - \\ & - \left(\frac{1}{2} x_2^2 x_1 - x_1^4 - k_2 x_1^2 - (a_n - k_3) x_1 \right)^2 - \\ & - \left(\frac{1}{2} x_2^2 x_1 - k_1 x_2^2 - (a_{n-1} - k_4) x_2 \right) - (a_{n-2} x_3)^2 - \dots, - (a_1 x_n)^2 \end{aligned} \quad (8)$$

From (8) we get that the total time derivative of the Lyapunov vector-valued function is a sign-negative function, hence a sufficient condition for the asymptotic stability of system (3) with respect to the stationary state (5) is satisfied.

By a gradient from the Lyapunov function we construct Lyapunov functions in the form

$$V(x) = \frac{1}{4}x_2^2x_1^2 + \frac{1}{5}x_1^5 + \frac{1}{5}x_2^5\frac{1}{3}k_2x_1^3 + \frac{1}{2}(a_n - k_3 - 1)x_1^2 + \frac{1}{2}(a_{n-1} - k_4 - 1)x_2^2 + \frac{1}{2}(a_{n-2} - 1)x_3^2 + \dots, + \frac{1}{2}(a_1 - 1)x_n^2 \quad (9)$$

$$\begin{cases} a_n - k_3 - 1 > 0 \\ a_{n-1} - k_4 - 1 > 0 \\ a_{n-2} - 1 > 0 \\ \vdots \\ a_1 - 1 > 0 \end{cases} \quad (10)$$

Thus, the stationary state (5) of system (3) will be asymptotically stable if conditions (10) are satisfied

Let us investigate the stability of the stationary state (7) and write for this equation of state (3) in the deviations with respect to the stationary state (7)

$$\left\{ \begin{array}{l} \frac{dx_1}{dt} = x_2 \\ \frac{dx_2}{dt} = x_3 \\ \dots \dots \dots \dots \dots \dots \dots, \\ \frac{dx_n}{dt} = -x_2^2 x_1 - x_1^4 - k_1 x_2^2 - k_2 x_1^2 - 2(a_n - k_3)x_1 + \\ + (a_{n-1} - k_4)x_2, \dots, -a_2 x_{n-1} - a_1 x_n \end{array} \right. \quad (11)$$

We find the gradient vectors from the components of the Lyapunov vector-valued function:

[illegible]

From (11) we find the decomposition of the components of the velocity vector into coordinates

$$\begin{aligned} \left(\frac{dx_1}{dt}\right)_{x_1} &= 0, \left(\frac{dx_1}{dt}\right)_{x_2} = x_2, \left(\frac{dx_1}{dt}\right)_{x_3} = 0, \dots, \left(\frac{dx_1}{dt}\right)_{x_n} = 0 \\ \left(\frac{dx_2}{dt}\right)_{x_1} &= 0, \left(\frac{dx_2}{dt}\right)_{x_2} = 0, \left(\frac{dx_2}{dt}\right)_{x_3} = x_3, \dots, \left(\frac{dx_2}{dt}\right)_{x_n} = 0 \\ &\vdots \\ \left(\frac{dx_{n-1}}{dt}\right)_{x_1} &= 0, \left(\frac{dx_{n-1}}{dt}\right)_{x_2} = 0, \left(\frac{dx_{n-1}}{dt}\right)_{x_3} = 0, \dots, \left(\frac{dx_{n-1}}{dt}\right)_{x_n} = x_n \\ \left(\frac{dx_n}{dt}\right)_{x_1} &= -\frac{1}{2}x_2^2x_1 + x_1^4 + k_2x_1^2 + 2(a_n - k_3)x_1, \\ \left(\frac{dx_n}{dt}\right)_{x_2} &= -\frac{1}{2}x_2^2x_1 + k_1x_2^2 - 2(a_{n-1} - k_4)x_2 \\ &\vdots \\ \left(\frac{dx_n}{dt}\right)_n &= -a_1x_n \end{aligned}$$

The total time derivative of the Lyapunov vector-valued function is defined as the scalar product

$$\begin{aligned} \frac{dV}{dt} = & -x_2^2 - x_3^2 - \dots - x_n^2 - \\ & - \left(\frac{1}{2} x_2^2 x_1 - x_1^4 - k_2 x_1^2 - 2(a_n - k_3) x_1 \right)^2 - \\ & - \left(\frac{1}{2} x_2^2 x_1 - k_1 x_2^2 - 2(a_{n-1} - k_4) x_2 \right) - (a_{n-2} x_3)^2 - \dots - (a_1 x_n)^2 \end{aligned} \quad (13)$$

It is obvious from (13) that a sufficient condition for asymptotic stability will always be satisfied, that is, the total derivative of the Lyapunov vector-valued function is a sign-negative function.

Using the gradient (12), we construct the Lyapunov function

$$V(x) = \frac{1}{4}x_2^2x_1^2 + \frac{1}{5}x_1^5 + \frac{1}{5}x_2^5\frac{1}{3}k_2x_1^3 + \frac{1}{2}(a_n - k_3 - 1)x_1^2 + \\ + \frac{1}{2}(a_{n-1} - k_4 - 1)x_2^2 + \frac{1}{2}(a_{n-2} - 1)x_3^2 + \dots, + \frac{1}{2}(a_1 - 1)x_n^2$$

Necessary conditions for the asymptotic stability of the equilibrium state (7), that is, the condition for positive definiteness of the Lyapunov function for the equilibrium state (7), which exists only when $k_3 - a_n > 0$ that is to say $a_n < k_3 < \infty$ will be satisfied if

$$\begin{cases} a_n - k_3 - 1 > 0 \\ a_{n-1} - k_4 - 1 > 0 \\ a_{n-2} - 1 > 0 \\ \vdots \\ a_1 - 1 > 0 \end{cases}$$

Results and discussion

Thus, the system (3) due to the introduction into the contour of the control law in the form of four-parameter structurally stable mappings becomes stable over unlimitedly wide limits of the variation of the indeterminate parameter a_n , a_{n-1} and adjustable controller parameters k_3 and k_4 . The stationary state of the system (5) exists and it is stable when the parameters a_n , k_3 and a_{n-1} , k_4 in the regions $-\infty < k_3 < a_n$ and $-\infty < k_4 < a_{n-1} - 1$ respectively, and the stationary state (7) exists and is stable when the parameters a_n , k_3 and a_{n-1} , k_4 in the regions $< k_3 < a_n$ and

$a_n < k_3 < \infty$ and $a_{n-1} < k_4 < \infty$. For the rest of the object parameters there are restrictions $a_i > 1, i \leq n-2$.

In real control systems, uncertainty is inevitably present, and the control system must be operative in the presence of uncertainty. Such a control is called robust.

Conclusion

As a result, we see that the control system with increased potential of robust stability in a class of four-parameter structurally stable mappings for objects is stable with any changes of uncertain parameters accordingly excludes the generation of deterministic chaos in dynamic system and guarantees the performance and reliability of control system under conditions of uncertainty.

References

1. Kharitonov V.L. Asymptotic stability of the equilibrium position of a family of systems of differential equations // Differential equations. - 1978. - No. 11. - P. 2086-2088.
2. Andronov AA, Pontryagin LS Rough systems, DAN SSSR. 1937. T14.
3. Andronov AA, Witt AA, Haykni S.E. The theory of oscillations. Moscow: Nauka, 1959.
4. Beisenbi M.A., Yermekbayeva J.J. Construction of the Lyapunov function in the study of robust stability of linear systems// Herald of KazNTU, Almaty, 2013. - №1. –pp. 315-320
5. Beisenbi M.A., Yermekbayeva J.J. The research of the robust stability in Linear system// Proceedings Engineering and Technology, pp.142-147.
6. Beisenbi M.A., Zakarina A.Zh., Nikulin V.V., Bulatbayeva Y.F. Design of Control System with Increased Potential of Robust Stability in a Class of four-parameter structurally stable mappings for Spacecraft Model //International Journal of Applied Engineering Research (IJAER) – 2016. – V.1. – №22. – pp. 11041-11045
7. JJ Yermekbayeva Structurally Steady Control of Tumor Cell Populations// Biomedical and Pharmacology Journal 6 (2), pp. 293-300
8. Beisenbi M.A., Abdrakhmanova L.G. Research of dynamic properties of control systems with increased potential of robust stability in a class of two-parameter structurally stable maps by Lyapunov function //ICCNC 2013. – Published by Atlantic Press, 2013. – pp. 201-203
9. A Gulnara, B Mamyrbek, A Aliya, Y Janar The Study of Stability Control Systems for the Technological Processes// Proceedings of the 2014 International Conference on Industrial Engineering
10. Janar Yermekbayeva, Beisenbi Mamyrbek Construction of Lyapunov function to examine Robust Stability for Linear System// International Journal of Control, Energy and Electrical Engineering (CEEE)

MAIN CHARACTERISTICS OF THE RADIATION FROM DOMESTIC EARTH

ОСНОВНИ ХАРАКТЕРИСТИКИ НА РАДИАЦИЯТА ОТ ВЪТРЕШНОСТТА НА ЗЕМНОТО КЪЛБО

Ass. eng. Dolchinkov N. T., Prof., Doctor of chemical sciences, eng. Haralampiev M. S.

National Military University „Vasil Levski“, Veliko Tarnovo, Bulgaria

n_dolchinkov@abv.bg, mihail43@yahoo.com

Abstract: The basic radionuclides that cause natural radiation – potassium, uranium, radium, thorium, radon, thorom. Is described their content in different soils and rocks, as given more attention to potassium because it is the most widespread in the earth's crust and its influence is strongest. An analysis of radiological monitoring of soils in Bulgaria in the past two years, which show that there is no deviation from the normal background values.

Keywords: radionuclides, uranium, radiological monitoring, natural radiation, radioactive background, normal background values, soils, rocks

1. Introduction

Vinogradov A.P. brings the following table for the content of uranium, thorium and radium in the rocks (Table 1). According to these data the lowest content of uranium and radium in the primary and especially in the ultramain rocks, that have the lowest total radioactivity. The average data for the content of uranium and thorium in the various types of rock is represented by Clement (Table 2 and Table 3). The highest radioactivity is due the uranium and thorium, except for the acidic eruptive rocks is characterized in some sedimentary rocks, slates and clays. It is known that phosphate minerals, some types of coal and bitumen have higher radioactivity [5]. Uranium and thorium are mostly found in their distracted state, sometimes they occur in the form of minerals. Both elements are concentrated mainly in the surface layers of the earth's crust. In some areas of the world there are geochemical provinces with high content of radioactive elements which are observed. Some of the larger ones are established in Canada, Brazil, USA – Colorado, India – the state of Kerala, South Africa and others. Smaller ones are found in Europe – in Portugal, France, Czech Republic, Slovakia and others. Thorium minerals are distributed in Brazil and India and in the other countries we have found uranium minerals (Table 2)

Rocks and soils	Ra	U	Th	Th:U
Ultramain	$1,0 \cdot 10^{-12}$	$3,0 \cdot 10^{-6}$	$6,0 \cdot 10^{-4}$	1,7
Main	$2,7 \cdot 10^{-11}$	$8,0 \cdot 10^{-5}$	$3,0 \cdot 10^{-4}$	4
Medium	$6,0 \cdot 10^{-11}$	$1,8 \cdot 10^{-4}$	$7,0 \cdot 10^{-4}$	4
Corrosive	$1,2 \cdot 10^{-10}$	$3,5 \cdot 10^{-4}$	$1,8 \cdot 10^{-3}$	5
Sludgy (shale and clay)	$1,0 \cdot 10^{-10}$	$3,2 \cdot 10^{-4}$	$1,1 \cdot 10^{-3}$	4

Tabl. 1. Content of Uranium, thorium and radium in rocks, in %.

The group of singles, non-radioactive series radionuclides is not outnumbered. It is important for them that they are also rarely found (excluding potassium) in nature, they have a long half-life period most of them are absorbed poorly by plants and little

relevance regarding the dose of the radiation. Two of them, however are very important from a biological point of view: potassium – 40 and rubidium – 87. As the element potassium is essential for life, then the radioactive isotope potassium – 40 can be found in all living beings.

Types of rocks	Concentration of uranium m/kg
ultramain	0.001
basalt	1
granite	3
syenite	3
slate	3,7
sand	0,45
limestone	2,2
deep sea clay	1,3

Table.2. Content of uranium in different rocks

Type of rock	Uranium Bq/kg	Thorium Bq/kg
eruptive	48,10	48,10
sand	14,80	24,05
Slate	14,80	40,70
limestone	14,80	5,18

Table 3. Activity of uranium and thorium in different types of rocks.

As is known, the contribution of potassium – 40 in the isotopic mixture of potassium is small – only 0.012%, giving a specific activity on natural potassium 31,6 Bq/gr. The half-life of potassium – 40 is 1.26×10^9 years as the main product of the decay is stable potassium – 40 (89%) in beta radiation – particles with 1,314 MeV max. Potassium – 40 emits photons (11%), which can be measured by gamma-spectrometry.

Types of rocks	Concentration $\mu\text{g/g}$
Ultramain	0,0047
basalt	0,98

High calcium granite	2,97
Low calcium granite	4,96
Syenite	5,66
Slate	3,14
Sand	1,26
Limestone	0,32
Deep sea sediments	
Limestone	0,34
Clays	2,95

Table 4. Potassium-40 in the earth's crust

Calcium is widely distributed element in nature. For his presence in various rocks of the earth's crust can be judged from the table. 4. The lowest content in ultramain rocks, basalt and limestone rocks, while granite and syenite is dozens of times more. Sandstone occupy the middle position between those other rocks. The average radioactivity of the rock, due to potassium-40, is 0,63 Bq / gr, but there granites poor in calcium and syenites, the activity of potassium-40 exceed 1,85 Bq / gr.



Figure 1. Radio Geochemical provinces on the globe

Soil as a product of weathering of rocks, inherit their mineral composition and the dispersed small amounts of naturally occurring radioactive elements. Therefore, the radioactivity of the soil depends to a large extent on the composition and type of soil and formation rocks.

Major natural radioactive elements in the soil are: potassium-40, uranium-238, thorium-232 and radium-226. The content of potassium can be influenced not only by the rocks it can also be influenced by the practical activity of man - the use of potassium fertilizers, the growing of potassium loving plants, land reclamation and others. The importance of other rare radioactive elements is very limited. Even less importance for soil radioactivity have cosmogeneous elements - carbon - 14, tritium (3H), which enters the soil thanks to the rainfall. Fundamental studies on the content of radioactive elements in the soil are performed by famous Soviet scientists A.P.Vinogradov, Baranov V.I., Grodzinskiy DM and others that build on the basic ideas of Vernadskiy V.I. participation and role of radioactivity in the biosphere processes.

The studies covered large and diverse soils from Russia and neighboring republics, defined as a large number of naturally occurring radioactive elements. The general conclusion from these studies is that about 2/3 of soil radioactivity is due to potassium-40, and the remaining 1/3 is split roughly equally between uranium, radium and thorium. Recently conducted research on the soil of Belarus, Moldova, Georgia, Kazakhstan, Kyrgyzstan and other republics and regions show that the content of uranium-238 in the soil of these countries fluctuates from 1 to 43 Bq / Kg; thorium-232 from 2 to 91; radium-226 from 3 to 90; and potassium-40 of 129 to 1238 Bq / Kg. The average content of the said radio- elements

respectively 16,35,33 and 618 Bq / Kg. Participation of potassium-40 in the natural radioactivity of the soil reaches 88%, and other elements take from 2 to 5.5% from her.

Data from the radiological monitoring of uncultivated soils are the result of analyzes carried out by laboratories for radiation measurements of the EEA in 2012 year and are presented in fig. 2.



Figure 2. Specific activity of natural radionuclides in non-arable land, Bq / kg [1]

Soil formation is the result of the cumulative effect of various natural factors and conditions; rocks, topography climate (temperature, humidity), age of the rocks, plant and animal organisms, then the appearance of man on Earth and its business. The interaction of these factors determines the course of the various basic physical, chemical and biological processes that determine the type and nature of soil formation process and formation of the transformative properties of soil in rock. Although there are some assumptions it is not scientifically proven role of radioactive elements in the process of soil formation. Although there are some assumptions it is not scientifically proven that there is a role of radioactive elements in the process of soil formation. Some authors, proceed from the constant radiation of radioactive elements allow an activating effect on the activity of the micro flora, plants and other organisms, which can lead to the destruction of non-crystal lattice of clay minerals and other processes related to soil formation. These questions are not yet sufficiently studied. Yet little is known about the role of radio- elements in soil formation, although there is accumulated interesting data on certain biochemical processes.

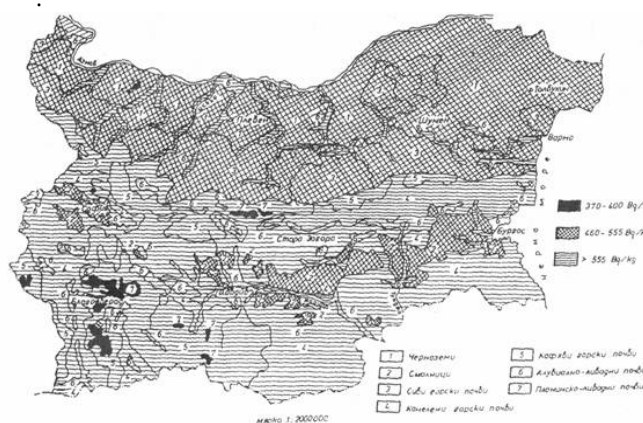


Figure 3. Total beta radioactivity of soils developed on loess, loam, marl and other sedimentary rocks from North Bulgaria[2]

Of the scheme (Figure 3) shows that the total beta radioactivity of soils developed on loess, loam, marl and other sedimentary rocks from Northern Bulgaria, black and gray forest soils, compared with soils from South Bulgaria, developed mainly on acidic solid crystal rocks (brown wood, cinnamon forest soils) is significantly lower. The lowest total beta radioactivity are mountain-meadow soils due to their low levels of potassium-40, which is the main component of

total beta radioactivity. These are summarized data - in any soil type deviations due to diverse geographical basis of soil forming rocks of different types of soils

2. Characteristic of the solar radiation

Different areas of the planet's rocks, minerals and others are characterized by a certain constant proportion of their isotopic composition, which can be established genetic link, continuity and other natural formations and their development. Thus, the ratios of the isotopes of chlorine in meteorites, volcanic and sedimentary rocks individual are the same. However, there are data showing that common in geochemical and biochemical processes prejudice isotope ratios. This is observed especially in the involvement of elements in both cycles, when migration and others. The benchmark in such cases isolate the ratio of isotopes in the ocean, where the isotopic composition of elements is the constant. Radiation status of soils, bottom sediments and waste products from the activity of enterprises - potential pollutants in the environment is measured by carrying out destructive gamma-spectrometric analysis of samples from the points set out in the monitoring network throughout the country [3]. In the third quarter of 2014 of Burgas region were tested 15 pcs. soil samples. Not observed abnormal radiological indicators compared to those of previous years. The values of technogene deposits in the soil cesium-137 are 1,73 Bq / kg for Tsarevo 87,5 Bq / kg for Lyulyakovo. With the tested samples of the bay "Vromos" establishes the characteristic pollution flotation waste. The sample of the "sandbox" of a control point on the beach with the usual inflated activities, such as: 533 Bq / kg of uranium-238, 598 Bq / kg for radium-226 and 326 Bq / kg for lead-210. The same applies to natural radionuclides in the sample from the "fresh" deposit from the surf beach "Vromos" in which uranium-238 is a value of 235 Bq / kg, radium-226 is 231 Bq / kg, and lead-210 is 247 Bq / kg. During the period from July to September of 2014. the territory of Varna, Dobrich and Silistra areas were tested 19 pcs. soil samples and 4 pcs. sediments. There have been typical for the region values of natural radionuclides. Technogene cesium-137 in soil in the region is in the range (0,6 ÷ 23,4) Bq / kg respectively and with Shabla. Rosica [1]. The radiological monitoring in the region of Vratsa for the third quarter of 2014. It consists in analyzing the 5 pcs. samples of sediment and 16 pcs. soil samples, 13 of them are from the 30 km zone of the NPP "Kozloduy". No deviations in the measured specific activity of natural radionuclides compared to their previous values. Data for cesium-137 are in the range 0,89 Bq / kg for NPP - farm and 19,3 Bq / kg for Krushovitsa. During the same period they analyzed 21 pcs. samples of uncultivated soils from Montana and Vidin, as 10 pc. they come in a range of 30 km zone of the NPP "Kozloduy", and a sample of river sediment. Timok at Bregovo. There have been observed in previous years values of the specific activity of natural radionuclides. The content of Cs-137 in the range of 0,42 Bq / kg to about Vidin 60,2 Bq / kg for Bregovo.

Was also examined soil from the area of the tailings pond of TPP "Vidin", they are not considered excessive amounts of natural radionuclides.

