

**2016 13TH INTERNATIONAL SCIENTIFIC-
TECHNICAL CONFERENCE ON ACTUAL
PROBLEMS OF ELECTRONIC INSTRUMENT
ENGINEERING (APEIE) – 39281
PROCEEDINGS**

APEIE – 2016

In 12 Volumes

Volume 1

Part 2

Novosibirsk, October 3-6, 2016

**ТРУДЫ XIII МЕЖДУНАРОДНОЙ НАУЧНО-
ТЕХНИЧЕСКОЙ КОНФЕРЕНЦИИ
АКТУАЛЬНЫЕ ПРОБЛЕМЫ
ЭЛЕКТРОННОГО ПРИБОРОСТРОЕНИЯ**

АПЭП – 2016

В 12 томах

Том 1

Часть 2

Новосибирск, 3-6 октября, 2016



**2016 13TH INTERNATIONAL SCIENTIFIC-
TECHNICAL CONFERENCE ON ACTUAL
PROBLEMS OF ELECTRONIC INSTRUMENT
ENGINEERING (APEIE) PROCEEDINGS**

IEEE Catalog Number:	CFP16471-PRT
ISBN:	978-5-7782-2991-4 978-5-7782-2992-5 (т. 1)
ISBN:	978-1-5090-4068-1

Information about proceedings placed in <http://apeie.conf.nstu.ru/apeie2016/>

© Novosibirsk State Technical University, 2016
© Новосибирский государственный
технический университет, 2016
© IEEE, 2016

ORGANIZERS
ОРГАНИЗАТОРЫ КОНФЕРЕНЦИИ

	<p>Novosibirsk State Technical University Новосибирский государственный технический университет</p>
	<p>Institute of Electrical and Electronics Engineers Американский институт инженеров электротехники и электроники</p>
	<p>ФГУП "Сибирский государственный НИИ метрологии"</p>
	<p>Academy of Medical-Technical Sciences of Russian Federation Siberian Branch Академия медико-технических наук Российской Федерации СО</p>
	<p>A.S. Popov Siberian Scientific-Technical Society for Radio Engineering, Electronics and Telecommunications Сибирское научно – техническое общество радиотехники, электроники и связи им. А. С. Попова</p>
	<p>LLC «Power Electronic of Siberia» ООО «Силовая электроника Сибири»</p>
	<p>АО "НИИ измерительных приборов – Новосибирский завод имени Коминтерна" (АО "НПО НИИИП-НЗиК")</p>

Solution of the Problem of Searching for an Energy-efficient Functioning Mode of a Continuous Production Using Simulation and Artificial Intelligence Methods

Natalya M. Zaytseva
Innovative University of Eurasia, Pavlodar, Kazakhstan

Abstract. The article examines the problem of searching for an energy-efficient functioning mode for a power-consuming continuous production characterized by nonlinearity, inertness and closed-circuit operation. It suggests a method to construct a multi-criterion target function on the basis of technological production process simulation. A genetic algorithm was used to solve an optimization problem, which made it possible to receive values of controlling technological production parameters that ensured decrease in energy consumption.

Keywords — energy efficiency, modeling, genetic algorithm, alumina production, energy saving technological decisions

define its properties. This circumstance makes it difficult to apply classical optimization methods, because most of them are based on applying a priori information to the behavior of the target function.

Therefore, solution of such optimization problem should be made on the basis of one of artificial intelligence methods, for example, genetic algorithm[7,8,9], and to obtain values of technological production parameters ensuring improvement of its efficiency.

I. INTRODUCTION

MODERN economic conditions demand that industrial enterprises improve their energy efficiency[1,2,3]. This task is particularly important for energy-intensive enterprises with continuous inertial process production, such as enterprises in nonferrous metallurgy and chemical industry. A complex of measures helping to achieve this goal includes searching for a strategy to control production technology and minimize its energy consumption.

Solution of this optimization problem requires development of a multi-criterion target function which should be based on simulation[4,5,6] of basic technological processes of the production in question. It is obvious that such function cannot have analytical expression, and, consequently, is it impossible to

II. SIMULATION

Solution of this problem was made on the example of exothermic hydrochemical production of technical aluminum oxide, a raw material for electrolytic aluminum production. The resources used in the production are electric energy and steam.

In order to solve the optimization problem we developed a model describing this technological production process with its input parameters. The model is built on the basis of balance equations imitating basic technological transformations in production[10,11]. Fig. 1 shows the structure of the mathematical model of alumina production using the Bayer method, applied in the majority of alumina plants in the world.

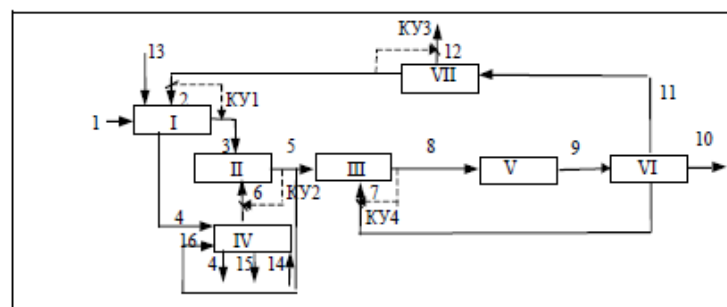


Fig. 1. The structure of the suggested model of alumina production using the Bayer method.