In the region of Pleven region during the period from July to September of 2014. They analyzed 10 pcs. samples of arable land and 6 pcs. bottom sediments. There have been typical for this area background values of natural radionuclides. The measured specific activity of technogene cesium-137 is in the range (0,86 ÷ 40,7) Bq / kg, respectively Glojene and Voneshta voda [2].

The results of analyzes of soil samples from the territory of Plovdiv and Smolyan districts indicate that there are no significant deviations in the measured specific activity of natural radionuclides from the values from previous periods. For the third quarter of 2014 were studied 14 pcs. samples of arable land and 2 pcs. sediments. Data on the distribution of technogene cesium-137 deposited in the soil following the accident at the Chernobyl nuclear power plant range from 10,4 Bq / kg for Barutin to 132 Bq / kg for Mihalkovo.

The performed radiological monitoring in the areas of facilities-potential pollutants: vol. "Assarel"- Adit Bisa Bisa 1A and 1B at the "Obrochishte" and Adit 1, 2 and 4 in the newspaper "Location" vol. "Renaissance"; region of p-k "Geranium" and in the area of project

"Sunrise" -under Adit 3 to p. Barutinska, found no increased values of natural radionuclides. Only in the "Potato levels" of the last object is observed as in previous years, twice elevated to the specific activities of natural radionuclides uranium-238, radium-226 and lead-210 [4].

During the period from July to September of 2014. from the territory of Sofia, Kyustendil and Blagoevgrad were tested 34 pcs. soil samples, 10 pcs. sediments. Absent over the background values of natural radionuclides. The specific activity of cesium - 137 is in the range (0,64 ÷ 116,8) Bq / kg respectively Eliseina Gueshevo.

Tested 23 pcs. samples uncultivated soil and sampling sediments from areas of objects-potential contaminants: objects "Babeshka River," "White Water", "Eleshnitsa", "Igralishte" "Iskra" mine "gold" and in the newspaper "Probainitsa. In performed radiological monitoring in the area listed former uranium mining industry sites are usually set higher values of radiological indicators at the following locations:

- Soils from the area of career "Kopitoto" and the area of the plant, vol. "Eleshnitsa"
- Soil from the area of the heaps, vol. "Igralishte"
- Sediment from the river. Ochushnitsa after vol. "White Water";
- Sediment from the river. First before infusion into the river. Milkyovska by vol. Mina " The Wicked."

3. Conclusions:

1. A well developed and organized national system for monitoring the radiation environment status. Real-time monitor the change of the background radiation of the atmosphere, soil and water in Bulgaria.;
2. Radiation background is within the typical country background values. Over the past 20 years are not deviations from normal;
3. With regard to the radiation status of soils not be ascertained values above background. Periodically exercise control in different parts of Bulgaria by the competent authorities - Ministry of Environment and Water.

4. Literature:

1. Bulletin gamma background in Bulgaria the NRA;
2. National report on the status and protection of the environment in Bulgaria of the EEA in 2013;
3. National report on the status and protection of the environment in Bulgaria of the EEA in 2014;
4. Quarterly bulletin on the state of environment for the period July-September 2016;
5. Vasilev D., Radioecology, Titus Consult, Sofia 2005

THE ASSESSMENT ANTHROPOGENIC IMPACT OF INDUSTRIAL OBJECT FOR ECOLOGICAL SYSTEM BASED ON INTEGRATED CRITERION

ОЦЕНИВАНИЕ ТЕХНОГЕННОЙ НАГРУЗКИ ПРОМЫШЛЕННОГО ОБЪЕКТА ЭКОЛОГИЧЕСКОЙ СИСТЕМЫ НА ОСНОВЕ ИНТЕГРАЛЬНОГО КРИТЕРИЯ

Ph.D., Abramova A.

National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute", Kyiv, Ukraine, alla_abramova@ukr.net

Abstract: *This article explores the main problems of assessment of anthropogenic impact on the ecological system of the projected industrial facility. It proposed used as an indicator of environmental risk as an integral criterion. The calculation of risk is based on the method of "risk index".*

KEYWORDS: *PROJECTED INDUSTRIAL FACILITIES, HUMAN IMPACTS, INDEX, ENVIRONMENTAL RISK, INTEGRAL CRITERION*

1. Introduction

Currently, there is a human impact on the ecosystem Ukraine due to pollution of the environment by chemical, metallurgical, mining industries, nuclear, thermal power plants, sugar plants, road, and drainage systems. Industry influences on the ecosystem mainly through of their direct destruction particularly as a result of emissions into the atmosphere and hydrosphere pollutants.

The main task for the near future is to minimize the increase of anthropogenic impact on the environment. Therefore, the development approach to the assessment of anthropogenic impact on the implementation of the industrial ecological system designed industrial facilities is a topical direction of research.

2. Background and means for solutions problems

The *object* of research is assessment of projected impacts of industrial facilities on the ecological system to determine the anthropogenic impact.

The main purpose of evaluation of anthropogenic impact of projected industrial facilities is accumulation, systematization, and analyzing information about the quantitative connection between industrial objects and the environment.

This assessment is carried out to obtain the following results:

- estimates quality of components of the environment;
- identify the causes of adverse disorders in the environment, establishing sources and factors of negative external influence;
- predicting the admissibility of impact on the environment in general;
- identifying the most dangerous impacts and comparing the contribution of various types of impacts.

There are many normative methods to assess the contribution of various factors of environmental impact.

The most simple and common method is a method that involves comparing the obtained quantitative estimates with approved standards which applied at the design stage industrial facility [1].

Today, the definition of risks at the design stage is a compulsory procedure of Environmental Impact Assessment (EIA) [1].

In accordance with the publication [2], risk is considered as the probability of adverse effects on human health and does not account for the impacts from the industrial facilities at the design stage; the authors proposed a mathematical based on assessment of such risk.

In the publication [3] the authors propose to use the integral environmental indices in the assessment of anthropogenic impact on atmospheric air, surface water, soil that can be used in the EIA procedure, but the mathematical correlations do not offer.

In the publication [4] propose methods for assessment of environmental safety with the use of indices and risk assessments. The authors not offered the quantitative procedures for determining these estimates.

In the publication [5] it was investigated the main causes which create risks and affect the condition of environmental safety.

The authors of the publication [6] have analyzed the threats to human health. Risk assessment is proposed should consider the impacts and danger on the human body; the design stage of the object is not taken into account.

The authors of the publication [7] propose to use a probabilistic approach to the evaluation of environmental risks with the use of probabilistic models. This approach cannot be applied at the design stage. This is due to a lack of information about the distribution function of the parameters of random variables as well as incomplete statistics on the equipment failures and the occurrence of various negative events.

It is necessary to build integral criterion for the practical estimation of anthropogenic impact at the design stage. This approach summarizes the groups of indicators and gives the possibility to quantify the influence of man-made object at the design stage and continue to make decisions regarding the acceptability of introducing such a facility in the industrial ecosystem.

Thus, the development of dependency of the assessment of environmental risk as integral criterion using the index ratings in the EIA is a topical area of research.

3. The solution of the problem

Develop an approach to the assessment of the anthropogenic impact with the use of environmental risk as integral criterion is the solution of the problem.

For calculating environmental risk as integral criterion of estimation of anthropogenic impact at the design stage it is necessary to consider the impact; realize industrial facility on the ecosystem.

In case of insufficient source information at the design stage it is proposed to use developed by the authors estimates calculated using the desirability function Harrington with the use of benchmarks that implicit in the methodology of the EIA [8, 9].

In general, the unified index evaluation of the level of influence has the form (1) [8, 9]:

$$(1) \quad I_i = 1 - d_i = 1 - e^{-(e^{-y_i})},$$

where I_i – index evaluating for the i -th type of the impact of an industrial facility on the environment, dimensionless, d_i – desirability function of the impact of an industrial facility on the environment, dimensionless, e – exponent; y_i – quantitative indicator that takes into account the industrial object for the i -th type of impact the components of the environment that is

associated with a quantitative indicator Π_i (determined in accordance with the norms of Ukraine).

To calculate anthropogenic impact on the ecological system is proposed to use the indexes the chemical and physical effects of the projected industrial facility on the environment (tabl.1, tabl.2) [8, 9].

Table 1. Indices for evaluation of chemical impact of projected industrial facilities

Component of the environment	Mathematical dependence for the index definition	Legend
Atmosphere ($i=1$)	$I_i = 1 - e^{-(e^{0,25 \cdot KII-1})}$	KII – the multiplicity of regulatory excess pollution, dimensionless;
Surface water ($i=2$)	$I_i = 1 - e^{-(e^{0,33 I_E-1,33})}$	I_E – the integral ecological index, dimensionless;
Soil ($i=3$)	$I_i = 1 - e^{-(e^{0,016 \cdot Zc-1})}$	Zc – the total index of soil pollution, dimensionless.

Table 2. Indices of the assessment of the physical impacts of projected industrial facilities

The impact parameters	Mathematical dependence for the index definition	Legend
Noise ($i=4$)	$I_i = e^{-(e^{0,025 \cdot LA-1})}$	LA – noise level;
Infrasound ($i=5$)	$I_i = 1 - e^{-(e^{0,1 \cdot \Delta L-1})}$	ΔL – sound pressure level;
Ultrasound ($i=6$)	$I_i = 1 - e^{-(e^{0,01 \cdot Lvg-1})}$	Lvg – logarithmic vibration level;
Electromagnetic impact ($i=7$)	$I_i = 1 - e^{-(e^{2 \cdot W-1})}$	W – maximum allowable value of the energy flux density;
Vibration ($i=8$)	$I_i = 1 - e^{-(e^{0,018 \cdot Lv-1})}$	Lv – logarithmic vibration level;
Radiation exposure ($i=9$)	$I_i = 1 - e^{-(e^{0,0015 \cdot A_{ef}-1})}$	A_{ef} – total effective specific activity of natural radionuclide.

On the basis of the index values, you can set the level of effects on components of the environment. It is proposed to conduct evaluations of hazard category of the object using the developed scales evaluating the impact on the environment from the design of industrial facilities (table. 3 (for atmosphere) [8, 9].

Table 3. Grading scale chemical exposure of projected industrial facilities

The interval of changes of index values	The level of impact	The name of the category of danger of the object
<i>Atmosphere</i>		
$0 < I_1 \leq 0,37$	Allowable	Safe
$0,37 < I_1 \leq 0,45$	Conditionally valid	Few hazardous
$0,45 < I_1 \leq 0,66$	Inadmissible	Middle hazard
$0,66 < I_1 \leq 0,93$		Hazardous
$0,93 < I_1 \leq 1$		Particularly dangerous

Integrated environmental hazard index of the projected industrial facility was developed for summarizing evaluation of environmental impacts (2):

$$(2) \quad I = \max \{I_1, \dots, I_i, \dots, I_n\},$$

where I – environmental hazard index of the projected industrial facility; I_i – index evaluating for the i -th type of the impact of an industrial facility on the environment, dimensionless.

The algorithm was developed to determine the environmental risk assessment in the case of anthropogenic impact on the implementation of the projected industrial facility:

- quantitative indicators should be calculated for the evaluation of impacts on environmental components using the pre-research, process design and active normative documents;
- need to recalculate the values of the quantitative assessment of the impact on components of the environment in the indexes;
- decision is made on the admissibility of the project design for the index value of a component of the environment;
- environmental risk is calculated and determined its level of acceptability provided for each component of the project and the environment as a whole;
- set the level of anthropogenic impact of the facility on the ecological system in the value of environmental risk.

Mathematical formulas were proposed for determining environmental risk industrial facility of the projected according to the concept of EIA.

For the calculation of environmental risks method of the "index - risk" was modified [10].

The modification was carried towards establishing a functional dependence between developed system of indices and normalized levels of environmental risk in the form of probability methods using nonlinear regression. Mathematical formulas were developed to determine environmental risks presented in Table 4 [8, 9].

Table 4. The formulas for calculating the environmental risk

Environmental risks	Mathematical dependence	Output information
Integral environmental risk	$R_E = \sum_{i=1}^m r_i$	
Environmental risk	$r_i = a_i \cdot e^{b_i \cdot I_i}$	a, b – constants: $a_1 = 5,17 \cdot 10^{-9}$, $b_1 = 11,29$ (atmosphere); $a_2 = 4,84 \cdot 10^{-13}$, $b_2 = 21,01$ (surface water); $a_3 = 6,083 \cdot 10^{-8}$, $b_3 = 5,48$ (soil); $a_4 = 1 \cdot 10^{-6}$, $b_4 = -37,05$ (noise); $a_5 = 8 \cdot 10^{-10}$, $b_5 = 7,67$ (infrasound); $a_6 = 1 \cdot 10^{-8}$, $b_6 = 6,89$ (ultrasound); $a_{7,8} = 1 \cdot 10^{-7,8}$, $b_{7,8} = 4,95$ (electromagnetic impact, vibration); $a_9 = 2,47 \cdot 10^{-9}$, $b_9 = 8,93$ (radiation exposure).

An evaluation of environmental risks and anthropogenic impact is carried out according to the proposed scale taking into account normal levels established risks for Ukraine (Table 5).

Table 5. Classification of risk levels

Level	Risk r_i
Unacceptable	$>10^{-6}$
Conditionally acceptable	$10^{-6} - 10^{-7}$
Acceptable	$10^{-7} - 10^{-8}$
Definitely acceptable	$< 10^{-8}$

Next, decision is made on the admissibility of the introduction of an industrial facility in the industrial ecological system based on levels of anthropogenic load.

Therefore, the author proposes an approach to evaluating anthropogenic impact by identifying environmental risks introducing an industrial facility in the industrial ecological system based on the calculation of indices. Determining the value of environmental risk allows you to control the level of anthropogenic impact and focus not only on human health but also on other environmental impact.

The approach of anthropogenic impact assessment approved for the project of Alchevsk Steel Mill reconstruction.

The goal of the reconstruction of the Alchevsk Steel Mill is building a new industrial platform, thus revealed adverse effects on the environment. Such impacts associated with the occurrence of violations of various negative conditions and cleanliness of air, surface water, soil and others.

The main priority pollutants released into the air are nitrogen dioxide, carbon monoxide, methane. Pollution of surface waters of two rivers nearby is direct and indirect receivers wastewater facility. It was conducted soil testing to evaluation the current condition of soil were found soil contaminants such as arsenic, mercury, zinc, copper, chromium, manganese, barium, strontium, cadmium. The noise sources were found (technological equipment, smoke exhausts, fans, etc.).

Assessment of anthropogenic load of project of reconstruction Alchevsk Steel Mill on the environment is done by using the developed computational dependencies environmental risks (table. 6).

Table 6. The evaluation of anthropogenic load of the project of reconstruction Alchevsk Steel Mill

Component of the environment		Atmosphere	Surface water	Soil
Qualitative composition		CH_4, NO_2, CO	pH, O_2 , biochemical oxygen demand, chemical oxygen demand, dry residue, chlorides, sulfates, nitrates, nitrites, phosphates, iron	Pb, Zn, Cu, Cr, Mn, Ba, Sr, ets
Index estimates	Indices	$I_1=0,75$	$I_2=0,4$	$I_3=1$
	Environmental risks	$r_1=2,5 \cdot 10^{-6}$	$r_2=2,2 \cdot 10^{-9}$	$r_3=1,5 \cdot 10^{-5}$
Level of impact		Inadmissible	Allowable	Inadmissible
Level of risk		Unacceptable	Acceptable	Unacceptable
Total evaluation index of environmental safety				
		$I=1$ Inadmissible	$R_E=1,75 \cdot 10^{-5}$ Unacceptable	

Object parameters were established such as the level of risk that is unacceptable and the level of impact that is inadmissible.

The results of this assessment suggest that there is an excess concentration of certain pollutants in ambient air, surface water, and soil.

Program complex RISK_OVNS was designed to simplify the calculations of index parameters of environmental safety. Program complex RISK_OVNS provides a constant assessment of environmental conditions and environmental components designed for use in the operating systems Microsoft Windows XP, implemented in the programming language Delphi. Program complex RISK_OVNS has a comfortable intuitive interface that facilitates the process of determining the level of risk; automate work with databases, issue results of calculation of estimates of environmental safety in the form of informative, convenient reports. The main windows of program complex are depicted in fig.1. - fig.4.

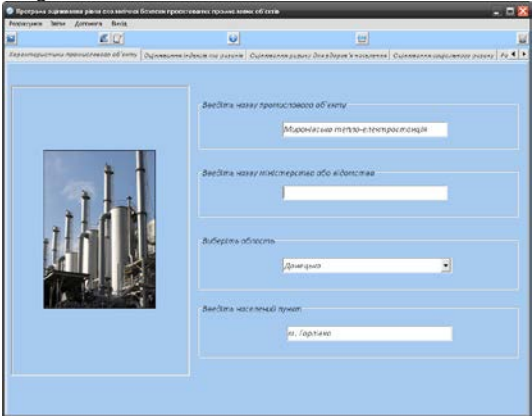


Fig.1. Main window

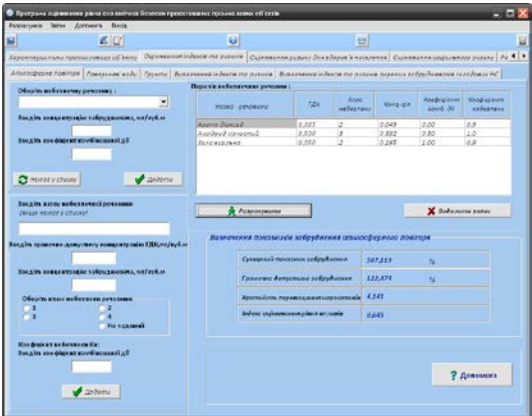


Fig.2. Window evaluation of the of environmental safety projected industrial facilities - tab "Atmosphere"

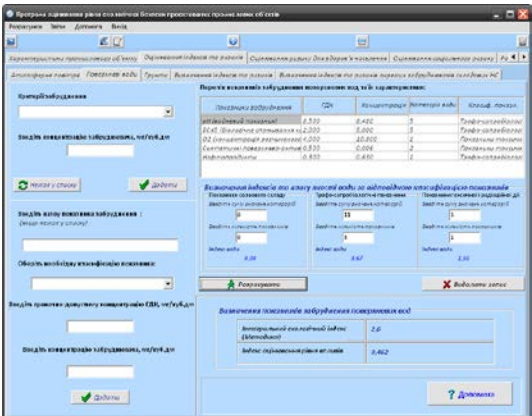


Fig.3. Window evaluation of the of environmental safety projected industrial facilities - tab "Surface water"

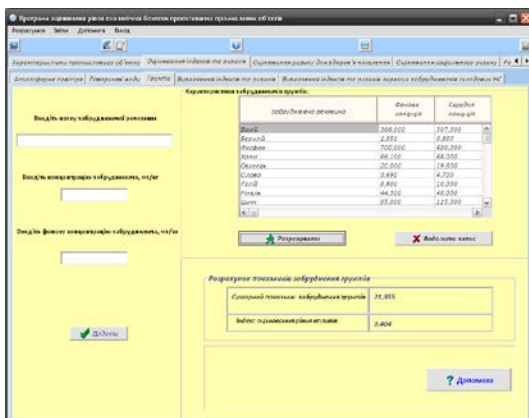


Fig.4. Window evaluation of the of environmental safety projected industrial facilities - tab "Soil"

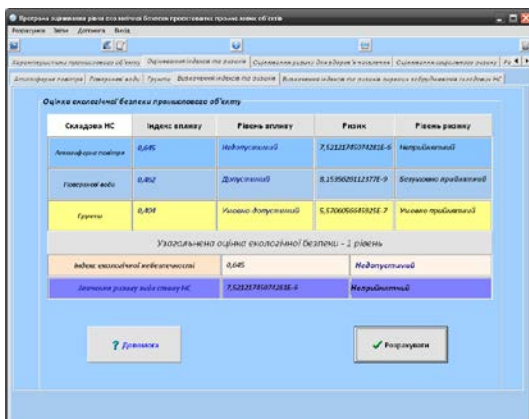


Fig.5. Window evaluation indexes of environmental safety - Tab "Defining the indices and risks"

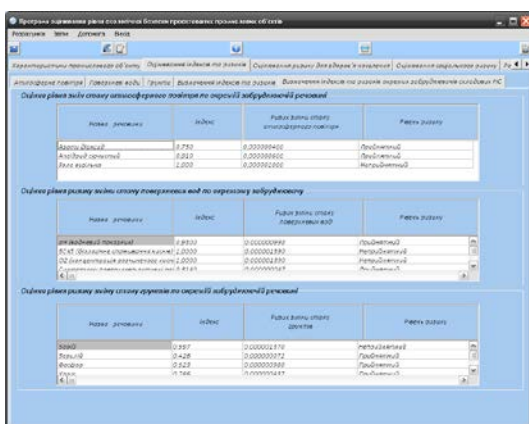


Fig.6. Window evaluation indexes of environmental safety - Tab "Defining the indices and risks of certain pollutants elements of the environment"

Thus, the developed program complex allows the evaluation of the environmental safety of the projected industrial facility.

4. Conclusion

The mathematical dependences have been proposed to determine environmental risks as an integral criterion for estimating anthropogenic impact for the purpose of controlling the level of environmental safety at the design stage of any industrial facility.

It was developed a method of forming index impact assessments of individual components of the environment and generally based on desirability functions.

The universal dimensionless index evaluations of environmental hazard impacts on the environment were built.

Mathematical dependences have been developed definition of environmental risk for the individual components of the environment and overall implementation of the planned industrial facility in the industrial ecological system that lets you identify dangerous threats in the design phase of industrial facilities.

The approach to the assessment of anthropogenic impact on the ecosystem enables you to take into account the chemical and physical influences from such an object by calculating the environmental risk.

Reference

1. ДБН А.2.2-1-2003. Зміна №1. Проектування. Склад і зміст матеріалів оцінки впливів на навколишнє середовище (ОВНС) при проектуванні і будівництві підприємств, будинків і споруд [Текст] / Наказом Мінрегіонбуду України від 20.11.2009 р. № 524 та введені в дію 01.07.2010 р. – К.: ДП «Укрархбудінформ» Мінрегіонбуд, 2010. – 10 с.
2. Прибилова, В. М. Неприятливі фактори навколишнього середовища та оцінка ризику здоров'я населення [Текст] / В. М. Прибилова // Вісник Харківського національного університету. – 2009. – Вип. 30, № 864 – С. 221–224.
3. Ємець, М. А. Проблеми та напрямки удосконалення екологічного нормування [Текст] / М. А. Ємець // Екологія і природокористування. – 2009. – Вип. 9. – С. 115–127.
4. Аналіз та систематизація існуючих методів оцінювання ступеня екологічної небезпеки [Текст] / М. С. Мальований, В. М. Шмандій, О. В. Харламова, Л. І. Челядин, Г. В. Сакалова // Екологічна безпека. – 2013. – № 1 (15). – С. 37–44.
5. Екологічна безпека України: Системні принципи та методи її формалізації / А. Б. Качинський, Ю. В. Егоров // Національна безпека:Український вимір. – 2009. – № 4(23). – С. 71–79.
6. DFO. 2013. Summary of the Environmental and Indirect Human Health Risk Assessment of AquAdvantage Salmon [Text] // Her Majesty the Queen in Right of Canada, 2013. – 26 p.
7. Gormley, A. Guidelines for Environmental Risk Assessment and Management. Green Leaves III. [Text] / A. Gormley, S. Pollard, S. Rocks // Defra and the Collaborative Centre of Excellence in Understanding and Managing Natural and Environmental Risks, Crown, 2011. – 82 p.
8. Статюха, Г. О. До питання кількісної оцінки екологічної безпеки при ОВНС [Текст] / Г. О. Статюха, В. А. Соколов, І. Б. Абрамов, Т. В. Бойко, А. О. Абрамова // Східно-Європейський Журнал передових технологій. – 2010. – Т. 6, № 6 (48). – С. 44–46.
9. Абрамова, А. О. Індексна оцінка рівня екологічної безпеки проєктованих промислових об'єктів [Текст] / А. О. Абрамова // Технологический аудит и резервы производства. – 2012. – Т. 6, № 1 (8) – С. 39–40.
10. Бойко, Т. В. Особливості використання метода «індекс-ризик» для оцінки техногенної безпеки об'єктів [Текст] / Т. В. Бойко // Восточно-Европейський Журнал передових технологій. Информационные технологии. – 2009. – Т. 6, № 5 (42). – С. 44–47.

INTEGRATED PERFORMANCE MEASUREMENT SYSTEM

M.Sc. Ahmed O.¹,

Faculty of Management – Technical University- Sofia, Bulgaria ¹
sdim@tu-sofia.bg

Abstract: *This work deals with issues concerning the performance measurement in SMEs. There has been a literature search of existing methods and practices for performance measurement. The Characteristics of Performance Measurement and Factors Influencing Performance Measurement in SMEs are studied. Concept and objectives of the Integrated performance measurement system are developed. The structure and configuration of the performance measurement system are conceptualized.*

Keywords: PERFORMANCE MEASUREMENT; PERFORMANCE MEASUREMENT IN SMES; INTEGRATED PERFORMANCE MEASUREMENT

1. Introduction

The performance measurement revolution started in the late 1970s with the dissatisfaction of traditional backward looking accounting systems.

Businesses are facing tough challenges to succeed in a global competitive market. Customer demand is changing rapidly in terms of sophistication of the products and services they require. As a result, companies need to become more responsive to customers and market needs, with a greater number of customer specific products and/or services, more flexible processes, suppliers and resources co-ordinated through a number of organisations along the supply chain, whilst reducing costs. In order to proactively respond to these challenges, management requires up-to-date and accurate performance information on its business. This performance information needs to be integrated, dynamic, accessible and visible to aid fast decision-making to promote a pro-active management style leading to agility and responsiveness.

One of the objectives this work is to provide industry with a comprehensive and rigorous set of tools, techniques and procedures to allow auditing of existing performance measurement systems against a reference model and consequently design more robust, flexible and integrated performance measurement systems.

The main objective of this work is to introduce and develop the concept of Performance Management as a key business process and focus on the criticality of the Performance Measurement System embedded within. It presents a reference model for the Performance Measurement System which is based on industry best practices.

2. Performance measurement systems in SMEs

In recent years, literature has identified the increasing complexity of small and medium-sized enterprises (SMEs) and highlighted their sensitivity to differences in managerial culture and management systems. Research has shown that performance measurement systems (PMSs) could play an important role in supporting managerial development in these companies.

In fact, it has often been said [7] that the critical factors for the success of these SMEs can mostly be found in the attributes of a model of a company whose success basically depends on the figure of the entrepreneur-owner, who is personally responsible for managing the activities of the company. This model is characterized by: flexibility and an ability to react quickly and adapt to the competitive and changing environment; organizational processes which are not very structured or 'engineered'; significant concentration of decision-making processes in the entrepreneur-owner; focus on technical aspects and production; and the existence of specialist and tacit knowledge that is essentially technological and evolves through learning processes based on learning by doing [18,21].

Several important changes that have taken place in recent years have created a favourable context for the implementation of PMSs in manufacturing SMEs (for brevity in the following we refer to

SMEs). The four main factors that will be discussed here are: the evolution of the competitive environment and the propensity to grow in dimension (in the sense that they must increase the volume of business because of the geographical expansion of competitive spaces), the evolution of the concept of quality, increased focus on continuous improvement, and significant developments in information technology.

2.1. Characteristics of Performance Measurement in SMEs

After a thorough literature review five common characteristics were identified.

- The difficulty in involving SMEs in performance measurement projects. Moreover, the companies that do take part in these projects rarely continue on to the last phase because of the lack of time available for non-operational activities and the poor involvement of the entrepreneurs or top managers in the PM project [30].
- The studies indicate that SMEs either do not use any PM model or they use models incorrectly. Many companies often implement only some parts of a general model, while others modify the models without carefully considering the changes made. In other words, they eliminate some dimensions without first carefully understanding and analysing the characteristics of the model and the company.
- SMEs' approach to performance measurement is informal, not planned and not based on a predefined model; performance measurement is introduced to solve specific problems and the PMS grows out of this process spontaneously rather than as a result of planning [3].

- SMEs have limited resources for data analysis. Data are gathered and the processes analysed in an imprecise way, and this informalized approach increases the ambiguity of the measurement objectives. The information is then presented in the same way: SMEs usually use tables rather than graphs, making it difficult to interpret the information [1,3].

2.2. Factors Influencing Performance Measurement in SMEs

Many researchers state that the specific characteristics of SMEs can be obstacles to the implementation and use of a PMS. These characteristics are briefly described in the following paragraphs.

- Lack of human resources. SMEs have limited human resources. All the staff are involved in the activities of managing daily work, and have no extra time for additional activities, such as implementing a PMS [3,14,17].
- Managerial capacity. Technical excellence in products and operational processes is often perceived as the only key critical factor in SMEs. A managerial culture is often lacking in these companies and therefore managerial tools and techniques are perceived as being of little benefit to the company. Very often, employees occupy different positions at the same time, the organizations are flat, and though the entrepreneur is in charge of

both operational and managerial functions, he/she usually neglects the managerial activities [21].

- Limited capital resources. The impact of the resources needed to implement a PMS is proportionally more onerous in SMEs than in large companies [3,9,10,14,17]. Moreover, the absence of affordable software platforms that focus on the specific needs of SMEs further obstructs the introduction of PMSs in these companies [5].

- Reactive approach. SMEs are characterized by poor strategic planning and their decisionmaking processes are not formalized. The lack of explicit strategies and methodologies to support the control process promotes both a short-term orientation and a reactive approach to managing the company's activities [8,21]

- Tacit knowledge and little attention given to the formalization of processes. One of the main barriers to organizational development in SMEs is the lack of a managerial system and formalized management of the processes. Furthermore, since knowledge is mainly tacit and context-specific, the information required to implement and use a PMS is difficult to gather [18,21].

- Misconception of performance measurement. Hudson et al. [15] underlines that a PMS can only be effectively implemented and used when the company perceives the benefits of the PMS. SMEs often do not understand the potential advantages of implementing a PMS; these systems are perceived as a cause of bureaucratization and an obstacle to the flexibility of SMEs [16,17].

The limited resources of SMEs require approaches and models that respond to their specific needs and are efficient and easy to implement. The employees involved in implementing and using PMSs must clearly understand the short- and long-term advantages in order to maintain their enthusiasm and commitment [13]. PMSs for SMEs must be dynamic and flexible in order to respond to the needs of these companies, but at the same time they must also be structured to a certain degree in order to favour activity planning [3,12,15]. Though the design of PMSs for SMEs must consider strategy, there must also be a strong focus on operational aspects, since traditionally these are the aspects that are critical for the success of SMEs. Finally, the performance measurement process has to be based on a management information system which keeps in mind the limited financial and human resources of small and medium enterprises.

All these factors underline the differences between SMEs and big companies and the need for a different approach to PM in SMEs. Moreover, these factors could be useful in the study of the dimensions of PMSs for SMEs.

3. Concept and objectives of the integrated performance measurement system

Many authors have focused attention on how organizations can design more appropriate measurement systems. Hudson et al. [15] identify nine requirements for an effective PM development process. These include (1) need evaluation/existing PM audit, (2) key user involvement, (3) strategic objective identification, (4) performance measure development, (5) periodic maintenance structure, (6) top management support, (7) full employee support, (8) clear and explicit objectives, and (9) set timescales. Identifying the procedures for developing strategic PM systems is rather more problematic, as these will vary between processes. However, to ensure strategic alignment, a procedure for identifying strategic objectives should be included. A method for developing the measures is necessary, along with a procedure for maintaining the new PM system [15]

The author's concept of Performance Management presents a reference model for the Performance Measurement System which is based on industry best practices.

3.1. The structure and configuration of the performance measurement system

The literature review revealed two critical considerations with respect to the structure and configuration of Performance Measurement Systems. These are:

- Integrity of the System
- Deployment

3.2. Integrity of the System

Integrity refers to the ability of the performance measurement system to promote integration between various areas of the business. Previous research on manufacturing systems integration identified the value of the Viable Systems Model [4,6] as a framework for assessing a systems integrity. The theory behind the Viable Systems Model (VSM) is that for any system to be viable it must have five sub-systems. The VSM identifies these five sub-systems as System 1, System 2, System 3, System 4, System 5 and the Meta System which is a combination of the Systems 3, 4 and 5. These systems are discussed below.

System 1 are the operational units which produces the goods or services. In other words it represents the productive function of the organisation. It could be interpreted that system 1 consists of Business Processes such as Order Fulfillment, Product Development, Get Order, and so on. From a performance measurement systems perspective system 1 will consists of performance measures which objectively measure the performance of an individual Business Process.

System 2 is the supervisory system which co-ordinates the activities of operational units. This system represents the Business Process which co-ordinates the activities of system one.

System 3 represents the tactical management system which manages the operations of the systems 1 and 2 by setting targets and priorities. Also, in terms of the meta system it would be the system for the implementation of change. This is the management system which is responsible for the performance of business processes and activities in line with the requirements of the higher level systems. From an performance measurement systems perspective this is the system which deploys the strategic policies and priorities. It is therefore responsible for deploying targets and priorities to the measures under systems 1 and 2

System 4 is the developmental system which concerns itself with the external environment and therefore the future. Its focus is on improvement. In terms of the meta system this is the system which identifies the changes necessary to the lower level systems, i.e. systems 1, 2 and 3. This effectively is the benchmarking system which by focusing externally identifies the improvement gaps. The performance measures used in this system tends to be externally focused and comparative, e.g. delivery performance with respect to the competitors or market requirements. In addition to measuring the performance gaps with respect to the external environment, one other key function of this system is the prioritisation of the these gaps in line with the corporate and strategic objectives set by the higher level system 5.

It would be appropriate to combine the external focus of this system with the Results category of the EFQM model for TQM where the focus is on Customer Satisfaction, People satisfaction, Business results and Society satisfaction. From a reference model point of view it may be appropriate to expect externally oriented measures corresponding to each one of the four areas.

System 5 is the boss, this system sets the direction, the policy and strategy the organisation would be adopting in the future. With respect to performance measurement system, this systems sets the high level priorities and targets by relating the performance gaps, from system 4, to business objectives and priorities.

The Meta System is the combination of systems 5, 4 and 3 which is responsible for identifying and managing change. System 5 sets policy and direction, system 4 identifies the necessary changes and system 3 implements these changes.

3.3 Deployment

Deployment refers to the deployment of business objectives and policies throughout the hierarchical structure of the organisation as illustrated earlier in figure 2. Objective of deployment, in this context, is to ensure that:

- Performance measures used at various levels of the organisation reflect the business objectives and policies.
- Deployment is consistent through the hierarchy of the organisation.
- Deployment is relevant and correct with respect to the impact and influence of individual business areas (i.e. processes, functions and activities).

4. A reference model

The reference model developed by the author is based upon the two facets of the performance measurement systems as identified above. These are:

- Integrity
- Deployment

A reference model has been developed following a study of best practices. At each level of the structure four key factors are considered, these are: Stakeholders, Control criteria, External measures, Improvement objectives and Internal measures. The reference model places emphasis on the amplification, transduction and attenuation of performance objectives between these levels.

The reference model uses this basic structure to integrate a following concepts into a single framework:

- Policy Deployment. The deployment of corporate and stakeholders objectives throughout the organisation.
- Competitive Criteria and Benchmarking. The definition of key competitive factors and position of the Business and the Business Units within its competitive environment.
- Process Orientation. Focusing on key business processes to manage business performance.
- Normative Planning. The measurement methodology which differentiates between Actuality, Capability and Potentiality.
- Active Monitoring. The use of proactive performance measures rather than reactive measures.



Figure 1. A Reference model

5. The audit method

Having identified and defined the key characteristics of an integrated performance measurement system (i.e. Integrity and

Deployment), the author has developed a method for auditing the Integrity and Deployment of the performance measurement system as defined in the reference model.

The audit process consists of three phases. These are:

- Data Collection
- Integrity Audit
- Deployment Audit

5.1. Data Collection Phase

The Data Collection Phase, using a workbook developed by the author, collects all information relevant to the Performance Management Process of the business. The information collected includes:

- Identification of Business Units (BU) within the business.
- The market requirements in terms of qualifiers and differentiators for each BU.
- The development plans or objectives for the business or each of its BU's.
- The performance measures used and reviewed by the executive management team within the business, i.e. the Strategic Performance Measures
- The performance measures used and reviewed within each function of the business, i.e. the Functional or Operational Performance Measures.
- Personal objectives and any associated incentive scheme for the executives, managers, supervisors and operational personnel
- Review, reporting and performance responsibilities associated with measures used at all levels.

Once the data is collected it is then analysed to conduct the Integrity and Deployment audits respectively.

5.2. Integrity Audit

In order to conduct the Integrity Audit in a comprehensive, rigorous and repeatable manner, the author has compiled a checklist to search for objective evidence supporting the existence of all five systems within the VSM. Following the analysis of this data against this checklist various gaps are identified with respect to the completeness and integrity of the performance measurement system.

5.3. The Deployment Audit

During the process of creating the model it became apparent that most businesses, small or large, consists of discrete business units which in turn may be treated as stand alone businesses. The common terminology applied to these business units are Strategic Business Units (SBU). The configuration of SBU's within an organisation could vary dramatically. In one organisation it could be very much product driven in others it could be market driven and in some it may be a hybrid of market and product characteristics.

In the first instance the deployment audit requires the identification of the individual SBU's and their strategic requirements in terms of the qualifiers and the differentiators. The performance measurement system should ensure that the priorities between the above two criteria are balanced and appropriately managed in a dynamic environment.

In order to audit the deployment of the performance measurement system a three stage audit method has been developed:

- Stage one focuses on to the requirements of each SBU environment and through a series of matrices assesses the deployment of environmental requirements through business objectives to strategic and functional performance measures.

- Stage two focuses on to the business objectives and through a series of similar set of matrices assesses their deployment through the strategic performance measures to functional levels.
- Stage three focuses on the deployment of strategic performance measures to the functional levels, again through the use of similar matrices.

The audit process is designed to be rigorous in order to ensure repeatability. A scoring system has been devised to measure the strength of deployment which results in a rigorous approach and repeatable conclusions.

6. Conclusion

The research and development effort of the author is aimed at development of practical tools and techniques to facilitate more scientific and precise management of business performance. More specifically the research and development work presented in this paper may be summarised as follows:

- The research work carried out by author as part of a overall work on dissertation focusing on performance measurement systems identified the need to study Performance Management as a process.
- The Performance Management Process is seen as a closed loop control system which deploys policy and strategy, and obtains feedback from various levels in order to manage the performance of the business.
- The Performance Measurement System is the information system which is at the heart of the Performance Management Process and it is of critical importance to the effective and efficient functioning of the Performance Management System.
- Research Identified two critical elements with respect to the content and structure of the Performance Measurement System, these are: Integrity and Deployment.
- The Viable Systems Model (VSM) provides a framework for assessing the Integrity of the performance measurement system.
- Within the VSM framework, Deployment is an integral element which largely corresponds to system 3.
- The Reference Model developed for Integrated Performance Measurement Systems provides a framework against which performance measurement system can be designed and audited.
- The Audit Methods developed to assess the Integrity and Deployment of the performance measurement system provide simple but rigorous and repeatable tools which may be used to improve the effectiveness and efficiency of the Performance Management Process.

References

1. Antonelli, V., Cerbioni, F., & Parbonetti, A. (2002). The rise of cost accounting: evidence from Italy. *Accounting, Business & Financial History*, 12(3), 461-486.
2. Atkinson, A. and Waterhouse, J.H. (1997). A stakeholder approach to strategic performance measurement. *Sloan Management Review*, 38, 25-37.
3. Barnes, M., Dickinson, T., Coulton, L., Dransfield, S., Field, J., Fisher, N, Saunders, I. and Shaw, D. (1998). A new approach to performance measurement for small to medium enterprises. In *Proceedings of the Performance Measurement - Theory and Practice Conference*, Cambridge, 14-17 July.
4. Beer, S. (1984). The viable system model: Its provenance, development, methodology and pathology. *Journal of the operational research society*, 35(1), 7-25.
5. Bititci, U.S., Turner, T, Nudurupati, S.S. and Creighton, S. (2002). Web enabled measurement systems - management implications, *International Journal of Operations and Production Management*, 22, 1273-1287.
6. Blenkinsop, S. A. (1993). Organisational aspects of information processing systems (Doctoral dissertation, © SA Blenkinsop).
7. Bridge S., O'Neill, K. and Cromie, S. (1998). *Understanding Enterprise, Entrepreneur ship & Small Business*. London: Macmillan.
8. Brouthers, K., Andriessen, F. and Nicolaes, I. (1998). *Driving blind: strategic decision-making in small companies*. Long Range Planning, 31, 130-138.
9. Burns, P. and Dewhurst, J. (1996). *Small Business and Entrepreneurship*. London: Macmillan.
10. Ghobadian, A. and Galleary, D. (1997). TQM and organisation size. *International Journal of Operations and Production Management*, 17, 121-163.
11. Greatbanks, R., & Boaden, R. (1998, July). Can SMMEs afford to measure performance?. In *Conference Proceedings Performance Measurement-Theory and Practice (Vol. 1, pp. 117-124)*.
12. Hudson, M. and Smith, D. (2000). Running before walking: the difficulties of developing strategic performance measurement systems in SMEs. In the *Proceedings of the 7th International Annual EurOMA Conference*, Ghent, 4-7 June.
13. Hudson, M., Bennett, J., Smart, PA. and Bourne, M. (1999). Performance measurement for planning and control in SMEs. In *Proceedings of the Advances in Production Management Systems Conference -Global Production Management*, Berlin, 6-10 September.
14. Hudson, M., Bourne, M., Lean, J. and Smart, PA. (2000). Only just managing - no time to measure. In *Proceedings of Performance Measurement -Past, Present and Future Conference*, Cambridge, 19-21 July.
15. Hudson, M., Smart, A., & Bourne, M. (2001). Theory and practice in SME performance measurement systems. *International journal of operations & production management*, 21(8), 1096-1115.
16. Hussein, M., Gunasekaran, A. and Laitinen, E.K. (1998). Management accounting system in Finish service firms. *Technovation*, 18, 57-67.
17. Hvolby, H-H. and Thorstenson, A. (2000). Performance measurement in small and medium-sized enterprises. In *Proceeding of the International Conference on Stimulating Manufacturing Excellence in SMEs*. Coventry, 17-19 April.
18. Jennings, P. and Beaver, G. (1997). The performance and competitive advantage of small firms: a management perspective. *International Small Business Journal*, 15, 34-58.
19. Kaplan, R. and Norton, D. (1996). Using the Balanced Scorecard as a strategic management system. *Harvard Business Review*, Jan-Feb, 75-85.
20. Lynch, R. and Cross, K. (1991). *Measure Up! Yardsticks for Continuous Improvement*. Cambridge: Blackwell.
21. Marchini, I. (1995). *Il governo della piccola impresa*, vol. 3 - La gestione delle funzioni, Genova: ASPI/ INS-EDIT.