The model consists of seven blocks describing the Bayer process (fig. 1). Block I – bauxite leaching, block II – bauxite pulp dilution with alkaline water from sludge washing, III block – pulp mixing with seed alumina, block IV – sludge washing for alkali extraction, block V – pulp decomposition and obtaining alumina, block VI – separation into alkaline solution, production and seed hydrate, VII – evaporation of circulating alkaline solution with steam to the required concentration.

The diagram shows that the process being modeled has four control circuits (KU1-KU4), existing in the production. Those control circuits help to support the concentration mode of the process units. Input and output material flows of seven blocks-production units are shown on the scheme with numbered arrows.

Energy consumption in this production accounts for transformation and movement of material flows. It is connected to volumes of those flows by proportional dependences determined a priori and is calculated by the formula:

$$W = K_e \cdot \sum_{i=1}^{16} K_{ie} \cdot F_i. \quad (1)$$

Here K_{ie} is specific costs of electric energy of the i -th material flow in the production (kWh/unit.F), K_e is a correction factor reflecting the share of unaccounted costs of electric energy.

Consumption of steam used for evaporation of the circulating solution with a reagent in block VII is determined by the amount of material flow F_{12} ($m^3 \cdot hour$).

The simulation of j -th of blocks-process units ($j=I, II, \dots, VII$) is based on nonlinear algebraic material balance equations written down for all i -th flows ($i=1, 2, \dots, 16$), passing through the modeled block:

$$\sum_{i=1}^n L_{ij} \cdot A_i \cdot G_i \cdot F_i = 0 \quad \sum_{i=1}^n H_{ij} \cdot F_i \cdot G_i = 0 \quad \sum_{i=1}^n K_{ij} \cdot B_i \cdot G_i \cdot F_i = 0$$

$$\sum_{i=1}^n L_i \cdot F_i = 0 \quad \sum_{i=1}^n L_i \cdot F_i \cdot D_i = 0 \quad M_i = 1.645 \cdot \frac{B_i}{F_i \cdot H_{ij}}$$

where F_i are flows of solutions, D_i is density of solutions, H_{ij}

is a weight ratio between liquid and solid, A_i and B_i are concentrations of a liquid phase of Al_2O_3 and Na_2O_2 respectively, G_i is a concentration of the solid phase of Al_2O_3 ; L_i, K_i, L_i, H_{ij} are nonlinear functions of the i -th, having a positive value for the input flow, negative one for the output flow and value equal to 0 if the flow does not pass through the modeled block.

Simulation of block IV is carried out using the Montvid formula: $C_n = \frac{R_n \cdot C_B - 1}{(R_n \cdot C_B)^{N_n+1} - 1}$, where $C_B = \frac{F_{14} \cdot D_5}{F_4 \cdot H_m}$, where H_{sl}, R_n are technological parameters, N_n is a number of sludge washing steps.

Simulation of block V (aluminum oxide transition from the solution into a solid phase) is based on a kinetic equation of the 2nd order: $\frac{dA}{dt} = -R_d \cdot K_d \cdot (A - A_p)^2$, where A is the

aluminum oxide concentration in the solution, A_p is its equilibrium concentration, 1 is duration of the decomposition process, K_d is its speed.

K_d value is described by a complex dependence on temperature, reagent concentration and other parameters, this is why its value in this work was determined using a theory of fuzzy sets.

The present model has significant nonlinearity, and due to the interconnection between the parameters of the production in question, all equations of the model, including differential ones, should be solved in a single iteration cycle. As the result we performed analytical transformation of the systems of nonlinear equations into a form enabling convergence of the iteration process in three variants depending on the desired values of the variable found in the iteration process. We developed an algorithm according to which search for the solution was performed using one of three variants ensuring convergence.

III. CONSTRUCTION OF THE TARGET FUNCTION

The following criteria were specified for the solution of this optimization problem: minimization of energy consumption and steam consumption without increasing cost price of the finished goods. The following study was made to develop the multi-criterion target function.

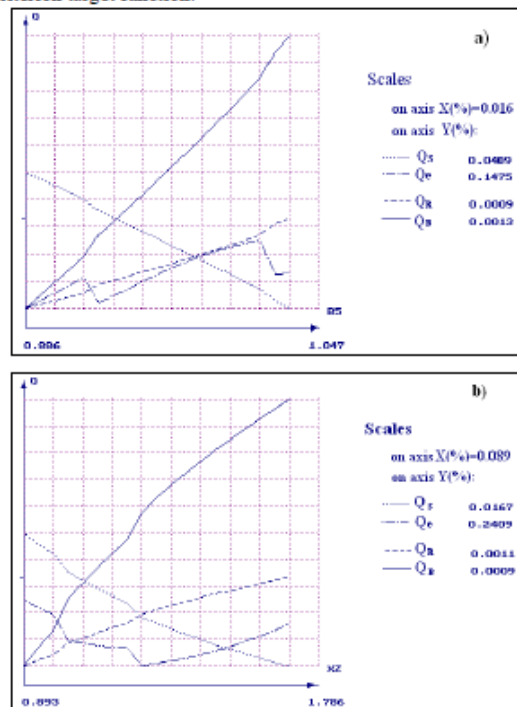


Fig. 2. Change of specific consumption of electric power (Q_e), steam (Q_s), and raw material (Q_B, Q_R) from the controlled parameters a) B5 in the range 0.11...0.13 and b) XZ in the range 1...2

Using a static model we plotted the functions of electric energy (Q_e), steam (Q_s) and raw material (Q_B , Q_R) consumption per ton of the finished goods from the controlled parameters $X = \{B2, B5, XZ, M3\}$. Graphical representation of the dependences for these two parameters is given in figure 2.

Analysis of the obtained dependences allowed us to make the following conclusions: all dependences are nonlinear, the global minimum is observed for parameters B5 and XZ in their variation range, but there are also local minima (fig. 2a, 2b), cost reduction for one parameter could lead to increase in the consumption of other parameters.

Therefore, it was decided to include in the criterion the costs of all kinds of consumption to make it possible to find a strategy to choose between conflicting tendencies. The following target function was developed as a result:

$$S = C \cdot Q(X) / F_{10} \rightarrow \min, \quad (2)$$

where

$$Q(X) = (K_1 \cdot W(X), K_2 \cdot Q_s(X), K_3 \cdot F_1(X), K_4 \cdot F_{13}(X)),$$

W is energy consumption calculated by formula (1),

Q_s is steam consumption, $Q_s = K_5 F_{12} (K_5 - \text{coefficient of steam consumption per } 1 \text{ m}^3 \text{ of evaporated water (MJ/m}^3\text{)}),$

F_1 and F_{13} are raw material consumption with values of operating parameters determined by vector X ,

F_{10} is output of the finished goods,

C are prices for electric power, steam and raw materials respectively, $CL1 - CL4$ are coefficients determining the share of unaccounted costs.

Thus, we obtained a criterion described by one analytical expression and taking into account the required consumption and prices for energy and raw materials. Therefore it could be used as unified criterion in this multi-criterion problem.

IV. SOLUTION OF THE OPTIMIZATION PROBLEM

It is obvious that for this 4-parameter optimization problem it is impossible to provide an analytical description of the target function and to determine its properties, because $Q(X)$ is determined using a model of the whole production with operational parameters value X . This circumstance complicates application of classical optimization methods because most of them are based on use of a priori information on the target function behavior pattern.

Recently such problems started being solved using artificial intelligence methods based on the mechanism of evolutionary development of the Nature, or so-called evolutionary search methods. From the point of view of information transformation evolutionary search is a consecutive transformation of one finite fuzzy set of intermediate solutions into another. In this statement differentiability, continuity and other conditions imposed on the target function in classical mathematical methods are not an obligatory property for the class of problems in question.

One of artificial intelligence methods – a classical genetic algorithm [7,8,9] was chosen for the solution of this optimization problem. This classical genetic algorithm looks as follows:

1. Initial population is created.
2. Fitness of each individual in the population is evaluated.
3. Individuals with high fitness are selected for cross-breeding.

4. Cross-breeding of the chosen individuals and obtaining descendants.

5. Mutation.

6. Formation of a new generation.

7. Check - if the population did not converge, than transition to point 2, otherwise the end of searching.

Since a genetic algorithm does not work with the parameters of our problem, but with a coded set of parameters, originally in its application we need to solve the problem of coding all parameters of the optimization problem, that is mapping of the solution domain onto a genetic code.

Coding of the initial population elements for this was performed in a binary code for the whole domain of acceptable values for 4 controlling parameters. Each parameter was coded by 5 binary symbols with values from 00000 to 11111. This code reflected the values of technological parameters constituting the domain of their acceptable values. So, for example, coding of the value of B5 parameter was performed in the range from 0.111 to 0.1265 with a step of 0.0005, and the value of M3 was coded in the range from 1.60 to 1.755 with a step of 0.005.

4 initial populations of "parental" chromosomes were created using random selection ("shotgun") from the whole solution domain for the problem in question. Left most column of markers in the form of small squares for parameter B5 in Fig. 3 and triangles for M3 parameter shows our random selection of initial populations on the solutions domain 0.111...0.1265 and 1.6...1.755 respectively.

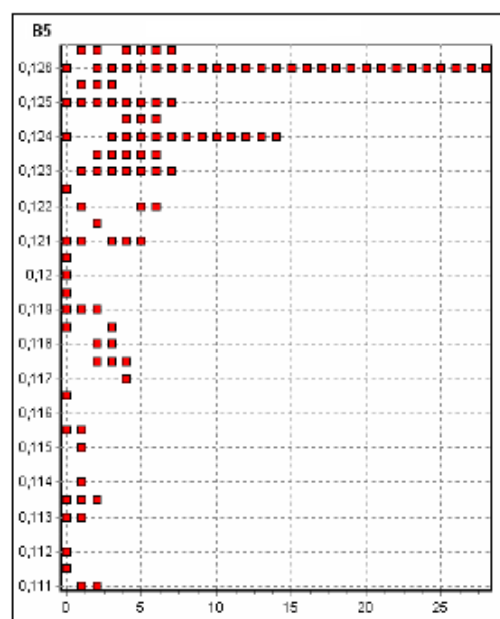


Fig. 3. Graphical representation of chromosome generations during the problem solution provided that the genetic algorithm is completed by restricting the number of generations (it is equal to 28).