RISK FACTORS INDUCED BY INSULATED MINE SELF-RESCUERS ON CHEMICALLY RELATED OXYGEN AFFECTING ON RESPIRATORY COMFORT

Prof. Gryzunov V.V. PhD.¹, student of the 3rd year Dzhemilev E.R.¹, student of the 3rd year Chipura S.I.¹
Saint-Petersburg Mining University, Russian Federation¹

bajnnemech2@yandex.ru@mail.com, enver.dzhemilev@mail.ru, s.chipura@mail.ru

Abstract: The high methane hazard of coal mines, despite safety measures, has led to a change in the structure of fatal injuries. More than 54% of miners die from carbon monoxide poisoning, which predetermines the need to study risk factors when activating a mine self-rescuer with chemically bound oxygen. These factors include normobaric hyperoxia, "nitrogen hazard", hyperoxic hypoxia, high temperature and dryness of the inhaled gas mixture, increasing hypercapnia, increased resistance to ventilation. The current situation predetermined the need to study the tolerability of physical loads when activating the mine self-rescuer. 18 healthy volunteers were examined. The obtained results demonstrated that already from 15 minutes the volume fraction of carbon dioxide begins to increase, indicating the formation of a "break point" of the mechanisms of voluntary control of breathing. The volume fraction of oxygen in the respiratory bag reaches its maximum values by the 25-35 minute and ranges from 96.0 to 97.3% v/v at a barometric pressure of 770.5 ± 1.70 mm Hg. Resistance to breathing during inspiration and expiration during physical exertion reached 77.5 ± 9.95 mm WG and 85.0 ± 9.06 mm WG, respectively, on the 30th minute. At the 40th minute, the aerodynamic resistance to ventilation reaches its maximum value and this zone can be considered as a kind of "reference point", with which deactivating of the self-rescuer due to severe dyspnea begins. Threat also consists in a decrease in the percentage of nitrogen in the gas mixture. Already from the level of 1.7 volume percent of the nitrogen content in the respiratory bag, the mine self-rescuer is deactivated under physical exertion. The main reason for stopping work is the lack of GDS for inhalation, which is probably due to micro-teleclactisation of the lungs and compensatory hyperventilation. Thus, the traditional system of training miners for the use of self-rescuers in emergency conditions does not allow miners to adequately compensate for the effects of negative factors associated with activation of the self-rescuer.

Keywords: COAL INDUSTRY, TRAUMATISM, CARBON MONOXIDE, POISONING, COAL MINE SELF-RESCUERS, RISK FACTORS, RESPIRATORY PROTECTIVE EQUIPMENT, BREATH

1. Introduction

The Russian coal industry is represented by a rather large range of enterprises for extraction of mineral resources. Coal mining is carried out at 63 coal mines, on which the conditions for the development of coal beds have changed: the volumes of worked out spaces have increased, the depth and length of the working faces has increased. Almost every third mine in Russia mines for coal at a depth of more than 500 m. Russian mines are not only the deepest, but also methane-hazardous. About 85% of miners die during explosions of methane dust-air mixtures. However, despite the decrease in the number of explosions in coal mines, the specific value of fatal traumatism has increased almost threefold (Fig. 1) [1].

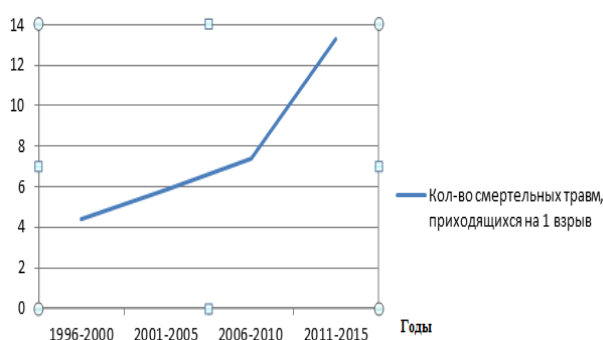


Fig. 1 The dynamics of quantity of fatal traumas per 1 explosion [1].

The structure of fatal traumatism has also changed, in which carbon monoxide poisoning dominates. The analysis of major accidents in coal mines showed that 54.5% of deaths occurred as the result of carbon monoxide poisoning. It should be noted that, according to other sources, lethal carbon monoxide poisoning occurs in 32.8 - 49%, and in some cases up to 80% of miners die [2]. It can be assumed that during an emergency situation in a coal mine, miners do not even have time to open and "breathe out" a mine self-rescuer, and in some cases cannot effectively use it. The increase in the length and depth of working is accompanied by large energy losses when leaving emergency areas and increasing of

pulmonary ventilation more than 70 L/min, which reduces the protective action time of the self-rescuer almost twice. In addition, any emergency situation is aggravated by the fact that 52% of miners have inadequate behavior, which is the evidence of psychophysiological instability of a number of workers caused by the phenomenon of "professional exhaustion". It is this phenomenon that can initiate the resistance to malfunctions of systems, equipment, and compliance with safety rules.

2. The prerequisites and means of problemsolution

The current situation is the evidence of the need to study the risk factors induced by the mine self-rescuer with chemically bound oxygen, affecting the respiratory comfort and the time of protective action. In the opinion of domestic researchers [3,4], miners die both when connected to isolating self-rescuers with chemically bound oxygen, and when leaving in mine self-rescuers from gassed working areas for the following reasons:

1) the imperfection of mine self-rescuers with chemically bound oxygen (the trigger device is not always activated, the breathing bag does not open, there is a large resistance to breathing during the inhalation and the exhalation due to the increase of "dead" space, a high temperature of inhaled air resulting from the exothermic reaction is formed);

2) the inability to use them.

In addition, these reasons can also include:

1) the insufficient adaptation of constructive and operational characteristics of a mine self-rescuer to the constitutional features and psychophysiological qualities of miners;

2) the lack of reliable dynamic control of the working condition of the mine self-rescuer;

3) the lack of personal-oriented qualification educational programs of professional training for admission to independent work in coal mines;

4) the personal attitude of miners to mine self-rescuers, as well as ambiguous requirements for their wearing;

5) the lack of individual educational routes for the formation of adaptive model of safe behavior when miners are included in the RPE (Respiratory Protective Equipment) in situations simulating emergencies in the coal mines, during evacuation stages;

In addition, when the miner is connected to RPE, he is affected by negative factors related to the design features and operational characteristics of the mine self-rescuer, the combined and associated effects of which can initiate life-threatening conditions for miners emerging in conditions of gas contamination, smoke, increased temperature. These pathogenic factors include the high temperature of inhaled GRM, which can cause burns of the upper respiratory tract, lungs; increasing resistance during the inhalation and the exhalation in hyperventilation conditions under the physical exertion; normobaric hyperoxia; toxic effects of normobaric hyperoxic GRM (gas-respiratory mixture); hyperoxic hypoxia; the phenomenon of nitrogen washing-out from the human body, which represents “nitrogen hazard”; the dryness of GRM; increasing uncompensated hypercapnia. Psychological and physical exertion in conditions of emergencies in a coal mine are able to potentiate the negative effects caused by connection to the mine self-rescuer. Therefore, it is reasonable to consider in detail the factors caused by the chemical reaction when connected to the mine self-rescuer, negatively affecting the respiratory system and respiratory comfort (Fig. 2).

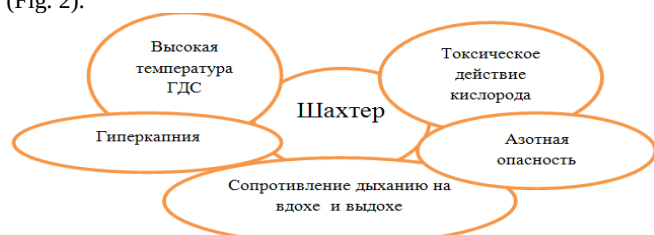


Fig.2. The main factors of adverse effects on a human induced by the mine self-rescuer.

3. Results and discussin

Normobaric hyperoxia. As the conducted studies on 18 practically healthy volunteers showed, the volume concentration of oxygen in the respiratory bag when the mine self-rescuer is connected reaches its maximum values by 25-35 minute and ranges from $96.0 \pm 1.19 - 97.3 \pm 0.56$ v/% at a barometric pressure of 770.5 $\pm$ 1.70 mm Hg, which allows to say that normobaric hyperoxia prevails in the GRM (Table 1). But within this framework, the volume concentration of carbon dioxide begins to increase from 15 minutes, which indicates the formation of “break point” of mechanisms for voluntary control of external breathing.

Table 1. The dynamics of volume concentration change of oxygen in a gas-breathing mixture

Time, min	1 min	5 min	15 min	30 min	45 min	50 min	65 min
Volume concentration of O ₂ (v%)	52,7 $\pm$ 4,9	60,7 $\pm$ 3,6	83,0 $\pm$ 2,6	97,0 $\pm$ 0,7	95,5 $\pm$ 1,5	93,6 $\pm$ 4,6	95,6 $\pm$ 1,7
concentration of CO ₂	0,07 $\pm$ 0,02	0,03 $\pm$ 0,01	0,13 $\pm$ 0,04	0,54 $\pm$ 0,13	0,96 $\pm$ 0,39	1,33 $\pm$ 0,54	1,46 $\pm$ 0,58

The reactions of organism to normobaric hyperoxia can be very diverse, and many issues of the effect of increased oxygen content in inhaled air during physical exertion in healthy people have not been sufficiently studied. Their directivity and intensity depend on the level of partial pressure of oxygen, carbon dioxide, nitrogen, water vapors in the respiratory bag and the duration of phases of respiratory cycle.

The initial reactions to normobaric hyperoxia are usually of an adaptive character and are aimed at limiting the excessive increase of O₂ in tissues, especially in the brain, which is very sensitive to the toxic effect of oxygen. It should be noted that the direction of

protective reactions is of dual character. The spasm of capillaries, slowing of blood flow induce the development of hypercapnia and pH shift to the acid side (metabolic acidosis), which triggers the mechanisms of mitochondrial dysfunction. It completely levels out the defensive reaction of organism. And the physiological adaptive reactions of organism develop into a pathological reaction of toxic effect of oxygen (Fig. 2). Traditionally it is considered that the safe exposure to normobaric hyperoxia for a healthy person does not exceed 2-3 hours. In addition, several researchers note the pronounced variability of individual sensitivity to the oxygen intoxication. The psychoemotional stress, intense physical exertion, hypercapnia can change the sensitivity to the toxic effect of hyperoxia. The pathogenesis of normobaric hyperoxia is due to the toxic effect of oxygen and is associated with the generation of active species of oxygen and nitrogen monoxide (NO). But the imbalance between the antioxidant defense of organism and oxidative stress is in the base of many pathological processes.



Fig. 3. General scheme of pathogenesis of normobaric hyperoxia during breathing when one use a mine self-rescuer with chemically bound oxygen.

Thus, endothelial, mitochondrial dysfunctions, the disruption of surfactant synthesis, alveolar-capillary membrane edema, and microatelectasis contribute to the impaired diffusion capacity of lungs and the decrease of active pulmonary surface. These changes can lead to the development of hypoxia and hypercapnia even in conditions of normobaric hyperoxia.

Increased resistance. When testing RPE on volunteers, it was found that the resistance to breathing during the inhalation and the exhalation during physical exertion varied on the first minutes from 26.7 ± 3.33 mm of w.c. to 51.4 ± 2.6 mm of w.c., and, on the 30th minute it reached 77.5 ± 9.95 mm of w.c. and 85.0 ± 9.06 mm of w.c., respectively. (Table 2). However, the resistance to exhalation up to 15 minutes is significantly higher than the resistance to the inhalation, which is largely due to the need to overcome the resistance force of respiratory bag. On the 40th minute, the aerodynamic counteraction to the inhalation (107.5 ± 23.8 mm of w.c.) and the exhalation (97.5 ± 17.8 mm of w.c.) reaches its maximum value and this area can be considered as a kind of “reference point”, from which disconnecting of RPE starts because of the shortage of GRM to the inhalation. One of the reasons for disconnecting of the mine self-rescuer is uncompensated hyperoxic hypoxia against the background of physiological hyperventilation, activation of auxiliary respiratory muscular system and switching to the metabolic level of respiratory regulation. But with increasing of aerodynamic resistance, the patients begin to breathe frequently, thereby contributing to the reduction of resistance. However, with frequent breathing, the respiratory volume of the lungs decreases, so the small airways can completely close. The mechanism of dynamic compression of bronchi is due to the fact that with the expansion of lungs, the bronchi are also expanded and their lumen increases.

Table 2. The dynamics of changes in resistance during the inhalation and the exhalation during the physical exertion using the mine self-rescuer ShSS-TM.

Min mm	1	5	10	15
Resistance to inhalation	26,7±3,3	39,7±4,7	56,2±4,9	63,7±5,9
Resistance to exhalation	51,4±2,6	50,0±6,3	70,0±6,5	77,5±8,2
Min mm	25	30	35	40
Resistance to inhalation	70,0±8,8	77,5±9,9	78,5±13,8	107,5± 23,8
Resistance to exhalation	78,5±9,5	85,0±9,0	95,0±13,2	97,5± 17,8

Therefore, the studied subjects arbitrarily choose the mode of hyperventilation, including the auxiliary respiratory muscular system with increasing energy loss. Such a situation will inevitably lead to a compensatory hyperventilation, and a large absorption of oxygen by respiratory muscles will restrict the limits of physical load.

Nitrogen hazard. Unfortunately, this problem did not find wide coverage in the scientific literature. However, it is well known that when breathing atmospheric air, the dynamic constancy of partial pressure of pO_2 , pCO_2 , pN_2 is maintained in the alveoli of the lungs, where nitrogen has more than 78%. The partial pressure of nitrogen in the alveolar gas mixture and its partial arterial tension is 76.6 kPa (573 mm Hg), and 1.9 mL of nitrogen is dissolved in 100 mL of blood. In addition, nitrogen penetrates into all tissues, especially fatty and nervous tissues. Therefore, the value of partial pressure level and the nitrogen intensity during breathing in insulating means of individual protection of respiratory organs with chemical bound oxygen acquires special significance. And the phenomenon of “nitrogen absence effect” can be observed when breathing GRM from the mine self-rescuer, which is based on increasing the excitability of the central nervous system, including the respiratory and vasomotor center, which leads to the development of compensatory hyperventilation and an increase in the level of systemic blood pressure. Therefore, the increase in activity of nervous system contributes to the development of energy deficiency under the condition of hyperoxic hypoxia and induces the mechanisms of apoptosis and necrobiosis. In addition, nitrogen acts as a support gas for the lung alveoli. Penetrating through the interalveolar pores of Kona and Lambert's channels, nitrogen provides collateral ventilation. Studies on volunteers demonstrated the tendency to reduce the level of nitrogen in the respiratory bag of mine self-rescuer when breathing gas mixture (Table 3).

Table 3. The dynamics of the volume concentration of nitrogen in the respiratory bag when connected to the mine self-rescuer.

Time, min	1	3	10	15	20	25	30	35	40
V.% nitrogen	46,5	36,3	29,4	16,9	8,5	3,7	2,5	1,8	1,7

And it is from the level of 1.7% v/% of nitrogen content in the respiratory bag that the studied subjects begin to disconnect from the ShSS-TM under the physical exertion. The main reason for the termination of work is the shortage of GRM for inhalation, which is due to microatelectasis.

High temperature of GRM. The temperature of the inhaled GRM of mine self-rescuers can vary within the range (according to

the technical data sheets) of 45-55°C, although according to the results of technical trials, the temperature of the inhaled gas fluctuated within the range of 55-72°C. However, even at the temperature of 45-55°C, the thermal denaturation of proteins-enzymes leads to the stop of enzymatic processes. The temperature within the range of 60°C can initiate the change in the state of delocalized electrons of biomolecules and, in particular, induce replication of DNA molecule, which can lead to a pronounced biological effect, and also affect the phase transitions of lipids in cell membranes.

Increase of functional dead space. When connected to the mine self-rescuer, the functional dead space (FDS) is increased due to the heat exchanger and the corrugated tube. But the dead space should be considered not as a static value, but it is reasonable to analyze it from the position of dynamic space, ensuring the constancy of alveolar environment. The analysis of FDS role from the position of adaptation to high temperature of GRM suggests that the increase in the respiratory rate, increasing the “dead space”, as well as the additional “dead space”, contribute to the evaporation of liquid from the surface of the mucosa of upper respiratory tract, mouth, tongue, increases the space volume, which provides a short-term phase of compensation during the thermal adaptation to high-temperature GRM.

4. Conclusion

The basic mechanisms of ventilation disturbance described above only occasionally appear in a pure form. The combination of these processes is much more common. In such conditions, physical exertion in conditions of normobaric hyperoxia does not always improve the saturation of arterial blood with oxygen. However, breathing with the help of RPE promotes intrapulmonary redistribution of blood flow, which can disrupt venous return. Therefore, it is appropriate to carry out the respiratory therapy to all employees who were connected to a mine self-rescuer and got to first-of-the-air in RPE. One of the most promising methods is PEEP (positive end expiratory pressure). The method is used for spontaneous breathing. The PEEP regimen affects not only breathing but also a circulation and a water-electrolyte balance.

REFERENCES

1. V.S. Zaburdyaev. Methane and dust explosive situation in coal mines//Labor Safety in Industry. **No. 11**, 30-32 (2016)
2. E.Ya. Fistol, V.V. Soloshenko. Modern opportunities and results of treatment of miners affected by explosions of methane-coal mixture//Medicine of Emergency Conditions. **No. 3-4**, 22-23 (2009)
3. V.A. Oguretsky, V.N. Egorov. Considerations on the use of isolating self-rescuers with chemically bound oxygen in coal mines//Labor Safety in Industry. **No. 4**, 54-60 (2012)
4. A.V. Nemtsev, E.M. Westmoreland. Actual issues on using of insulating industrial self-rescuers. Self-rescuers on chemically bound oxygen//Labor Safety in Industry. **No. 2**, 62-66 (2013)

COMPARATIVE STUDY OF NOISE MEASUREMENT IN WORK ENVIRONMENT WITH FREQUENCY WEIGHTINGS

Doc. Ing. Michaela Balážiková, PhD.¹, Ing. Martina Dulebová²

Faculty of Mechanical Engineering – Technical University of Kosice, Department of Safety and Quality of Production, Slovak Republic^{1,2}

michaela.balazikova@tuke.sk, martina.dulebova@tuke.sk

Abstract: The paper deals with the impact of noise (low frequency noise on threshold point) on human health and safety in the workplace. The first part of the article describes the main impacts of noise on human health - specific and systemic. Part of the paper is also the process of risk assessment according to the valid directive of the European Parliament and Council Directive 2003/10 / EC.

The paper deals with frequency weightings of low frequency noise. Authors describe frequency weightings A and Z and its difference in low frequency noise measurement and also the main goal of its usage. Part of article is experimental measurement of this noise in work environment.