The next step of the genetic algorithm is evaluation of each chromosome of the population by the fitness function. The higher is the value of this function for the selected individual, the higher is its quality. The fitness function depends on the problem being solved; this is why it was developed on the basis of

criterion (2). We also took into account basic requirements to the fitness function: it has to have non-negative values and to tend to a maximum. Moreover, as it was found during adjustment of the genetic algorithm for the solution of the given optimization problem, the fitness function for neighboring chromosomes (ch – is a symbol of a chromosome) has to take values that are considerably different from each other to ensure correct selection of the chromosomes forming the optimal solution of our problem.

As a result the fitness function for the optimization problem being solved got the following form:

$$G(ch) = \text{MAX}(S) - C \cdot Q(X) / F_{10} \rightarrow \max, (3)$$

where MAX (S) is the greatest possible value of expression (2) for this problem

Probability $P_s(ch_i)$ equal to the relation of its fitness function to the total fitness of the whole population was calculated to form parental chromosomes for each individual of the population:

$$P_s(ch_i) = \frac{G(ch_i)}{\sum_{i=1}^N G(ch_i)} \quad (4)$$

Then N chromosomes were selected (with replacement) into a so-called parental pool for further genetic processing according to the value of $P_s(ch_i)$ on the basis of the simplest proportional selection – "roulette".

An operator called "cross-breeding" (crossover) in genetic algorithms is responsible for the transfer of parental properties to the descendants. In the solution of the given optimization problem each pair of parents had a single-point crossover, and crossover points were determined randomly. A couple of descendants was formed as a result. The crossing operation was carried out for the whole population of each generation, and the mutation operation was carried out with the probability of 0.01. In a chromosome subject to mutation one of randomly chosen bits was changed to the opposite one.

A program was developed and debugged for realization of this algorithm. The result of the solution by 2 parameters is shown in Fig. 3. It is clear from the figure that from population to population individuals closest to the optimal solution survive from the originally selected population of individuals-solutions: $B5=0.126$, $M3=1.61$.

After completion of the search process using a genetic algorithm the average value of the fitness function of chromosome population grew from 341.17 to 546.17, and values of technological parameters became $B5=0.126$, $M3=1.61$, $Z=1.1$, $B2=0.18$. The obtained values of technological parameters make it possible to reduce electric energy consumption by 10 % and steam consumption by 14 % in comparison with the mode when

the controlled parameters were kept at a level of their average acceptable value.

V. CONCLUSIONS.

Analysis of the results of the solution of the optimization problem showed, that a genetic algorithm helped to find values of technological parameters allowing to reduce energy consumption for production of 1 ton of the finished goods without increasing its cost price.

Solution of the optimization problem using classical methods of gradient descent and random search strongly depends on initial approximation and does not always bring the expected results because of the absence of functional dependence between output and input parameters.

REFERENCES

- [1] Worrell, E., Bernstein, L., Roy, J., Price, L., & Harnisch, J. "Industrial energy efficiency and climate change mitigation". Energy efficiency, 2009, Vol. 2-2, P. 109-123.
- [2] H. Mirjam, L. Nilsson and R. Harmse. "Theory-based policy evaluation of 20 energy efficiency instruments". Energy Efficiency, 2008, Vol. 1-2, P. 131-148.
- [3] P. Thollander and M. Ottosson. "An energy efficient Swedish pulp and paper industry-exploring barriers to and driving forces for cost-effective energy efficiency investments". Energy Efficiency, 2008, Vol. 1, P. 21-34.
- [4] Veri A., Abele E., Heisel U., Dietmair A., Eberspächer P., Rahäuser R., Braun S. "Modular modeling of energy consumption for monitoring and control". Globalized Solutions for Sustainability in Manufacturing. – Springer Berlin Heidelberg, 2011, P. 341-346.
- [5] Schmitt R., Bittencourt J. L., Bonefeld R. "Modelling machine tools for self-optimisation of energy consumption" Globalized Solutions for Sustainability in Manufacturing. – Springer Berlin Heidelberg, 2011, P. 253-257.
- [6] Seow Y., Rahimifard S. "A framework for modelling energy consumption within manufacturing systems". CIRP Journal of Manufacturing Science and Technology, 2011, Vol. 4 –3, P. 258-264.
- [7] Pavlyuchenko D. A., Manusov V. Z. "Electrical network optimization by genetic algorithm". // European Transactions on Electrical Power. – 2006. – Vol. 16, № 6. – P. 569-576.
- [8] Pavlyuchenko D. A., Manusov V. Z. "Real power optimization by genetic algorithms". //Proceedings of the 2 international conference on technical and physical problems in power engineering (ICTPE-2004), Iran, Tabriz, 6-8 Sept. 2004. – Tabriz, 2004. – P. 200-203.
- [9] Pavlyuchenko D. A., Manusov V. Z., Lubchenko V. Ya. "The application of the genetic algorithms in the optimization of transmission systems expansion". //The 6 Russian-Korean international symposium on science and technology (KORUS-2002): proc., Novosibirsk, 2002. – Novosibirsk: NSTU, 2002. – Vol. 1. – P. 452-455.
- [10] Zaytseva N. M. "Modeling of power consumption by nonlinear inertial production". International Conference Mechanical Engineering, Automation and Control Systems (MEACS). –IEEE, 2014, pp. 1-4.
- [11] Zaytseva N. M. "Increase of Energy Efficiency of Alumina Production on the Basis of Process Modeling". International Conference on Mechanical Engineering, Automation and Control Systems (MEACS). –IEEE, 2015, pp. 1-4.



Zaitzeva Natalia Mikhailovna, PhD.

Professor at the Innovative University of Eurasia, Pavlodar, Kazakhstan.

Dissertation subject "Research and creation of mathematical models for operational control of closed hydro chemical production", Novosibirsk State Technical University, 1998.

MS in Computer Sciences and Applied Mathematics from Novosibirsk State Technical University, 1974.

СОДЕРЖАНИЕ
THE CONTENTS

ALGAZIN E. I. ¹ , KOVALEVSKIY A.I. ¹ , VESHKURTSEV Y. M. ² Algorithm of processing of signals relative phase modulation in the presence at them the initial angle of shift of phases and correlation between two next instant values, ¹ Novosibirsk, Russia, ² Omsk, Russia	13
BAKHAREV A.V., ZELENTOV B.P., MAXIMOV V.P., SHUVALOV V.P. Achieving of reliable multigigabit data delivery in presence of multiple receivers with P2M, Новосибирск, Россия	17
VARDANYAN V.A. Single-fiber optical transmission system with dwdm channels. Effect of four-wave mixing products, Novosibirsk, Russia	23
GORBACHEV A.P., DENISENKO I.A. The planar dipole antenna excited by modified microstrip via-hole balance unit, Novosibirsk, Russia	26
NOSOV V. I., DEGTYAREV S. S. Research of the amplitude-phase conversion impact on the 16-apsk signal noise immunity, Novosibirsk, Russia	30
KRASIKOV M.S., NOSOV V. I. Research of the satellite transponder beams interference impact, Novosibirsk, Russia	37
ABRAMOV S. S. ¹ , PAVLOV I. I. ¹ , ABRAMOVA E. S. ¹ , STARYSH D. YU. ² Ways to ensure quality of work radiopure-sensors to base stations, ¹ Novosibirsk, Russia, ² Nefteyugansk, Russia	40
NOSOV V.I., YANTSEN A.S. Definition of mimo technology noise immunity by correlated channels, Novosibirsk, Russia	45
DROZDOVA V.G., RUSLAN V. AKHPASHEV R.V. The analysis of distribute inter-cell interference control efficiency algorithms of in LTE, Novosibirsk, Russia	49
BOGOMOLOV P.G., RUBANOVICH M.G., RAZINKIN V.P. Methods of expanding the bandwidth of multicascade microwave attenuators, Novosibirsk, Russia	54
DOROSINSKIY L.G., N.V. BUDYLDINA N.V. Synthesis and analysis of detection algorithm of distributed sources against background with distributed clutter, Yekaterinburg, Russia	57
BUDYLDINA N.V., TRUKHIN M.P. Methods for digitizing weak signals much less the LSB level, Yekaterinburg, Russia	60
MAYSTRENKO A. ¹ , BOGACHKOV I.V. ¹ , KOPYTOV Y. ¹ , LYUBCHENKO A.A. ¹ , LUTCHENKO S.S. ¹ , CASTILLO P.A. ² An approach for estimation of integrated reliability indices and maintenance intervals of fiber-optic communication lines. ¹ Omsk, Russia, ² Granada, Spain	64
KROPOTOV Y.A., BELOV A.A. Application Method of Barrier Functions in the Problem of Estimating the Probability Density of the Parameterized Approximations, Murom, Russia	69
KROPOTOV YU.A., PROSKURYAKOV A.Y. Correlation methods of estimation parameters acoustic signals and interference in telecommunications, Murom, Russia	73
LEBEDYANTSEV V.V., LEBEDYANTSEV M.V. The theory of invariant communication systems and the prospect of its development, Novosibirsk, Russia	79
MAYSTRENKO A.V., MAYSTRENKO V., LYUBCHENKO A.A. Distortion effect analysis of n-ofdm signal with frequency drifts of carrier wave, Omsk, Russia	82
FILIMONOVA Y.O., LAYKO K.A., PODOYNIKOV D. I. Applying of dolph-chebyshev amplitude distributions by the criterion of maximum aperture efficiency for given side-lobe level, Novosibirsk, Russia	87
LEONOV A.V. Modeling of bio-inspired algorithms ant colony and beehive for flying ad hoc networks (fanets), Omsk, Russia	90