Keywords: RISK ON WORKPLACE, LOW FREQUENCY NOISE, NOISE MEASUREMENT

1. Introduction

Noise is unwanted sound that can cause impairments or damage to health. The employee is surrounded at the workplace by various noises. Some are necessary, because they have meaning as signals, enable him to orientate in space and influence his behaviour and communication with other people; others are undesired, because they have a disruptive or even damaging effect. [1]

The risk of damage (changes) to the hearing of employees occurs after long-term exposure to noise with a level over 80 dB. The effects of noise can be divided into two basic groups, namely specific and systemic (non-auditory) – Fig.1. The specific effects of noise on a person are those influences whose final effect is directly dependent on damage and changes to the auditory organs. The systemic effects of noise on a person are those influences that in a crucial way change the functioning of part of the central nervous system other than the auditory organs. These are then mediated by special structures of the nervous system. [1] [2]

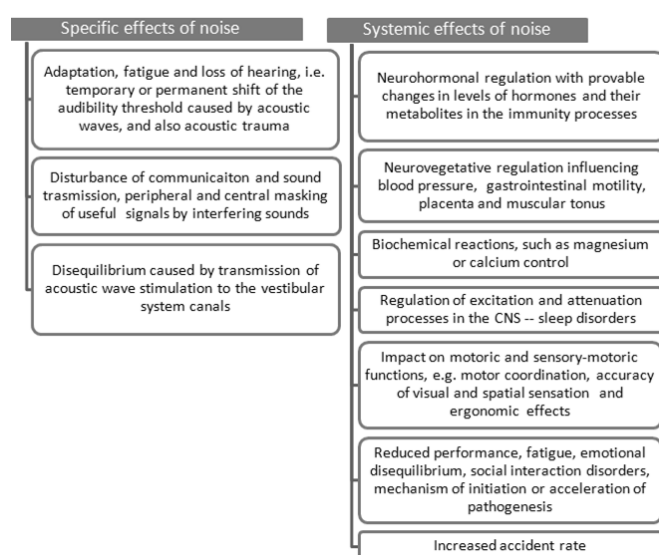


Fig. 1: Specific and systematic effects of noise

2. Low frequency noise

Low frequency noise is one of the most harmful factors occurring in human working and living environment. Low frequency noise components from 20 to 250 Hz are often the cause of employee complaints. [3]

In recent years, some European countries have adopted national criteria for low frequency noise, including Sweden ((Socialstyrelsen-Sweden, 1996)), Denmark (Jakobsen, 2001)

Netherlands ((N S G, 1999) Germany (DIN: 45680, 1997), Poland (Mirowska, 2002). Some of these methods assume a threshold curve for limitation of annoyance, based approximately on the ISO226 threshold, or a curve parallel to this threshold, but extended to frequencies below 20Hz. [4]

Human hearing has in general different sensitivity with different vibrations. During the perception of noise distortion occurs, and for this reason weight filters A, B, C, D, G and Z are introduced which are used for the conversion of the actual measured values of noise level to other levels. These filters are inverse to the curves of the equal noise volume at levels of 40 dB, 80 dB and 120 dB, and their frequency sensitivity is similar to the frequency sensitivity of the human ear.

2.1 Sources of low frequency noise

Low-frequency mechanical vibrations generated by machines and machine systems evoke disruptive dynamic forces, which are most often caused by imbalanced rotating material or material with reverse movement, abaxial connection of rotational components, disproportional shaking of mutually moving components, a mechanical release, seismic excitement and technological process. [5]

One of the most important sources of low-frequency noise is the flowing of a fluid in machine systems, ventilation and air-conditioning systems, combined units, transport vehicles, combustion turbines, compressors, entertainment businesses and festivals as well as household appliances. Low-frequency wavelengths can also have a natural character, such as, for example, the atmospheric flowing of air. [4][5]

2.2 Effects of low frequency noise

The adverse health effects of community noise include subjective annoyance, interference with speech communication, disturbance of rest and sleep, impaired psychological function, and negative behavioural effect. Besides the psychosocial effects of community noise, there is also concern about the impact of noise on the cardiovascular system. [4]

Studies have found that low frequency noise can be annoying and can create potential health hazards for people exposed to them, especially for highly sensitive subjects. [6]

From experience, it can be concluded that working and resting in such an environment can lead to headaches, and unpleasant feelings which, in turn, can lead to a reduction of working or relaxing efficiency. In general, it has been found that if people are exposed to very low frequencies of sound and infrasound, they may experience difficulties in performing mental work, as well as a general sense of discomfort. As the intensity increases or exposure continues for longer periods of time, dizziness,

nervousness, fatigue, irritation, nausea, and headaches may occur. [6] [7]

3. Measurement of low-frequency noise on workplace

Measurements are essential for assessing the negative effects of noise and for setting permissible values (criteria) which influence health, comfort and performance in a negative way. Measuring the exposure of employees to noise during work is among the quantitative measurements, and it is done for the purpose of assessing the health-risk of noise exposure and the assigning of a job to a category. An important part of any management of acoustic risks is introducing appropriate criteria for determining a favourable solution to the problems of noise. The required minimizing subsequently determines the resources for making alternative proposals for reducing noise and in the end the resources for estimating costs when meeting the required criteria. [8]

The measuring and setting of noise exposure ran at a workplace where automobile parts are machined using a CNC cutting machine. (Fig.2)



Fig. 2: Noise source – CNC cutting machine

The application range of the CNC milling machine Raptor X- SL is extremely wide due to the adjustable work surface height. The Z axis stability is excellent, allowing you to work as accurately on large 3D objects as one can on flat sheet materials. Chosen technical data of this CNC milling machine shows Table 1.

Table 1: Technical Data of CNC cutting machine [9]

Technical data Raptor X-SL 1200/S20	
Clamping Area	X -1500 x Y-2200 mm
X-axis Travel	1200 mm
Y-axis Travel	2010 mm
Z-axis Travel	300 mm Standard, optional up to 600mm available
Positioning speed X+Y / Z	40.000 mm/min max. (in Verb. mit WIN PCNC USB)
Working speed	20.000 mm/min max./ 3D-travel up to 10.000 mm/min
Step width X	0,0213 mm
Step width Y + Z	0,0113 mm
Repeat accuracy	approx. 10 µm
Positioning error	can be calibrated
Drive X / Y / Z	Stepper motor 9,4 Ampere / 930 Ncm holding torque!
Drive type X / Y / Z	Low backlash precision planetary gears with 11000 Ncm output torque
Power supply 3-channel controller	380 Volt / 50 Hz
Full version Software CAD/CAM	ConstruCAM-3D
Total weight	approx. 820 kg incl 3-channel controller
Construction and surface	Massive steel construction, fully powder coated, light grey

The measuring of the noise was performed at the workplace of the equipment operator during operation; noise was measured using a 2250 noise analyser from the company Brüel & Kjær (Fig.3), which serves for performing broadband measurements of noise exposure in the field. The B&K 2250 host a number of software modules, including frequency analysis, logging (profiling) and recording of the measured signal. [10]

Key features of hand-held Analyzer Type 2250:

- General-purpose Class 1 sound measurements to the latest national and international standards
- Occupational noise assessment
- Environmental noise assessment and logging
- Product development and quality control
- FFT analysis of sound and vibration
- Building acoustics, loudness and noise rating measurements
- Tone assessment using 1/3-octave and FFT methods
- Low-frequency building vibration according to ISO 8041:2005 and DIN 45669 – 1:2010 – 09
- Infrasound (G-weighting) measurements according to ISO 7196:1995 and ANSI S1.42 – 2001 (R2011)



Fig. 3: Hand- held Analyzer Type 2250, module for frequency analysis and time module

During the measurement of noise only a CNC cutting machine was active at the workplace. The axis of the microphone was set for the CNC cutting machine, and the noise meter was placed at a height of 1.5 m above the floor. The results were stored in the memory of the measuring device and subsequently processed using the relevant computer software. Operator of technical device is not using hearing protectors and during milling he is right next to the CNC milling machine (Fig.4).

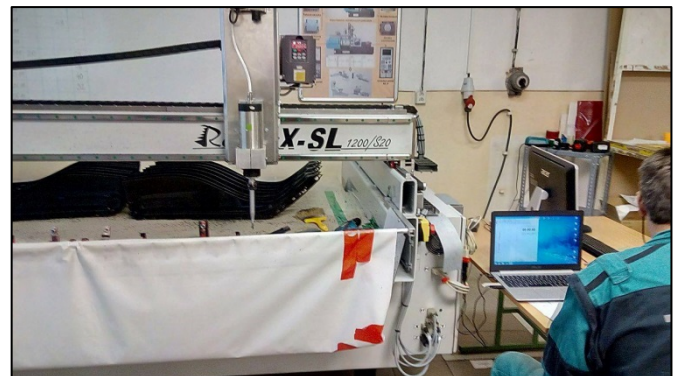


Fig. 4: Workplace of measurement of low frequency noise from machine

During the experimental measuring the equivalent level A of acoustic pressure L_{Aeq} and the equivalent level Z of acoustic pressure L_{Zeq} were measured over time during the performance of the machining work. The main reason and aim of this measurement was to point out the different levels of acoustic pressure using the A-scale filter and the Z-scale filter at low frequency 80 Hz and at frequency 500 Hz. Records from measurements at various

frequencies and weightings are shown in Fig.5 - Fig. 8.

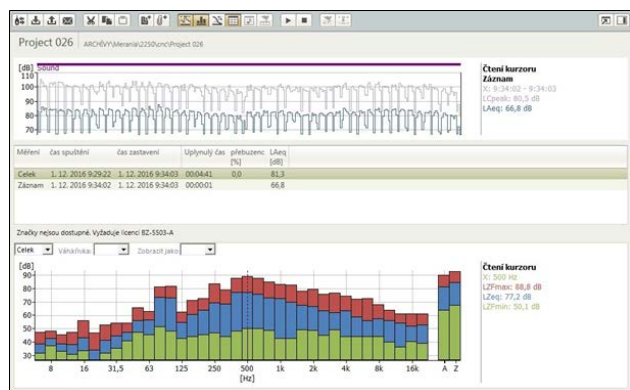


Fig. 5: Record of measurement of noise level A exposure at 500 Hz

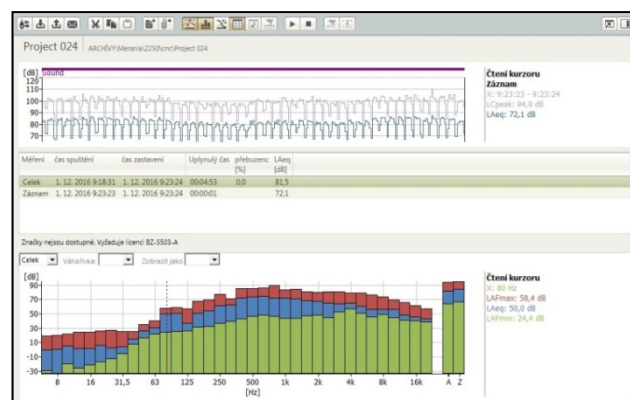


Fig. 6: Record of measurement of noise level A exposure at 80 Hz



Fig. 7: Record of measurement of noise level A exposure at 500 Hz

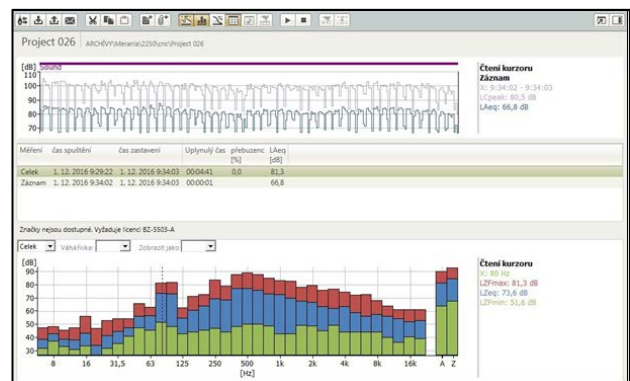


Fig. 8: Record of measurement of noise level Z exposure at 80 Hz

Summary of measured values are in Tab.2.

Table 2: Summary of measured data

Weight filter A	
L_{Aeq} value (500 Hz)	73,7 dB
L_{Aeq} value (80 Hz)	50 dB
Weight filter Z	
L_{Zeq} value (500 Hz)	77,2 dB
L_{Zeq} value (80 Hz)	73,6 dB

4. Evaluation of the experimental measurement

The measuring of the noise load during machining points to the fact that acoustic wavelengths of low frequency (specifically at 80 Hz) have a higher value with weighted Z than with the weighted A, with the difference in values of 23.6 dB. Such low frequencies are able to influence the cardiovascular system, the neuropsychic system and the sensory-motor functions of a person.

Fig. 9 describes the process of risk assessment of noise on selected workplace during the low frequency noise measurement with A - weighting and Z - weighting at frequencies 80 Hz as well as the comparison at 500 Hz.

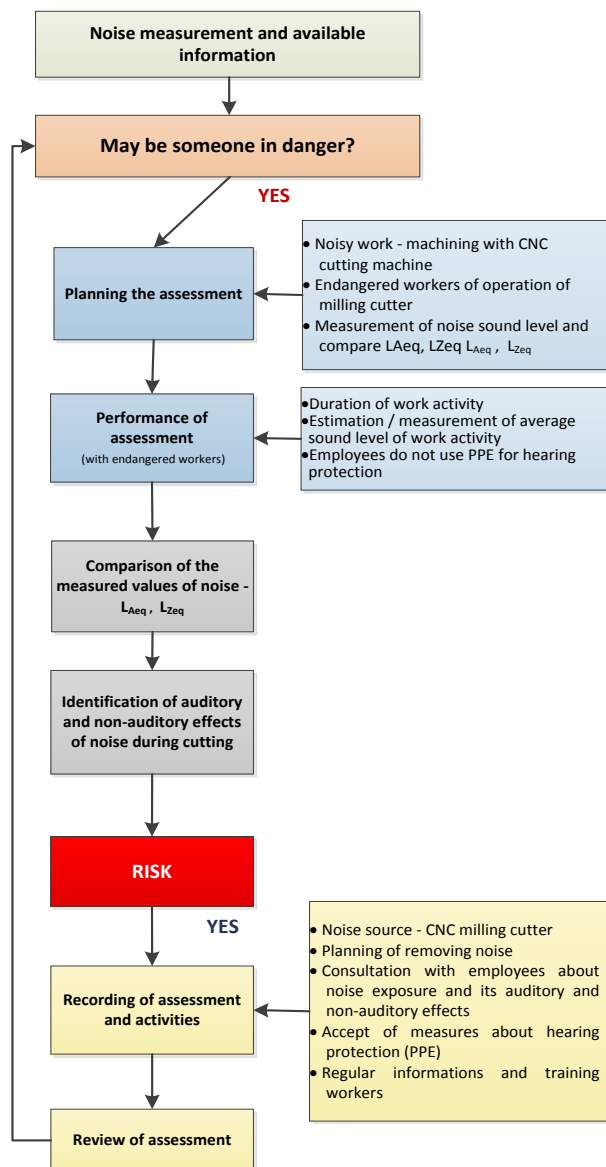


Fig. 9: Process of risk assessment of noise on selected workplace

The Z-weighting represents the real influence of acoustic energy on a person and the environment, and the A-weighting represents the sensory expression of the acoustic energy, which is mainly lower and does not correspond to the real state. [7]

It is impossible from the viewpoint of the working of energy to correctly evaluate the acoustic wavelengths at low frequencies of the A-weighting; therefore, it is more appropriate to use the Z-weighting, or even the C. A small sensitive portion of the population can feel discomfort of very low frequencies (infrasound) even from levels of 65 dB, if the relevant combination of frequency and length of working occur. [7]

5. Conclusion

The mutual working of noise and other factors of the work environment increase the risks that employees are exposed to during their work activities. Employers have the legal obligation to ensure that the level of safety and protection of health is such that risks arising at the workplace with individual work activities are acceptable. On the basis of exceeded values the employer is obligated to immediately take measures following from general principles of prevention, to take the relevant measures (so long as this is possible) for removal of the source of noise, or reducing it at the given workplace, and provide workers with appropriate and adequate personal protective equipment (PPE).

At present, when one of the most significant problems is becoming the securing of reliable operation of newly proposed mechanical systems, questions on studying the origin, spread and isolation of low-frequency wavelengths from machines and their parts are very topical. It is possible to ensure the required reduction of the unwanted effects of low-frequency noise on a person and the surrounding environment using vibrodiagnostics and vibroisolation.

Measures for noise reduction can significantly change the surrounding machine-person environment. Therefore, it is recommended that all interested parties make use of each proposed measure and actively take part in its preparation. Representatives who perform a variety of functions can or should take part.

Because low-frequency noise is a major component of many occupational and community noises the effects of such noises may be viewed as, in part, the effects of low frequency noise. Regularity authorities must accept that annoyance by low frequency noise presents a real problem which is not fully described by the commonly used assessment methods. There is an increasing acceptance that low frequency noise needs to be specifically attended to, but only a few countries have adopted specific guidelines for low frequency noise.

The investigations show that these limits are not sufficient from viewpoint of human health in the generation of specific low frequency noise. Therefore, it is needed to define the limit values and procedures describing the circumstances under which compliance with the regulations can be verified. These procedures can be based either on calculations from sound prediction models or on measurements. [6]

This contribution is the result of the project implementation:

“APVV 15-0351 Development and application of risk management models in terms of technological systems in line with the industry (Industry) 4.0”.

“VEGA 1/0150/15 Development of methods of implementation and verification of integrated systems for safe machines, machine systems and industrial technologies”.

“University Science Park Technicom for Innovation Application Supported by Knowledge Technology, ITMS: 313011D232”.

6. Literature

- [1] BALÁŽIKOVÁ M., SINAY, J.: Implementation of auditory and non-auditory effects of noise in the risk assessment process in mechanical engineering. In: *Procedia Engineering*. 2012, No. 48, p. 621-628. ISSN 1877-7058S
- [2] BABISCH W., BASNER M., DAVIS A., et al. Auditory and non-auditory effects of noise on health. In: *Lancet*. 2014;383 (9925):1325-1332
- [3] SHEHAP M.A., SHAWKY H.A., EL-BASHEER, T. M.: Study and Assessment of Low Frequency Noise in Occupational Settings. In: *Archives of acoustics*. 2016. roč. 41, č. 1, s. 151–160.
- [4] BERGLUND, B., HASTEN, P., JOBR, F.: Sources and effects of low-frequency noise. In: *J. Acoust. Soc. Am.* roč.99, č. 5, 1996, s. 2985–3002.
- [5] ŽIARAN, S.: *Nízkofrekvenčný hluk a kmitanie*. Bratislava: STU, 2016. 316 s. ISBN 978-80-227-4536-9.
- [6] ŽIARAN S. The assessment and evaluation of low-frequency noise near the region of infrasound. *Noise Health* -2014;16:10-7
- [7] PAWLACZYK- ŁUDZCZYNSKAM, MALGORZATA A KOL.: The impact of low frequency noise on human mental performance. In: *International Journal of Occupational Medicine and Environmental Health*. roč. 18, 2005, č. 2, s. 185 - 198.
- [8] BALÁŽIKOVÁ, M.: *Riadenie akustických rizík: Habilitačná práca*. Košice: TU, 2014. 111 s.
- [9] Operating Instructions Raptor X-SL-Series. 2010. 102 p. <https://www.cnc-step.de/wp-content/uploads/2014-12-17-Operating-Instructions-RaptorX-SL-Series-1.pdf> [cit. 2017-30-03]
- [10] Product Data Hand-held Analyzer Types 2250 and 2270. 20p. <http://www.bruel.hu/pdf/bp2025types225070G4.pdf> [cit. 2017-30-03]

EXPERIENCE APPLICATION OF THE DUPLICATING WAY "WSEM-PC" FOR THE NOTIFICATION OF PEOPLE AT FIRE IN OFFICE BUILDINGS OF JSC RUSSIAN RAILWAYS

ОПЫТ ПРИМЕНЕНИЕ ДУБЛИРУЮЩЕГО СПОСОБА «СОУЭ-ПК» ДЛЯ ОПОВЕЩЕНИЯ ЛЮДЕЙ ПРИ ПОЖАРЕ В АДМИНИСТРАТИВНЫХ ЗДАНИЯХ ОАО «РОССИЙСКИЕ ЖЕЛЕЗНЫЕ ДОРОГИ»

Sharkhun S.¹, Doctor of Engineering Sirina N.²

The Ural Institute of State Firefighting Service of Ministry of Russian Federation for Civil Defense, Emergencies and Elimination Consequences of Natural Disasters¹, Ural State University of Railway Transport², Russian Federation
E-mail: S_sharkhun@mail.ru, NSirina@usurt.ru.

Abstract. The results of the natural observation of evacuation of office buildings workers of JSC "Russian Railways" with application of various notification ways are presented in the article and the time of their response to a signal is defined. Confidential level of the possibility of use of the considered mathematical laws of distribution for the time of response description of the «Fire» signal depending on the notification way is determined. Based on the chosen law of distribution comparative assessment of efficiency of the notification at the fire depending on a notification way in comparison with standard values, and also the existing traditional ways of the notification has been conducted.

KEYWORDS: THE WARNING SYSTEM OF PEOPLE AT FIRE, THE NOTIFICATION DUPLICATING WAY, THE DISTRIBUTION LAW, NATURAL OBSERVATION, EVACUATION TIME.