XIII Международная научно-техническая конференция АПЭП – 2016

GOVORUKHIN V.I., UNRU N.E. A ring power divider/combiner integrated with circle-shaped ballast resistor, Novosibirsk, Russia	100
KALACHIKOV A.A., SHELKUNOV N.S. Measurement and statistical analysis of indoor mimo radio channel parameters, Novosibirsk, Russia	103
GRISHKO A.K. Parameter control of radio-electronic systems based of analysis of information conflict, Penza, Russia	107
GRISHKO A.K., GORYACHEV N.V., KOCHEGAROV I.I., KALAEV M.P. Mathematical models of the system of measurement and analysis of temperature parameters of radio electronic modules, Penza, Russia	112
KOCHEGAROV I.I., DANILOVA E.A., YURKOV N.K., BUSHMELEV P.YE, TELEGIN A.M. Analysis and Modeling of Latent Defects in the Printed Conductors., Penza, Russia.	116
STENNIKOV V.N. The scientific development of brazing technology electronic devices, Ekaterinburg, Russia	121
YURKOV N.K., TRUSOV V.A., LYSENKO A.V. Methods of providing reliability of avionics and aerospace equipment at the design stage, Penza, Russia	123
VOLKHIN D. I., DEVYATKOV G. N. Synthesis of Broadband Impedance Transformers with Predetermined Phase Response, Novosibirsk, Russia	128
KOVAL M.V., DEVYATKOV G.N. Synthesis of broadband balun on the coupled transmission lines, Novosibirsk, Russia	132
RADCHENKO S.E., KOZLOV I.N. Statistical Processing Algorithms of Signals at Ultrasound Distance Measurement, Novosibirsk, Russia	136
RADCHENKO S.E., PITSUN D.K., KRIVETSKY A.V. Statistical Algorithms for Superconducting Q-bits Parameters Measurement, Novosibirsk, Russia	139
STARUKH A.A. The Creation of a Digital Element Base from Components of Library ABM to Study Asynchronous Circuits, Taganrog, Russia	143
BELYAEV B.A., KHODENKOV S.A. The Investigation of Filters with Wide Stop Band, Based on Electromagnetic Crystals of Microstrip Resonators 2D Disposition, Krasnoyarsk, Russia	146
AFONIN K.N., OLISOVEC A.U., RYAPOLOVA Y.V., SOLDATKIN V.S., STAROSEK D.G., TUEV V.I. Optimizing the design of LED lamps for the minimum of uneven light distribution in space, Tomsk, Russia	153
IVANOV A.V., REVA I.L., USHAKOV A.E. Features of identification and the analysis of collateral electromagnetic radiations from USB flash drives, Novosibirsk, Russia	156
KASHIRIN I.A., USMANOV D.R., REVA I.L., ZAHAROV K.V. Development of Optical Transceivers SFF standard with support for cryptographic kernel, Novosibirsk, Russia	159
ZHERNAKOV S.V., GAVRILOV G. N. Malicious software detection in operating system (OS) for mobile devices (the case of Android OS), Ufa Russia	163
RAKHIMOV N.R., SER'EZNOV A. N., RAKHIMOV B.N., ALIJANOV D.D. Jig-Sensitive Optical Detectors Based On Semiconductor Films With Anomalous Photovoltage, Novosibirsk, Russia	166
GORBACHEV A.P., TARASENKO N.V. The Novel Reentrant Power Splitters And Band-Stop Elliptic Filters, Novosibirsk, Russia	173
BOGOMOLOV P.G. STUDENT MEMBER, RUBANOVICH M.G., RAZINKIN V.P. Methods of Expanding the Bandwidth of Multicascade Microwave Attenuators, Novosibirsk, Russia	177
NOVIKOV A.V., KHLUSOV V.A. A Receive Linear Array Beamforming Using Spatially Variant Apodization, Tomsk, Russia	180
NIKULINA YU.S., STEPANOV M.A. Permissible Deviation Ranges of a Collimating Lens Irradiator, Novosibirsk, Russia,	184

STEPANOV M.A., SUKHANOV I.I. The Spherical and Aspheric Surfaces Lens Collimators: the Aperture and Aberration Features, Novosibirsk, Russia	187
CHEREVKO A.G. Patent activity of developed countries in the terahertz range – Comparative analysis, Novosibirsk, Russia	190
CHEREVKO A.G., MORGACHEV Y.V. Simulation of phased array in THz region, Novosibirsk, Russia	193
NIKULIN A.V. Dependence of the Mistake in Noise of Coordinates Parameters from the Error in Installation of Capacities of Signals of Radiators, Novosibirsk, Russian Federation	200
BLINOV P.YU., LEMESHKO B.YU. The simulation system and research of functions of random variables, Novosibirsk, Russia	203
BIRYULIN V.I., GORLOV A.N., LARIN O.M., KUDELINA D.V. Calculation of power losses in the transformer substation, Kursk, Russia	210
BIRYULIN V.I., GORLOV A.N., LARIN O.M., KUDELINA D.V. Neural network application for assessment of the asynchronous motors energy consumption, Kursk, Russia	213
VARNAVSKY A.N., SINITSINA N.V. Statistical modeling the probability of some types of automobile-pedestrian accidents, Ryazan, Russia	216
Veretelnikova E.L., Elantseva I.L. The Choice Of The Coefficient of criterion of a minimum of the Resulting Root-mean-square error, Novosibirsk, Russia	221
VOZHOV S.S., CHIMITOVA E.V. An investigation of statistical properties of parameter estimates of distributions on interval data, Novosibirsk, Russia	224
VOLKOVA V.M. Research of tukey's test statistic distribution under failure of the normality assumption, Novosibirsk, Russia	227
GINIS L.A., VOVK S.P. Modeling of achievement of the reference situation in the conditions of uncertainty, Taganrog, Russia	230
DAVYDOV A.P., ZLYDNEVA T.P. On the reduction of free photons speed in modeling of their propagation in space by the wave function in coordinate representation, Magnitogorsk, Russia	233
DENISOV V.I., FADDEENKOV A.V. Specification of spline regression model with variable penalties, Novosibirsk, Russia	241
DOMNIKOV P.A. Speedup of three-dimensional finite element geoelectromagnetic fields modelling in time domain, Novosibirsk, Russia	244
DOMNIKOV P.A. Finite element 3D-modeling of magnetotelluric field for a set of harmonics, Novosibirsk, Russia	247
ZAYTSEVA M.N. Solution of the problem of searching for an energy-efficient functioning mode of a continuous production using simulation and artificial intelligence methods, Pavlodar, Kazakhstan	250
KISELEV D.S., PERSOVA M.G., SOLOVEICHIK YU.G., KOSHKINA YU.I., VAGIN D.V., SIMON E.I. Comparison of approaches and the software for 3D finite element modeling of harmonic electromagnetic fields, Novosibirsk, Russia	255
KONDRATYEV N.V., PERSOVA M.G., KOSHKINA YU.I., KISELEV D.S. Approach to distributed computing system development for three-dimensional geoelectromagnetic problem solving, Novosibirsk, Russia	259
KONDRATYEV N.V., SOLOVEICHIK YU.G., VAGIN D.V., PATRUSHEV I.I. GPU implementation of iterative solver for linear systems obtained by fem discretization, Novosibirsk, Russia	263
KONDRATYEVA N.S., STUPAKOV I.M. Acceleration methods for the calculation of results in boundary element modeling, Novosibirsk, Russia	268
KOTOVA E.E. Application of dynamic approach to learning process modeling, Saint-Petersburg, Russia	271

KOSHKINA YU.I., PERSOVA M.G., SOLOVEICHIK YU.G., PATRUSHEV I.I. Development and research of geometric inversion of induction logging data measured in vertical wells, Novosibirsk, Russia	276
LEMESHKO B.YU., VERETEL'NIKOVA I.V. On power of randomness and absence of trend tests in dispersion characteristics, Novosibirsk, Russia	281
LIMANSKIY A.I., PERSOVA M.G. Software for multidimensional inversion of magnetotelluric data with recovering conductivity in the cells, Novosibirsk, Russia	287
MANUSOV V.Z., MATRENIN P.V. Optimization of fuzzy controller of a wind power plant based on the swarms intelligence, Novosibirsk, Russia	293
NEDEL'KO V.M. New explanation of boosting efficiency in classification problem, Novosibirsk, Russia	299
PERSOVA M.G., SOLOVEICHIK YU.G., VAGIN D.V., KOSHKINA YU.I. Grouping of transmitter-receiver positions when using the direct solvers of finite element equation systems in induction logging problems, Novosibirsk, Russia	305
PERSOVA M.G., TRUBACHEVA O.S., SOLOVEICHIK YU.G. Geometric 3D inversion application for recovering the polarizability of geoelectric-heterogeneous geological media, Novosibirsk, Russia	309
POPOV A.A., BOBOEV S.H.A. The use of robust criteria for the choice of regression model by LS-SVM method, Novosibirsk, Russia	313
POPOV A.A., GULTYAEVA T.A., UVAROV V.E. Training hidden Markov models on incomplete sequences, Novosibirsk, Russia	317
POPOV A.A., HOLDONOV A.A. Comparative research of estimation accuracy of parameters of fuzzy regression models with various types of M-estimates, Novosibirsk, Russia	321
ROYAK M.E., LYZOV E.R. Study of the effectiveness of curved finite elements on the example of solving a magnetostatic problem, Novosibirsk, Russia	327
ROYAK M.E., STUPAKOV I.M., KONDRATYEVA N.S. Coupled vector FEM and scalar BEM formulation for eddy current problems, Novosibirsk, Russia	330
SVYKH G.F., FAINER N.I. The simulation of evolution of crystal particle in vortex chamber, Novosibirsk, Russia	336
SOLOVEICHIK YU.G., PERSOVA M.G., VAGIN D.V. Software for finite element analysis of stress-raisers in composite laminates, Novosibirsk, Russia	339
SPESHILOV K.V., KHABAROV V.I. Using the event calculus for modelling an operator of a simulator complex, Novosibirsk, Russia	343
STUPAKOV I.M., ROYAK M.E., KONDRATYEVA N.S. The method for calculating magnetic field induced by current coils, Novosibirsk, Russia	347
SUKHORUKOV M. P. Mathematical modeling exposure of shock on the electronic equipment, Tomsk, Russia	351
TESSELKIN A.A., TESSELKINA K.V., KHABAROV V.I. Elements of data mining for the development of mathematical transport models, Novosibirsk, Russia	354
TIMOFEEV V.S., SHCHEKOLDIN V.YU., TIMOFEEVA A.YU. Geographically weighted regression: fitting to spatial location, Novosibirsk, Russia	358
TROYANOVSKIY V.M., OSPANIN S.A., ZAPEVALINA A.A. Recursive method of extracting the harmonic signal from a mixture with strong noise: limitations and the non-uniqueness, Moscow, Barnaul, Russia	364
PHILONENKO P.A., POSTOVALOV S.N. Test power in two-sample problem testing as the utility function in the theory of decision making under risk and uncertainty, Novosibirsk, Russia	369
CHIMITOVA E.V., SEMENOVA M.A., KARMANOV V.S., SMAGIN G.I. The optimization of drilling conditions by using accelerated life model, Novosibirsk, Russia	374