1. Introduction

Nowadays the main systems promoting safety of people at fire in office buildings are the automatic fire alarm system (AFAS) and the warning system and managements of people at fire (WSEM) evacuation. The main objective of this system is the operational notification of the people who are in the building and management of process of their evacuation to a safe zone [1,2].

As it is noted in [2,3], the evacuation process of people at fire can conditionally be divided into three main stages (fig. 1): lag effect of the FPO systems, time of making decision on the beginning of evacuation, the real movement time on the evacuation ways. It is also fair for the office buildings included into the JSC Russian Railways (JSC "Russian Railways") control system.

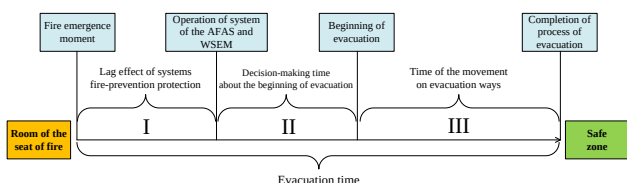


Fig. 1. Actual time of evacuation

The time spent for fire detection (a lag effect of systems of the AFAS) can take several tens of seconds and depends on a technical component of the AFAS system – correctness of installation, timeliness of maintenance and scheduled preventive maintenance. It is impossible to reduce this time interval to zero. However at today there are ways of decreasing the time of making decision of the evacuation beginning.

2. Prerequisites and means for a solution

Reduction of a time interval on making decision on the beginning of evacuation at the moment is an urgent task for the majority of buildings with a big congestion of people and the JSC "Russian Railways" objects are not exceptions. For the solution of this task in modern conditions it is possible to allocate two directions (fig. 2) – training of workers and personnel of the organizations in actions at receipt of a signal of the fire for the purpose of a conditioned reflex development: "alarm – immediate evacuation"; the use of special technical means aimed to persuade a person to make the right decision when his health and life are threatened due to the fire impacts.

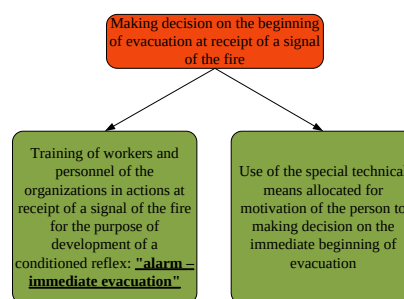


Fig. 2. Possible ways of time reduction of the evacuation beginning

The works on the first direction are being conducted for quite a long time – the requirements on the necessity of the evacuation plans working off and the conducting exercises for people at fire evacuation has existed for more than 10 years. However, the practice shows, when carrying out the announced doctrines in advance people act quickly and correctly, and hearing the same signal in other times people act differently – they try to establish the signal reliability, to find out what really happened, if the signal is to him personally or not, and in some cases a person just continues to perform his work.

Today great attention is paid to the creation of any technical system aimed to force a person to certain actions when receiving "Fire". It is done for the people to be able to evacuate from the building and as therefore save the people's health and life.

3. The solution of the considered problem

One of the funds allocated for the persons motivation to making decisions on the immediate beginning of evacuation is the duplication of people's warning about the fire of "WSEM-PK" [4]. It is based on the use of a technical component which allows to adjust interrelation between the WSEM system and the local computer network (LCN) which is available at the enterprise for the purpose of duplication of a fire signal on all personal computers connected to a LAN of the office building.

The essence of the applied duplicating way is that in office buildings the installation of the special software "WSEM-PC" is installed in the server computer. It allows, when receiving the fire signal from the reception and the control device of the fire alarm system on the communication line means, to carry out this fire signal duplication on all personal computers (PC) connected to a LAN. At the same time there are messages in the personal computer screen on the fire and the scheme of evacuation from the room with the definite personal computer indicating the nearest emergency exit. The personal computer blocking is conducted to avoid its further work. Except for a

visual signal to increase the efficiency of the warning in the program complex WSEM-PC the alarm voice of the displayed information is provided, on means of the previously recorded voice warning. For example: "Attention! The building's on fire! All Personnel proceed to the emergency exit immediately!". This way is described in works in detail [5,6,7]. Its application is possible in office buildings of JSC "Russian Railways" without essential material inputs and doesn't contradict the existing normative documents as its introduction is carried out in the existing WSEM and LAN system.

4. Results and discussion

For the analysis of the efficiency of the offered duplicating notification way there are natural observations of people's behavior when receiving a "Fire" signal are conducted. Observations were made in five various office buildings of JSC "Russian Railways" (further - the Building No. 1, No. 2 ... No. 5). In different days, approximately in identical time during the working day the signal of the fire was given; the notification was carried out by the 4th options:

- the standard warning system and managements of evacuation of people at fire (WSEM);
- standard WSEM + the duplicating notification way "WSEM-PC" (only sound component);
- standard WSEM + the duplicating notification way "WSEM-PC" (a sound component and the visual notification);
- standard WSEM + the duplicating notification way "WSEM-PC" (a sound component, the visual notification and blocking of the personal computer).

During the observation the response time to the fire signal, that is, the period from the signal receiving till making the decision to the evacuation beginning by each person. The received temporary indicators were included into the protocol. The generalized results of the observation are given in table 1.

Table 1

The generalized results of natural observation of people's behavior, when receiving a signal of the fire, at various notification ways

Experiment No.	Name of the building	Way notification of people	Number of people	As much as possible time of response to a signal, min.
1	Building №1	standard WSEM	153	1,94
2	Building №2		174	2,05
3	Building №3		162	1,98
4	Building №4		158	2,16
5	Building №5		147	2,05
6	Building №1	standard WSEM + "WSEM-PC" (only sound component)	158	1,70
7	Building №2		171	1,72
8	Building №3		155	1,81
9	Building №4		158	2,01
10	Building №5		143	1,95
11	Building №1	standard WSEM + "WSEM-PC" (a sound component and the visual notification)	163	1,65
12	Building №2		174	1,50
13	Building №3		163	1,58
14	Building №4		136	1,91
15	Building №5		149	1,84
16	Building №1	standard WSEM + "WSEM-PC" (a sound component, the visual notification and blocking of the personal computer)	151	1,57
17	Building №2		172	1,41
18	Building №3		159	1,51
19	Building №4		147	1,83
20	Building №5		142	1,72

The data obtained as a result of natural observation have been processed by means of the statistical graphic STATGRAPHICS for Windows [8] system during which the minimum, maximum and average time of response to a signal, and also an average square deviation were defined.

According to the obtained data graphic dependence (fig. 3) of dynamics of average time of response to the «Fire» signal in the examined buildings depending on the notification way from which it is obvious (on the example of the Building No. 1) that the average time of people's reaction if only a standard way of notification is used is 18.96 sec. The average reaction time at partial use (only sound notification) of an additional notification way about the fire (WSEM-PC) is 16,33 which is 13,90% less. The average time of reaction when using the sound and visual notification (WSEM-PC) is 13.60 which is 28,29% less. And the average time of an additional notification way about the fire (WSEM-PC) is 8.97 which is 52,70% less than initial.

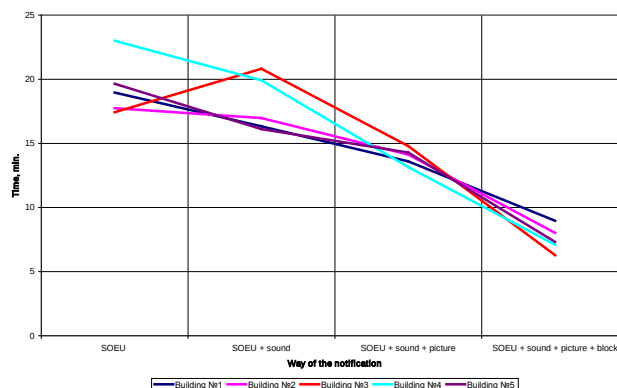


Fig. 3 Dynamics of the average time of response to the «Fire» signal depending on the notification way

When the obtained data research the determination of the confidential level of the possibility of the use of various mathematical laws for the description of the dynamics of the response time to the «Fire» signal was the main objective.

So for the choice of the mathematical law of distribution and the description of time of response to the fire signal, the following distribution laws have been analyzed:

- normal law;
- logarithmic normal law;
- gamma distribution;
- exponential law;
- Veybull's distribution.

5. Conclusion

From the analyzed five distributions the possibility of the normal law application has been rejected, other considered laws can be used for the modeled event description "has heard – has made the decision – has begun the movement".

The obtained data by the results of the mathematical research on the confidential level of various distribution laws use are provided in table 2.

Table 2.

Confidential level of a possibility of mathematical laws use for the obtained data research

Law of distribution	Normal law	Logarithmic normal law	Gamma distribution	Exponential law	Veybull's distribution
Confidential level of use, %	10	93	90	95	90

The data analysis and check of the possibility of the application of the considered laws of distribution to the results of the pilot study (criterion a chi-square, Kolmogorov-Smirnov's criterion, [9]) allows to make a conclusion that for the description of time to make a decision

begin evacuation it is possible to use the exponential law of distribution with the confidential level of 95% ($p=0,95$). On the basis of the used mathematical model a comparative evaluation of the fire notification efficiency depending on the notification way in comparison with standard values, as well as the existing traditional notification ways was conducted. As the result the following forecasts were received: by the time of $t=0,5$ min. the response to the standard WSEM is 43,77%, on WSEM+ a sound – 49,93%, on WSEM+ the picture on the PC monitors + a sound in speakers – 56,44% and for WSEM+ the picture on the PC monitors + a sound in speakers + compulsory personal computer block – 63,16%. Graphically the data are submitted in figure 4.

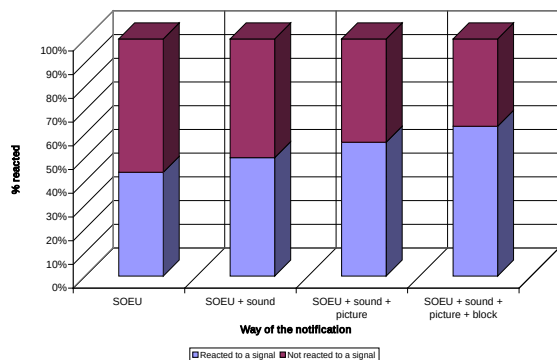


Fig. 4 Quantity of the ones to react to the notification signal in 0,5 min. time point.

Therefore, application of WSEM-PC will allow to increase the number of the ones to react to 0,5 min. time point for 19,39%. By the time of $t=1,0$ min. the response to the standard WSEM will be 68,38%, on WSEM+ a sound – 74,93%, on WSEM+ the picture on the PC monitors + a sound in speakers – 81,09% and for WSEM+ the picture on the PC+ monitors a sound in speakers + compulsory personal computer block – 86,43%. Graphically the data are submitted in figure 5.

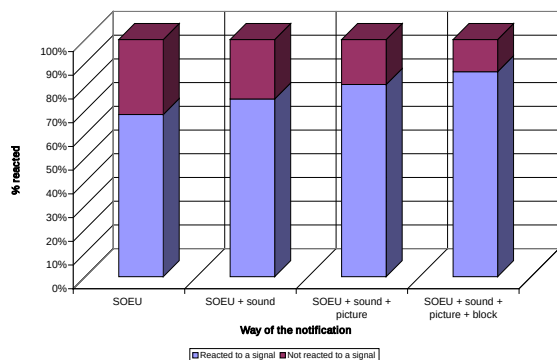


Fig. 5 Quantity of the ones to react to the notification signal in 1.0 min. time point.

Therefore, the number of the ones to react in 1,0 min. time point for 18,05% will allow to increase applications of WSEM-PC. By the time of 1,5 min. the response to standard WSEM will be 82,22%, on WSEM+ a sound – 87,44%, on WSEM+ the picture on the PC monitors + a sound in speakers – 91,74% and for WSEM+ the picture on the PC monitors + a sound in speakers + compulsory personal computer block – 95,00%. Graphically the data are submitted in figure 6.

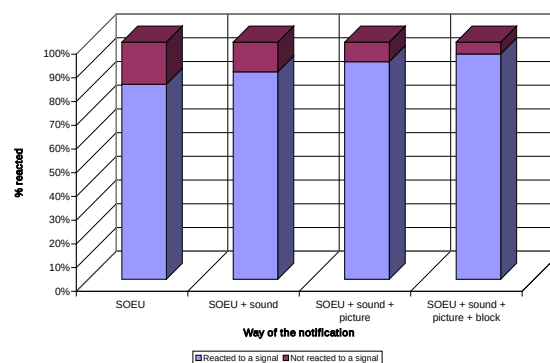


Fig. 6 Quantity of the ones to react to the notification signal in 1,5 min. time point.

Therefore, the number of the ones to react in 1,5 min. time point for 12,78% will allow to increase applications of WSEM-PC. Figures 4-6 show that the suggested notification way "WSEM-PC" makes the greatest impact at the initial stages of people's notification about the fire, just in time of fire when in actual practice people do not completely understand the danger of the emergency situation and do not always take actions, necessary for the evacuation. Thus, it is possible to make a conclusion that the application of the duplicating notification way "WSEM-PC" "Fire" has a noticeable positive impact on the average time of a signal response.

6. List of Reference.

1. Sharkhun S.V., Sirina N.F. Decrease in time of the beginning of evacuation at the fire as a basis of safety of workers of office buildings of JSC "Russian Railways"/Transport of the Urals. 2016. No. 2 (49). Page 34-38.
2. Sharkhun S.V., Bryukhov E.N. Timely has begun evacuations at the fire as a basis of its efficiency//Magazine No. 5 "Health and safety", May, 2015 of Page 54-57
3. Sharkhun S.V., Kolbin T.S., Bryukhov E.N. Stages of evacuation of people at fire//Modern technologies of ensuring civil defense and elimination of consequences of emergency situations: The collection of articles on materials VI of the All-Russian scientific and practical conference of cadets, listeners, students and young scientists with the international participation on April 17, 2015 – Voronezh, 2015. p. 255-259
4. The warning system and managements of evacuation of people at fire – the personal computer (WSEM-PC) / Sharkhun S.V.: it is twisted. No. 2012617518; owner: Sharkhun S.V.; application No. 2012615195; date of receipt 6/22/2012; registrated in the Register of the computer programs 8/20/2012.
5. Sharkhun S.V. Means of the notification and management of evacuation of people at fire on the basis of network technologies//the Magazine "Pozharovzryvbezopasnost" Volume 22 No. 2 February, 2013 p. 60-64.
6. Sharkhun S.V., Kolbin T.S., Shirinkin P. V. Means of the notification and management of evacuation of people at fire on the basis of network technologies//In the collection: Fire safety: problems and prospects the collection of articles on materials III of the All-Russian scientific and practical conference with the international participation, on September 20, 2012. FGBOU VPO Voronezh institute of the Public fire service EMERCOM of Russia. Voronezh, 2012. Page 108-110
7. Sharkhun S.V., Sirina N.F. O of a possibility of application of the duplicating notification way of people at fire on infrastructure facilities of railway transport of JSC Russian Railway//II International Conference "Safety Problems of Building Critical Infrastructures", (on May 26-27, 2016, Yekaterinburg, Russia) = II International Conference "Safety Problems of Civil Engineering Critical Infrastructures" (SAFETY2016): collection of theses [The electronic text edition] / Urals. federal un-t of the first President of Russia B. N. Yeltsin, Construction in-t; Research Center of Reliability of resource systems and mechanisms OURO RAHN; Co-funded by the Erasmus + Programme of the European Union; MARUEEB; [under the editorship of V.N. Alyokhin]. — Yekaterinburg: URFA, 2016. Page 301-305.
8. Duke V. V. Data processing on the personal computer in examples. – Spb: ST. PETERSBURG, 1997. – 240 pages.
9. G. Khan, S. Hapiro. Statistical models in engineering tasks. – M.: World, 1969. – 395 pages.

CROWDSOURCING LANGUAGE RESOURCES FOR SPEECH RECOGNITION

Ing. Daniel Hládek PhD., Ing. Ján Staš PhD., prof. Jozef Juhár CSc.
Technical University of Košice, Letná 9, 040 01 Košice, Slovakia
E-mail: daniel.hladek@tuke.sk, jan.stas@tuke.sk, jozef.juhar@tuke.sk

Abstract:

An important part of any speech recognition system is a language model. Creation of a language model requires proper processing of large quantities of textual data. Part-of-speech tags, named entities or semantic roles in the text help with precise statistical language modeling. The natural language processing methods are usually trained on annotated text corpora. Annotation of text corpora or dictionaries is a difficult process that requires a lot of human work involved. Crowdsourcing is a specific sourcing model in which individuals or organizations use contributions of Internet users to create a specific knowledge base.

KEYWORDS: CROWDSOURCING, SPEECH RECOGNITION, LANGUAGE RESOURCES, SPEECH CORPORA

1. Introduction

1.1. Preparation of Data for Statistical Processing

Statistical models are an important part of contemporary systems of human-machine interaction. Construction of a statistical model requires a large amount of manually annotated data. For the sake of building a good language model it would be very helpful to have a sufficiently large database of text that would unify various sources in one place. The database can be easily used to easily construct domain-specific corpora from the already collected and prepared data.

Annotation of speech and language corpora is timely and costly process. The first step is to find interesting patterns that will be subject of data modeling. The research team must design annotation conventions and train a group of contributors. The prepared data are distributed to annotators that mark the interesting phenomena in the database. Partial results from the annotation team are gathered and a training corpus is constructed.

The corpus is the input of statistical model training. Adequate method is selected and the model is composed from the prepared training data. The model is then able to predict events, even if they were not seen in the training corpus. It is able to generalize implicit knowledge, written by the human annotators during database creation.

The annotation team is often not available. The first problem is financing the required people to annotate a database. Employing a person demands administrative work and sufficient financial resources that are often not sufficient. Even if financing is available, finding a skilled personnel is a hard task. The whole process is timely, because proper annotation requires a lot of focus and effort.

The whole process of training database preparation can be described as a sequence of actions:

1. Task preparation: This step includes introduction of the task to the annotator and learning of the annotation conventions.
2. Annotation of data: Observing a part of data and marking interesting parts with proper tags.
3. Partial results gathering: Results from annotators are put in a common place. Missing and contradicting annotations have to be resolved.

4. Database finalization: giving the final form to the database. Data should be in a form that is feasible for statistical processing.

1.2. What is Crowdsourcing

There is a strong need to find an easier of annotated database creation methods. Annotation of data should be:

1. easier,
2. cost less,
3. be faster.

The solution is to automate the process of data annotation, and partial results gathering.

A task is split into several smaller sub-tasks that are easy to comprehend by a random user.

Jeff Howe defined “crowdsourcing” as “an idea of outsourcing a task that is traditionally performed by an employee to a large group of people in the form of an open call” [1].

1.3. State of the Art in Crowdsourcing

There are several works that give survey of the current literature in the field of crowdsourcing, such as [2] or [3]

The most common method of crowdsourcing utilizes a market of micro-services. The Amazon Mechanical Turk platform offers a potential paradigm for engaging many users for low time and monetary costs [4].

The process of crowdsourcing is described as [3]:

“The crowdsourcing site exhibits a list of available tasks, associating with reward and time period, that are presented by requesters; and during the period, workers compete to provide the best submission. Meanwhile, a worker selects a task from the task list and completes the task because the worker wants to earn the associated reward. At the end of the period, a subset of submissions are selected, and the corresponding workers are granted the reward by the requesters. In addition to monetary reward, a worker gains credibility when his task accepted by the requester. Sometimes, the task requester is obligated to pay every worker who has fulfilled the task according to the requirements. In some cases, workers are not motivated by rewards, but they work for fun or altruism.”

These voting tasks require a crowdsourcing worker to select his answer from a number of choices. The answer that the majority selected is considered to be correct. Voting can be used as a tool to evaluate the correctness of an answer from the crowd [3].

Crowdsourcing is used as a source of annotated data for various tasks. Named entity annotation using Amazon Mechanical Turk is proposed in [5] Email annotation for NE is proposed in [6], work [7] designs a system for word sense disambiguation.

2. Prerequisites for solving the problem

Each crowdsourcing process consists of the following steps:

1. Short survey form – gathers basic information about participant.
2. Task form – displays partial task to the participant.

The task form is displayed after new question item is requested from the participant. The task form has several states:

1. Question requested. The application script requests question item from the database and displays it to the participant.
2. Question displayed: The participant fills the required answer.
3. Question submitted: The application script sends the answer back to the database. A new item can be requested by the participant.

An important factor in crowdsourcing is motivation. A participant can be motivated by a good will, or money. Participation in speech and language resources annotation can be made a part of educational process and student assessment.

Amazon Mechanical Turk is not suitable for our purposes. The first reason is that participation in Amazon Mechanical Turk market requires financing as a motivation. The second problem is that understanding the language is a prerequisite and there are not enough Slovak speaking people on Mechanical Turk. It was necessary to implement our own approach to crowdsourcing.

3. Solution of the examined problem

3.1 Our crowdsourcing system

The crowdsourcing system consists of the following components:

1. Database – Stores answers from the participants.
2. Web Application – displays survey and task forms and serves supporting files
3. Client-Side Application Script: Processes task forms, requests task data from the server and sends answers back.

We have implemented the following crowdsourcing modules to gather annotated data for training models for a speech recognition system or natural language processing system.

3.2 Crowdsourcing Modules

The crowdsourcing system is divided into three parts, each part is focused on gathering a certain type of language or speech data. The gathered data types are summarized in the Table 1.

Figure 1: Dictionary Game

Table 1: Modules Summary

Module Name	Type of the Gathered Data
Dictionary Game	Dictionary
Spelling Experiment	Text
Your Voice	Audio data

Dictionary Game – purpose of the crowdsourcing is to create manually checked dictionary. Dictionary of good words is an important part of both acoustic and language model of a speech recognition system. A good dictionary helps to restrict a search space and increase a precision of the automatic speech recognition.

The task of the Dictionary game is to assign one of possible classes to a word. Some possible classes for a word are:

- Unable to Answer
- Unknown word
- Correct word
- Spelling error
- Foreign Word
- Proper Name

The participant selects one of the classes for the proposed word. The Class “Unable to Answer” is always pre-selected to filter out cases when participant marks the word without considering it. An example of a word category selection is in Fig. 1.

Result of the game is a set of decisions by the participants. The voting is used to select a class for a word that has most decisions. Output of the game is a dictionary, where each word has the most probable class.

Spelling Experiment – Purpose of this experiment is to observe common spelling errors. Language data from the internet that are

Figure 2: A Spelling Experiment Survey Form

part of the language model training are full of spelling errors. The annotation task is defined as follows:

1. A short survey form is filled
2. The spelling experiment plays a sentence read by artificial voice.
3. The participant writes the sentence in his smartphone and the application records key-presses.
4. Results are sent to the server and a new sentence is proposed.

A screenshot of the survey form for spelling experiment is in Fig. 2. Result of the spelling experiment is a set of manually transcribed sentences that can be used to create a model of spelling errors in the Slovak language. The modeling method was proposed in [8] and our research [9].

Your Voice – this experiment gathers audio data from recording of a mobile phone. The process is reverse as it is in the Spelling experiment. A sentence is displayed and the participant is requested to read it into his or hers mobile phone. The gathered data then can be used to train an acoustic model for recognition of voice in mobile phone.

1. The user fills a survey form. This step is important to get information about acoustic environment where a sound is recorded.
2. Then a sentence is shown on screen and a participant is requested to record it into the system. The sound is recorded in 16bit resolution using Recorder.js script and sent in an uncompressed form to the server.
3. Result of the crowdsourcing process is a set of recordings with transcriptions that can be used to train or adapt an acoustic model of the speech recognition system.

An example of a task form for Your Voice game is depicted in the Fig. 3.

Figure 3: Your Voice Task Form

4. Results and discussion

Results of crowdsourcing language resources should be applicable in the field of statistical language modeling in speech recognition. Our design of a system for quick annotation is applicable in the academic environment. Students are involved in the research by participating in creation and processing of language resources. Participating student becomes an integral part of research team and project. What we gathered from the application is summarized in the Table.2.

Table 2: Results Summary

Number of Gathered Items	Number of participants
8,079	123

5. Conclusion

The main task is split into small portions that are easily comprehensible even for a person without preliminary training, often in a form of a game. The web interface is accessible and an annotator does not need to install additional software. The process of annotation of language resources is easier, faster and has a low learning curve. This paper describes a design of a system for quick annotation of language resources for under-resourced languages by a group of volunteer annotators using crowdsourcing.

In the case of the Slovak language, the natural language processing technologies are just in the beginning. This initiative aims to support cooperation and sharing research results by allowing to easily try the tools by other researchers, without the need to compile sources, train classifiers or gather textual data. On the website <http://nlp.web.tuke.sk> a set of natural language tools can be tried out, enables members of the scientific community to easily see capabilities of the proposed tools, compare it with their own results and discuss it.

Acknowledgement

The research in this paper was supported by the Ministry of Education, Science, Research and Sport of the Slovak Republic under the research project VEGA 1/0511/17 and the Slovak

Research and Development Agency under the research project APVV-15-0517.

References

- [1] J. Howe, “The Rise of Crowdsourcing,” *Wired Mag.*, vol. 14, no. 6, pp. 1–5, 2006.
- [2] A. J. Quinn and B. B. Bederson, “Human Computation: A Survey and Taxonomy of a Growing Field,” *Proc. SIGCHI Conf. Hum. Factors Comput. Syst.*, pp. 1403–1412, 2011.
- [3] M. C. Yuen, I. King, and K. S. Leung, “A survey of crowdsourcing systems,” in *Proceedings - 2011 IEEE International Conference on Privacy, Security, Risk and Trust and IEEE International Conference on Social Computing, PASSAT/SocialCom 2011*, 2011, pp. 766–773.
- [4] A. Kittur, E. H. Chi, and B. Suh, “Crowdsourcing user studies with Mechanical Turk,” in *Acm*, 2008, pp. 453–456.
- [5] H. Fromreide, D. Hovy, and A. Sjøgaard, “Crowdsourcing and annotating NER for Twitter #drift,” *Proceedings of the Ninth International Conference on Language Resources and Evaluation (LREC’14)*, pp. 2544–2547, 2014.
- [6] N. Lawson and K. Eustice, “Annotating Large Email Datasets for Named Entity Recognition with Mechanical Turk,” *Comput. Linguist.*, no. June, pp. 71–79, 2010.
- [7] C. Akkaya, A. Conrad, J. Wiebe, and R. Mihalcea, “Amazon Mechanical Turk for Subjectivity Word Sense Disambiguation,” *Comput. Linguist.*, no. June, pp. 195–203, 2010.
- [8] E. S. Ristad and P. N. Yianilos, “Learning string-edit distance,” *IEEE Trans. Pattern Anal. Mach. Intell.*, vol. 20, no. 5, pp. 522–32, May 1998.
- [9] D. Hlášek, J. Staš, S. Ondáš, J. Juhár, and L. Kovács, “Learning string distance with smoothing for OCR spelling correction,” *Multimed. Tools Appl.*, pp. 1–19, 2016.

SYMPTOMS OF VERBAL DYSPRAXIA IN CHILDREN DIAGNOSED WITH SPECIFIC LANGUAGE IMPAIRMENT (SLI)

ПРОЯВИ НА ВЕРБАЛНА ДИСПРАКСИЯ ПРИ ДЕЦА СЪС СПЕЦИФИЧНИ ЕЗИКОВИ НАРУШЕНИЯ (СЕН)

Denitsa Krusteva

SOFIA UNIVERSITY "ST. KLIMENT OHRIDSKI", Faculty of Preschool and Primary School Education, Chair of Special Education- part time assistant.

Email: denitsalogoped@mail.bg

Abstract: *The purpose of this article is to provide information on the study of deficits in the functioning of praxis in children diagnosed with Specific Language Impairment (SLI). The performance of three groups of language disordered children, divided by age, and the respective control groups on tasks related to articulation, speech motor control and diadochokinesis are put on discussion.*

KEYWORDS: PRAXIS; VERBAL DYSPRAXIA; SPECIFIC LANGUAGE IMPAIRMENT (SLI); FINE MOTOR CONTROL; ARTICULATION; DIADOCHOKINESIS;

1. Introduction:

Dyspraxia means dysfunction at the level of speech praxis. But dysfunctions occurring by the same mechanism appear in children diagnosed with Specific Language Impairment (SLI), too. For this reason, from historical and contemporary points of view the fundamental question is whether the symptoms associated with impaired functioning of the higher cortical function praxis should be added to the symptom complex of Specific Language Impairment.

So far there is no study conducted in Bulgaria to reveal details on the functioning of verbal praxis mechanisms within the contingent of children diagnosed with Specific Language Impairment (SLI).

2. Experimental stand:

The samples presented below are part of wider research aimed to provide some answers related to that fundamental issue.

The study covered a total of 170 children - some diagnosed with "Specific Language Impairment" and a group with no language deficits at all. They were divided into three age groups as follows: 35 children aged between 4 and 5 years, 30 children aged between 5 and 6 years and 20 preschool children (6-7 years). The three experimental groups (EG) were composed of children with proven language pathology identified by an expert speech therapist. In view of the precision, prior acquaintance with individual records of each child, including details related to their personal history, were undertaken. The control groups (CG) mirrored the number and age of the children with language impairment. The research was conducted in three kindergartens in the country, two of which specialize in speech and language therapy in Sofia and Varna, and one non-specialized kindergarten. The survey was conducted individually with each participant, after a statement of consent was signed by the parents.

The following three diagnostic tasks were strictly connected to the articulation praxis level of one syllable (type CV) and the articulation praxis level of the diadochokinesis. The main focus of the samples was to define the maximum speed and duration of delivery of one syllable type CV, and then a combination of two and three syllables that each child must pronounce as many times as possible within 15 seconds. The

time of execution was measured. When the child does not utter anything, it scores 0 points. The maximum score is individual, according to the capabilities of each participant.

It is important to clarify that articulation praxis is examined in its kinetic aspect.

The first task for each child is to utter the syllable "PA" as many times as they can for 15 seconds. Every spoken syllable is scored 1 point. The sample represents the easiest level in the study of articulation praxis. It is known that the sound "P" is part of the speech sounds typical of the early articulation stage. In this sense, the combination of "P" with the wide open vowel "A" should not be an obstacle to the children tested. The instruction is: "Please, repeat "PA" as quickly as you can as many times as you can. I will give you a start!" The speech therapist demonstrates a task example.

The second task is upgraded in difficulty. Each child must pronounce two open syllables "PA-KA". Again the time and number of syllables pronounced is measured. Any pronouncement of the combination gets 1 point. The instruction is analogous to that of the previous sample, but refers to a combination of two syllables.

The third task is related to the pronunciation of three open syllables (PA-TA-KA) and is a classical sample of diadochokinesis in which the articulation starts from the lips, then goes onto the tip of the tongue and after that ends at the back of the tongue. The informative purpose of the sample consists in the different articulation posture during the pronunciation of the speech sounds "P", "T" and "K". Of all three tasks, this is the one with highest level of complexity. The instruction is similar: "Please, pronounce PA-TA-KA as quickly as you can and as many times as you can!"

Although being divided into three separate conditions, the described samples are interrelated. We are looking for information regarding the smoothness, successiveness, speed, switching on from the level of simple pronunciation of one syllable to pronunciation of a group of syllables. The aim is to find whether there are deficits in brain mechanisms that control planning of voluntary motor and speech skills. The samples described above possess a certain level of abstraction. The child has no language support in terms of communication or images, which means complete exclusion of meaningful code.

For the purposes of our research we formed two hypotheses :

1. We expect that between children with Specific Language Impairment and children with normal language development there will be no significant difference in terms of verbal praxis.
2. We assume that in children with Specific Language Impairment, the verbal praxis will improve in parallel with the age.

Comparing children with normal speech and those with Specific Language Impairment we were looking exactly for two things - a manifestation and development of speech praxis in three distinct ages.

3. Results and discussion:

The following graph (Fig. 1) gives the results of both groups - EG and CG from the first task "Repetition of one syllable".

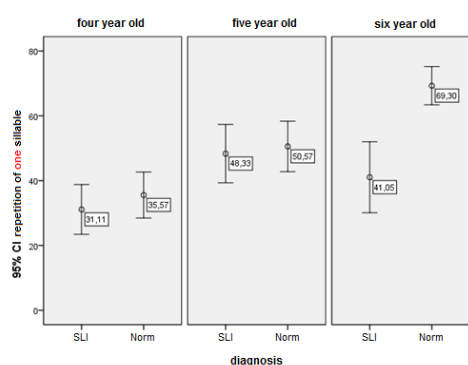


Figure 1: Mean value of **repetition of one syllable** divided by age;

At the first task the children between 4 and 5 years of experimental group showed an average subgroup score of 31 points. For the same task the result of children in the control group was 35 points.

Obviously, for the respective sample there is no significant difference between the results of the control and experimental groups. This was confirmed statistically by the coefficient "t" expressing significant differences, in this case less than 0.01 (less than 1%).

It could be concluded that the repetition of an open syllable, type "PA" for a specified time is equally difficult for 4-5 years old children which means that the assumption expressed at the first hypothesis is confirmed for that age.

The same task performed by 5-6 years olds shows subgroup average score of 48 points for EG and 50 points for CG. Obviously, for this sample at that age there is no statistically significant difference between the two groups, as shown by the ratio "t", which is less than 0.01 and again we can confirm the first hypothesis.

An interesting twist is observed in the sample with preschool children (6-7 years). Here it clearly outlines statistically significant differences between the results of EG and CG. Children from EG subgroup have 41 points, while children from CG - 69 points. The assumption embedded in the first hypothesis is not confirmed only for this age group. That means differences in articulation mechanisms at the level of praxis for serial naming of one syllable between children with normal speech and children with SLI, are established only in preschool. Brain mechanisms needed for the implementation of that sample are formed for the normally speaking children. But the same process of maturation

is not performed in children with SLI, whose results remain close as a statistical value to these of the smaller ones (5 - 6 years). From the graph (Fig. 1) it can be seen, also, that the results of the 6 years old children with SLI are lower than those of 5 years old with the same diagnosis. This suggests that the brain mechanisms at the level of naming of one syllable are not only entirely unformed in children with SLI, but there is also some decline concerning instrumental realization of the described level. How to explain this fact? Maybe it is worth mentioning here the main symptom associated with the concept of children's verbal dyspraxia, the ineffectiveness of the applied therapy, which might positively affect language development, but fails to support the maturation of praxis functions. On the other hand, the individual temp of formation of praxis skills in that period of age matters.

The results of the second task related to the repetition of a combination of two open syllables are graphically presented at Figure 2.

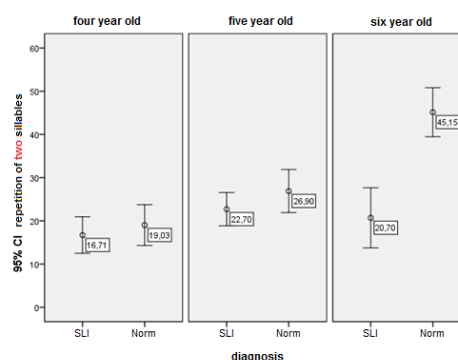


Figure 2: Mean value of **repetition of two syllables** divided by age;

As mentioned above, the sample represents a second level of difficulty compared to the previous one. Besides standard naming, here we have a switching between the two articulation postures associated with phonation of two different consonants - P and K. The first articulated with lips and the other through the back of the tongue. There is also a smoothness of the performance.

The task was harder for the children compared to the previous one. This was shown by the fact that some of them made an inert repetition of the syllable „PA“ from the previous sample, which required re-submission of the instruction.

It is interesting that here we have again statistically significant differences between the results of the experimental and control groups only for 6-7 years old. The graph (Fig.2 above) clearly shows the recurring trend in which 6 years old children with SLI have lower scores compared with 5 years old children with the same diagnosis. In our opinion this should not be regarded as a decrease in the formation of verbal praxis, but rather as an individual specifics of the studied groups of children. The line of skills in children with normal language development of all three ages unfolds through a gradual rise in results, while that of children with language pathology is expressed with an unequal dynamics.

The results from the third, the most difficult task, are presented graphically in Figure 3. The sample has a high diagnostic value as praxis symptoms associated with impaired diadochokinesis (switching between three or more articulation postures) are considered main characteristic of the verbal dyspraxia.

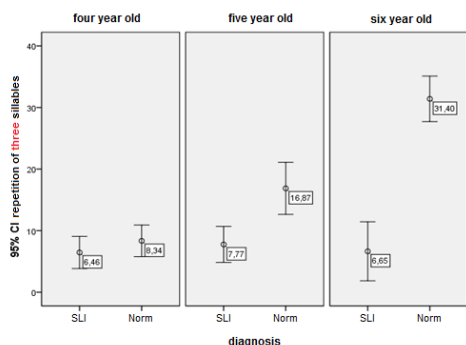


Figure 3: Mean value of **repetition of three syllables** divided by age;

We can see that the first hypothesis is confirmed partially and is not valid only for 5-6 and 6-7 years old children. In the results of 4-5 years olds we can't observe reliable differences in the performance. The results of children with normal speech development rise gradually which speaks of a stabilization of the mechanisms of speech praxis. While in the results of children with SLI we can't see dynamics in serial repetition of syllables, because the points of 4-5 years olds are approximately the same as those of 6-7 years old. We can conclude that we see an improvement of speech praxis skills and fine motor mechanisms connected with precise and fast switching between two or more articulation postures only in children with normal speech development. The same mechanisms practically do not develop in children with SLI at age period between 4 and 7 years of life.

To define more clearly the connection between the improvement of speech praxis skills and the children's age we made an Analysis Of Variance (ANOVA), disposed at the following tables.

Table 1: Mean Values of verbal praxis components in deferent age groups in **children with Specific Language Impairment (SLI)**;

Task	Age	Number of children	Average	Standard deviation	F
Repetition of one syllable	4 years olds	35	31,11	22,37	4,49
	5 years olds	30	48,33	24,13	
	6 years olds	20	41,05	23,35	
	Total	85	39,53	24,18	
Repetition of two syllables	4 years olds	35	16,71	12,29	1,98
	5 years olds	30	22,7	10,32	
	6 years olds	20	20,7	14,89	
	Total	85	19,76	12,46	
Repetition of three syllables	4 years olds	35	6,46	7,59	0,22
	5 years olds	30	7,77	7,82	
	6 years olds	20	6,65	10,24	
	Total	85	6,96	8,28	

The results demonstrate that a dependence between the advancing age and improvement of speech praxis skills in children diagnosed with SLI exists only for the first task. Only at starting level of repetition of one syllable type CV we find a positive development in the praxis functioning. This conclusion is confirmed by index $F = 4,49$, bigger than $0,01$.

Table 2: Mean Values of verbal praxis components in deferent age groups in **children with normal speech development**;

Task	Age	Number of children	Average	Standard deviation	F
Repetition of one syllable	4 years olds	35	35,57	20,63	19,94
	5 years olds	30	50,57	20,83	
	6 years olds	20	69,3	12,6	
	Total	85	48,8	23,06	
Repetition of two syllables	4 years olds	35	19,03	13,72	24,93
	5 years olds	30	26,9	13,35	
	6 years olds	20	45,15	12,11	
	Total	85	27,95	16,58	
Repetition of three syllables	4 years olds	35	8,34	7,46	40,8
	5 years olds	30	16,87	11,32	
	6 years olds	20	31,4	7,89	
	Total	85	16,78	12,7	

Table 2 above represents the results of the control groups, the children with normal speech development. We can see that at all consecutive ages, we have statistically significant differences. This means that children's performance on each of the tasks has improved alongside with age.

3. Conclusion:

Both the vowels and the consonants sounds differ in the different phonetic context in which they are located. In this sense, a fundamental element in studying the speech skills of children with doubts about dyspraxia should be the syllable. The three tasks presented begin at the level of one syllable and are graded by difficulty. The kinetic aspect of verbal praxis - serial naming, smooth passage and switching between two articulation postures, diadochokinesis - was observed. Establishing deficiencies in the functioning of these processes is important for the diagnosis of dysfunctions at the level of verbal praxis naturally involving the planning of the movements required for articulation and hence for communication.

The main goal of our research was to define clearly the exact symptoms of impaired praxis skills in children diagnosed with Specific Language Impairment. The results from the three tasks have shown clearly the existence of such difficulties in that particular contingent. Also we tried to specify the levels of manifestation throughout three different and consecutive ages of childhood.

At the praxis level for repetition of one syllable and repetition of two syllables we have statistically significant differences between EG and CG at the preschool age. We may

say that our first hypotheses doesn't confirm only for that period of age. The results from the third sample, concerning diadochokinesis, show that the children with normal speech development have higher scores than the others with SLI at the age of 5 years. So the differences in articulation capabilities start at an earlier age. The CG have better performance than the EG. If we look separately at the scores of both groups, we see that praxis functions improve with age only for the control group. Practically voluntary fine motor mechanisms do not develop in children with SLI at age period between 4 and 7 years of life.

4. Literature:

1. Корнев, А.Н. Основы логопатологии детского возраста: Клинические и психологические аспекты., Санкт Петербург, Речь, 2005.
2. Leonard B. L. Children with Specific Language Impairment. MIT Press, 2000.
3. Michael A. Crary. Developmental Motor Speech Disorders. San Diego, California, Singular Publishing Group Inc., 1993.
4. Muriel E. Morley. The Development and Disorders of Speech in Childhood. Edinburgh and London, Churchill Livingstone, 1972.
5. Тилков, Д., Бояджиев, Т. Българска фонетика. София. Наука и изкуство, 1977.
6. Ценова, Ц. Основи на логопедията. Университетско издателство „Св. Климент Охридски“, 2008.
7. Ценова, Ц. Логопедия; Описание, диагностика и терапия на комуникативните нарушения. Радар Принт, 2009.
8. Charron L., MacLeode A. La dyspraxie verbale chez l'enfant: identification, evaluation et intervention. Glossa, 2010, n. 109, 42-54.
9. Vellemane S. L. , Strand K. Developmental Verbal Dyspraxia. In: John E. Bernthal, Nicholas W. Bankson. Child Phonology: Characteristics, Assessment, and Intervention in Special Populations. New York. Thieme Medical Publishers Inc., 1994.
10. Vellemane S. Childhood Apraxia of Speech: Resource Guide. Delmar Learning, 2003.

ISLAM, THE BALKANS, IDENTITY

Assoc. Prof. Dr Veselin Bosakov, Institute for the Study of Societies and Knowledge – BAS, Sofia,

vesobos@abv.bg

Abstract: *Even before the conquest of the Balkan peninsula was completed by the end of the 15 century, the Ottoman Empire was faced with the need to increase the Muslim component of the local population so as to affirm Ottoman power in the new lands. The central authorities, the army and the clergy began to systematically implement a policy of Islamization. Colonization and migration were among the factors that led to the settlement of a numerous Muslim population. Conversion to Islam was linked to certain advantages, such as pardon for violations of law, the distribution of offices and positions, assistance for impoverished new Muslims, inclusion in Ottoman military organizations such as the spahi, the janissaries, the yaya (peasant infantry), the muslem (autonomous peasant cavalry), the akinji (advance cavalry), the yuruks, etc. There was a merging of ethnic and religious identity stemming from the way in which the Empire was organized and from the importance of religion for the exercise of power. Religious affiliation became an ethnonym of power, and power was in Muslim hands. Evidently, the causes and factors of the conversion to Islam of part of the Balkan population have not been definitively clarified and will remain debatable if the explanation is looked for in “coercion” alone or in “voluntary choice” alone. Perhaps the causes might be related to the internal political strategy of the Ottoman state with regard to the numerous population of the Balkans as well as to the medieval religiousness of the peasants and the incapacity of the Orthodox Church, in its subordinate position, to maintain their faith and provide them with material assistance.*

KEYWORDS: ISLAM, BALKANS, IDENTITY, ETHNOS, RELIGION, ISLAMIZATION, COLONIZATION, MIGRATION

During the period of Ottoman rule, a numerous Muslim population settled in the Bulgarian lands. The settlers included military contingents, administrative and religious officials, nomadic pastoral tribes, etc. The new migrants settled in cities and villages. Because of this migration, the Muslim population on the Balkan peninsula, including the Bulgarian lands, grew and in places became the majority. The spread of Islam in the Balkans led to changes mostly in the religious structure of the population rather than the ethnic. The statistical data, though limited, leave no doubt that the Muslim population was constantly growing in absolute numbers and in relative proportion. Various explanations have been offered for this growth. A considerable number of scholars from Bulgaria and other Balkan countries ascribed this trend – and some still do – to forced conversion to Islam. This was the official and dominant hypothesis at the time of the so-called Revival Process, when the policy of the Bulgarian Communist Party (BCP) required that historians emphasize, by all means, the coercive nature of the imposition of Islam. The shortage of source materials facilitated the assertion of this hypothesis. By contrast, the lack of first-hand testimony regarding mass-scale forced conversion pursued through a purposeful, specially prepared campaign, has led a number of authors to the conclusion that the spread of Islam may have partially occurred on a voluntary basis, and repeatedly over long periods of history. The Ottoman registers indicate that adherents of heretical religious movements were the first local residents to convert to Islam. The new religion also spread successfully among those who continued to be under the influence of paganism (Yalamov 2002). This view became dominant in the last decade of the 20th century. Based on new source materials, certain Bulgarian and foreign scholars have argued that Islam was embraced by the local population for a variety of reasons, including by personal choice of individuals, whole families, and groups of people in a village or town. The question as to the motives, however, remains disputed. More than a few historians attribute the change of religion only to the economic interests of individuals or entire social strata: specifically, the new converts could expect to share the privileged status enjoyed by Muslims in Ottoman society. Other researchers believe it would be mistaken to overemphasize the economic factors. “... The economic argument regarding conversion to Islam must be accepted with great reservation /.../ In any case, other factors were also involved. In the same context, we should not forget that, in the course of their crushing victories over the Christian armies of Europe, and especially after the fall of the then powerful Hungarian kingdom in 1526, the prestige of the Ottoman Empire grew very highly. Many must have thought that God was showing His favour towards Islam, and so it would be better to go

over to the side of the more powerful. Moreover, in the 16th century, Islam was ‘fashionable’” (Kiel 1998: 76).

Until the end of the 1980s, the “correct” theory prevailed among scholars, according to which Islamization in the Rhodope mountain region had been either imposed by force or came as the result of colonization directed by the Sultans (who brought over shepherds from Turkey, known as Yuruks, as well as slaves), as well as the emigration of Christian population. Although colonization was one method used by the Ottoman authorities to change the ethnic structure of the Balkans, the latest studies of sources show this factor was on too small a scale to be the chief cause of Islamization of the Balkans. Moreover, as Maria Todorova has pointed out, the settlement of population coming from Anatolia occurred chiefly between the 14th and 16th century, while the number of Muslims continued to grow after that time (Todorova 1987).

The trend of adopting Islam by the local Rhodopes population, and its causes, are a difficult object of study; much remains unclear about it. According to Antonina Zhelyazkova, it began with individual cases of conversion as early as the 16th century, gradually grew during the whole of the 17th, becoming especially strong in the second half of that century, and continued into the 18th century. At present, scholars acknowledge that in some cases, conversions to Islam were voluntary, being motivated by economic and social considerations: Muslims were exempt from tax burdens; moreover, conversion opened the way to social prosperity (Zhelyazkova 1990). Consequently, it would be more correct to refer to indirect coercion through economic pressure. Some forms of this pressure included: the slave trade in war captives, the forced recruitment of certain subordinate groups into the Ottoman Army, the well-known tithe, and the so-called *devshirme* (the practice of taking boys from the families of Christian residents of the Balkan provinces, for service in the so-called Janissary infantry units). But even these elements of Ottoman policy were not unequivocally perceived as negative by the population. Some families willingly gave their children to serve in the army, seeing in this an opportunity for rising in the social hierarchy.

Economic incentives played an important role. During the *first period*, they were an influential factor mostly for the local upper class. Quite a few Bulgarian boyars converted to Islam, in order to preserve possession of their estates, and seeped into the ruling class of the Ottoman Empire. Among them was Alexander Shishman, son of the last Bulgarian tsar, Ivan Shishman. Under the name Suleiman Pasha, Alexander was appointed vali (governor) of the Aydin Province. According to an unwritten rule, many offices and lucrative posts in the state hierarchy were assigned to aristocrats who had converted to Islam. During the 638 years of Ottoman rule,

there were, in all, 215 grand viziers (a position that corresponded to that of prime minister). Of these, only 78 were Turks; the other 137 were Christians who had converted to Islam (Yalamov 2002).

During the *second period*, however, a growing number of subjects converted for social-economic reasons. There was inequality among Muslims. The participation of non-Muslims in government was strongly restricted. Christians paid *jizya*, the annual per capita tax, and during a certain period, the *devshirme* (blood tax) as well. Conversion to Islam not only exempted people from additional taxes but also opened access to higher social ranks and a better economic status. The desire for a better life motivated quite a few local Christians to convert. Ottoman *defterleri* (registers) dating from 1679-1680 indicate that in the Odrin region alone, in just one year, 379 people converted to Islam. In many of the formal applications, passing over to Islam was grounded on the desire for appointments to official positions or recruitment in the Ottoman army (Yalamov 2002). Many such individual applications are preserved in the Ottoman archive collection of the Bulgarian National Library Saints Cyril and Methodius. For its part, the central government indirectly encouraged this trend, but in the period between the 14th and 17th century, it did not pursue a targeted policy of Islamization, because it was not in its economic interest to impose the religion on a mass scale.

Here are some examples of the social-economic motivation underlying the voluntary conversion to Islam in the 17th – 19th century (*Ottoman Sources...* 1990):

In a number of “applications”, the applicants request to be assigned some official state position, or to be included in a military unit as a reward for having entered the “true faith”. Neither the form nor the contents of these documents permit us to think they were written personally by the converts. Such applications were written by experienced scribes and schooled clerks from the chancelleries of the capital city, by the vizier *divans* or at least by the *cadi* offices. In the functional aspect, these documents are not exactly applications but rather serve as a start of a finance-related correspondence for justifying expenditures from the state treasury. They represent forms written according to certain rules, upon which the grand vizier and *bash-defterdar* (head-treasurer) had to pass a resolution in order to legalize the expenditure of state money.

Statement on acceptance into Islam on behalf of a boy from Yambol

Your Majesty, happy and magnanimous, my Sultan. May health be with you!

I am a Bulgarian boy from Yambol. My two brothers converted to Islam. I came before your fortunate person so that you may likewise award me, Your slave, with the honour of adopting Islam. Be so kind as to grant me clothes. The order is that of my Sultan.

Your servant, the new Muslim.

New entries and resolutions on the document

1. [*Resolution of the grand vizier*]: True! Clothes should be given to a young boy, a new Muslim, as is the custom. This is an order!...

9 jemazi-yul evvel 1097 (3. IV. 1686)

Statement on acceptance into Islam on behalf of a boy from the Kaza of Ruse

Your Majesty, happy and blessed, my Sultan. May health be with you!

I, Your slave, am a poor man from the Kaza of Ruschuk. In my native place, the desire was born in me to become a Muslim, and that is why I came to You. My request is to be granted the honour to adopt Islam in the presence of You, the Sultan. Grant that a set of clothes be allotted to me, as well as a bit of livelihood. I beg for your decision. The order belongs to Your Majesty, my brilliant Sultan.

Your slave, Abdullah.

Additional entries and resolutions on the document

1. [*Resolution of the grand vizier*]: True! The cost of the clothes is to be given to a boy awarded the honour of embracing Islam. Order!

16 muharrem 1124 (24. II. 1712) r.

2. [*Resolution of the bash defterdar*]: The receivable bill is to be issued!

3. [*Note from the Chief Accountancy*]: The receivable bill was issued on 16 muharrem 1124 (24. II. 1712).

Protocol from the session of the majlis of Vratsa, concerning the entry into Islam of a Bulgarian girl from the village of Tlachane

Tsena, daughter of Kara Tsono, a resident of the village of Tlachane, kaza of Ivrazhda, voluntarily declared that she adopts Islam of her own will in order to marry at her own desire Suleiman, son of Mehme, from the same village. Questioned by the majlis in the presence of the notables, she confirmed that she would marry the above-mentioned, that she would obey him and, adopting the true faith, [henceforth] would be called Hatidje.

On this occasion, we prepared and dared to bring to your knowledge a modest protocol. To be decided.

5 djemazi-yul evvel [12]70 [3. VII. 1854].

Protocol from the session of the majlis of Vratsa, concerning the entry into Islam of a Bulgarian girl from the village of Malo Peshtene, kaza of Vratsa

The twenty-year old Maria, daughter of Yole, resident of the village of Malo Peshtene, kaza of Ivrazhda, came to our humble majlis and stated that, glory be to Allah, she would take the righteous divine path. She was conferred the honour of the true faith, and adopting the name of Ayshe, was married to Podara Ibrahim, of the same village, who verbally expressed his consent [for this].

In composing this humble protocol, we dare to announce the event, as required by the high command on these matters. To be decided!

27 djemzi-yul evvel 1270 [25. XII. 1854] r.

Protocol on the adoption of Islam by girls from the village of Ostrets, Lovech district, and from Troyan

The 19-year old daughter of Denko, from the village of Ustorech, kaza of Lofcha, and the 20-year old daughter of Velichko, from the village of Toriyan in the same district, declared their desire to adopt Islam according to the Muslim rite. In fulfillment of the necessary formalities, the two girls were sent, together with their parents, to the district administration of Lovech. After questioning was conducted, it was established that the adoption of Islam occurred without the exercise of coercion. Despite the advice of the parents and the representatives of the metropolitan bishop that the two girls should not adopt Islam, the act of adoption of Islam was performed and the daughter of Denko received the Muslim name Hatidje, while Velichko's girl, Fatma.

14 djemazi-yul ahar [16. VII. 1876] r.

Letter to the district administration of Tarnovo concerning the adoption of Islam by an under-age girl from Sevlievo

To the district administration of Tarnova

The girl Kira, resident of the kaza of Servi, wished to become a Muslim and for that reason, a letter was sent here, №797 of 5 safer (12)92 (28. III. 1876).

Since it became clear that she is still a child that has not reached mature age, the Administrative Council of the willayah announces and reminds that it is natural that such persons not adopt Islam. It is brought to your attention that [the girl] needs to be returned and to adopt the religion she desires when she has attained maturity. This time, due to the indicated reasons, she was sent back.

[Note]: Written on 2 shaban 1293 [23. VIII. 1876]

Instruction on cessation of infringement upon the property, life and honour of Christian subjects of the Ottoman Empire

Your Excellency! It is known that, in order to set European public opinion in opposition to Islam, our enemies are

daily, everywhere presenting to the world groundless, meaningless, and false communications about what Muslims have done, or will do, to Christians, and spread these throughout Europe in the newspapers. It is needless to explain how much the scoundrels who are not ashamed to say such pure lies would exaggerate the smallest dispute or brawl between Muslims and Christians, and if, by mishap, a Christian be killed in such a brawl, they would even provoke an international trial through exaggerations and fabricated stories. Since the times are complicated, and the conditions not particularly favourable, the situation of our state is difficult and hard, which is why it is necessary to seek new approaches. Thus, it is very important and necessary precisely at this moment, more than ever, that the Muslim population, and especially the Circassians, keep still. Ignorant Muslim youths and Circassians in towns and villages, who are unaware of their own situation or that of the state, should not perpetrate arbitrary violence against the Christian population, not infringe upon the property, life and honour of Christians! Muslims and Christians must live in mutual understanding!

Foremost, the current situation should be very clearly explained to the district governors of the kazas, who in turn should explain to those who understand the situation of Islam and the reasonable notables in cities and villages, and through them, to the ignorant and thoughtless Muslims. The high-ranking persons must personally make the round of the kazas! Let them clarify with the most forceful words to the district governors, to the enlightened notables in the kazas, the police chiefs, that, at present, any small incident would draw upon the state and the Muslim nation the burden of great justifications and excuses. *[Let them be advised]* to refrain from such things. The district governors should also make a round of Muslim villages in order to convince with the same forceful words the notables of the villages, so that, with their collaboration, some evil-doers in the villages would not remain without supervision. The responsible and high-ranking persons are informed of the need that all this be done and the present order is delivered to them. It is the order of His Majesty.

On 10 sheffal 1293 [16. X. 1876]

Undated, report on adoption of Islam by an indebted Bulgarian family

Magnanimous, grand, powerful and great benefactor, my wise master! Long live Your happy imperial highness!

Having first of all prayed to God, now I make bold to care about my well-being in addressing this plea to You. My husband – Your humble servant – some time ago joined the ranks of those who confess the true faith. That is why I too – Your humble slave – with God's blessings want to achieve the same. I came, guided by the wish to become a Muslim, to pray You to explain the true faith to me as well. May I be illumined by the light that will cover me: may I stand in the ranks of those who have the privilege of the illumined; may I joint the submissive servants of the faith, granted with the honour of Islam, so that I too may benefit by it.

My great and brave master, I, Your humble slave, am very poor and have no home. In addition to that, Your humble slave, my husband, as he receives no resources from anywhere, by God's will has fallen in debt in the amount of 5-6 grosh. We seek a solution everywhere, but we will not be able to pay the debt soon and my husband will be imprisoned. No matter how urgent it is, neither I, Your humble slave, nor my husband, Your humble slave, will be able to pay our debt in any way. We are helpless and have not the slightest possibility of escaping from this situation, and may God forbid *[that worst things await us]*. This is why we seek compassion, and likewise shelter and protection, from God.

Mercy, all-merciful lord, mercy, gracious lords! I submit this plea for justice as an expression of our selfless devotion to the young, very attractive and life-loving prince, for the sake of his happiness. Our distressful situation must be resolved mercifully. For your saddened and desperate humble servants, there is no other recourse but Your favour. We offer our respects and wishes for happiness and merriment in Your fortunate days. We leave the issuing of the high order to Your decision,

Your humble slave, Dimie.

V. Dechov, author of a monograph on the history of Chepelare, has a different view on the question. According to him:

- The Islamization of the population of the Central Rhodope region began with the conquest of the Rhodopes and ended in the late 18th century.

- Even when the campaign of forced Islamization and the large-scale killing was stopped, none of those converted to Islam were allowed to return to Christianity.

- Those Christians who had avoided the forced conversion were forbidden to live with their Islamized families and neighbours and were ordered to migrate elsewhere.

- Many Christians converted to Islam from fear of their Muslim neighbours. It was under pressure from their neighbours that the residents of the village of Bogutevo converted to Islam.

- Many families were Islamized by Janissaries, i.e., by their own children, who had been recruited at a young age in the Janissary units.

- The Yuruks had sheltered Christians attempting to escape Islamization (Dechov 1987: 61-62).

Acts of violence did of course take place during certain periods, but not on as massive a scale as claimed by our 19th century historians. The specific local conditions, the desire of the oppressed population to survive by adapting to the new rule, the desire of people to switch to a different social and economic category, the efforts of the Balkan aristocracy to preserve its privileges and property, were all preconditions for the native residents' turning to the dominant religion (Zhelyazkova 1990). Violent administrative measures were applied on concrete occasions: suppression of revolts of the Christian population, in time of war, and especially during clashes between the Ottoman and Russian empires.

Conclusion: Various and complex causes determined the spread of Islam in the Balkans and the Bulgarian lands; the factors included colonization, resettlement, conversions to Islam, internal migration. Very probably, during the first period, the military successes of the Ottoman Empire struck respect in the local population. During the second period, economic incentives were foremost. Islamization did not in all cases lead to adoption of a Turkic identity. But it did create certain preconditions conducive to Turkization. The new converts to Islam lost the marks of their former ethnicity and, after a few generations, might merge completely with the Turks providing they lived in a Turkish linguistic and cultural environment. The history of the dissemination of Islam in the Bulgarian lands, and more generally in the Balkans, confirms this claim. The Ottoman government was interested not so much in ethnic as in religious assimilation. Islam, as many other religions, is not the faith a single nation and thus is open to all ethnic groups. The Ummah is a space of total identity not confined to a specific territory, language, ethnic group or nationality (Bosakov 2015).

REFERENCES

- Bosakov, V. 2015. *Islam and Modernity. Mutual Challenges*. Sofia: IvRay (in Bulgarian) [Босаков, В. 2015. *Ислям и модерност. Взаимни предизвикателства*. София: Издателство „ИвРай“]
- Dechov, V. 1987. *Chepelare in the Past*. Book One. Plovdiv (in Bulgarian) [Дечов, В. 1987. *Миналото в Чепеларе*. Книга първа. Пловдив]
- Zhelyazkova, A. 1990. *Dissemination of Islam in the Western Balkan Lands under Ottoman Rule. 15th – 18th century*. Sofia: Prof. Marin Drinov Academic Publishers (in Bulgarian) [Желязкова, А. 1990. *Разпространение на исляма в западнобалканските земи под османска власт XV-XVIII век*. София: АИ „Проф. Марин Дринов“]
- Kiel, M. 1998. *The Spread of Islam in the Bulgarian Village during the Ottoman Age 15th – 18th century: Colonization and Islamization*.

In: Gradeva, R., Ivanova, S. (eds.) *Muslim Culture in the Bulgarian Lands*. Sofia: IMIR (in Bulgarian) [Кийл, М. 1998. Разпространение на исляма в българското село през османската епоха (XV-XVIII в.): Колонизация и ислямизация. В: Градева, Р.; Иванова, Св. (съст.) *Мюсюлманската култура по българските земи*. София: IMIR]

Ottoman Sources on the Islamization of the Balkans 16th – 19th century 1990. Sofia: Marin Drinov Academic Publishers (in Bulgarian) [Османски извори за ислямизационните процеси на Балканите. XVI – XIX в. 1990. София: АИ „Проф. Марин Дринов”]

Yalamov, I. 2002. *History of the Turkish Community in Bulgaria*. Sofia: IMIR (in Bulgarian) [Ялъмов, И. 2002. *История на турската общност в България*. София: IMIR]

Todorova, M. 1987. Identity (trans)formation among Bulgarian Muslims. In: Crawford, B., Lipschultz, R.D. (editors) 1987. *The myth of “Ethnic Conflict”: Politics, Economics and “Cultural” Violence*. Berkley: University of California Press