CHIMITOVA E.V., CHETVERTAKOVA E.S., FADDEENKOV A.V. The construction of degradation trend using the "random-effect" models, Novosibirsk, Russia	378
CHUBICH V.M., FILIPPOVA E.V. Synthesis of D-optimal continuous input signals for stochastic linear systems, Novosibirsk, Russia	381
CHUBICH V.M., CHERNIKOVA O.S. Adaptive fading Kalman filter with applications in identification discrete system, Novosibirsk, Russia	385
SHAKHOV V.V., YURGENSON A.N., SOKOLOVA O.D. Analysis of fault tolerance of wireless sensor networks, Novosibirsk, Russia	390
SHURINA E.P., KUTISCHEVA A.Y. Numerical simulation of a solid deformation under the action of an external and internal pressure, Novosibirsk, Russia	394
SHURINA E.P., MIKHAYLOVA E.I. Modified multiscale discontinuous Galerkin method in the function space $H(\text{curl})$, Novosibirsk, Russia	398
SHORNIKOV YU. V., DOSTOVALOV D.N., BESSONOV A.V., NASYROVA M.S. Specification of electric power systems in ISMA simulation environment, Novosibirsk, Russia	403
SHTABEL N.V., SHURINA E.P. Variational formulation for a magnetic field on dual meshes, Novosibirsk, Russia	408
GUZAIROV M.B., YUSUPOVA N.I., SMETANINA O.N., RASSADNIKOVA E.YU. Models and algorithms for vehicle routing problem with time windows and other conditions, Ufa, Russia	412
RABINOVICH E.V., VAYNMASTER P.I. Information technology for monitoring of hydraulic fracturing, Novosibirsk, Russia	417
RABINOVICH E.V., PUPYSHEV I.M., SHEFEL G.S. Layout of seismic location dots for hydraulic fracturing monitoring, Novosibirsk, Russia	421
KHAIRETDINOV M.S., VOSKOBOYNIKOVA G.M. Detection of signals and identification of sources in the monitoring networks, Novosibirsk, Russia	424
KHAIRETDINOV M.S., POLLER B.V., BRITVIN A.V., SEDUKHINA G.F. An acoustooptic information system of infralow frequencies, Novosibirsk, Russia	428
YAKIMENKO A.A., KHAIRETDINOV M.S., GRISHCHENKO M.V., MATVEEV I.N., MORGUNOV A.S. Access technology to high performance resources by means of information systems, Novosibirsk, Russia	434
KARAVAEV D.A., YAKIMENKO A.A., BULAVINA N.A. A technology of full seismic field simulation on high-performance computing systems, Novosibirsk, Russia	439
KOVALEVSKY V.V., BRAGINSKAYA L.P., GRIGORYUK A.P. An information technology of verification of earth's crust velocity models, Novosibirsk, Russia	443
KHANOV V.KH., CHEKMAREV S.A. Fast SEU fault injection in the SoC-memory, Krasnoyarsk, Russia	447
KROPOTOV Y.A., DOGADINA E.P. Decision support system to determine the effective values the parameters of the production process on the Pareto set, Murom, Russia	451
GAVRILOV A.V., PANCHENKO K.O. Methods of learning for spiking neural networks. A survey, Novosibirsk, Russia	455
MALIAVKO A.A., GAVRILOV A.V. Towards development of self-learning and self-modification spiking neural network as model of brain, Novosibirsk, Russia	461
ROMANOV E.L., NOVITSKAYA Y.V. Program toolkit for auditory scenes' analysis, Novosibirsk, Russia	464
MILUKIN Y.A., PODCHUKAYEV V.A., FILONOVICH A.V., FILATOV E.A. Method recognition of mathematical formulas for the arbitrarily given of the control law, Kursk, Saratov, Russia	471

KURNOSOV M.G. Dynamic mapping of all-to-all collective operations into hierarchical computer clusters, Novosibirsk, Russia	475
KOKOULIN A.N. Distributed storage approach in content delivery networks, Perm, Russia	479
CHUGUNKOV I.V., PROKOFIEV A.O. , STRELCHENKO P.A., MATRIUKHINA Y.A. Research of statistical properties of stochastic calculations using the improved test of distribution on the plane, Moscow, Russia	485
IGUMNOV A.O., SONKIN D.M. Forecasting algorithm of time arrival with statistical data using based on the principle of templates selection, Tomsk, Russia	489
GRIF M.G., KOCHETOV S.A., GANELINA N.D. Functional-structural theory based techniques for human-machine systems optimal design, Novosibirsk, Russia	494
GRIF M.G., MANUEVA J.S. Russian sign language machine interpreter system based on the analyses of syntax and semantic construction, Novosibirsk, Russia	498
PRIHODKO A.L., LUKOYANOV A.V., GRIF M.G. Approach to the analysis and synthesis of the sign language, Novosibirsk, Russia	502
BATYGIN R.I., ALSOVA O.K. Software system for different types of data classification based on the ensemble algorithms, Novosibirsk, Russia	506
ALSOVA O.K., KAZANSKAYA O.V. Training simulators for support of inductive method in teaching, Novosibirsk, Russia	510
AVDEENKO T.V., PUSTOVALOVA N.V. The ontology-based approach to support the requirements engineering process, Novosibirsk, Russia	513
SOKOLOVA O.D., KRATOV S.V. Information systems for popularization of scientific and knowledge-based software, Novosibirsk, Russia	519
ALT V.V., ISAKOVA S.P., LAPCHENKO E.A. The mathematical model of forming of optimal combination of machineries and tractors park subject to social factor, Novosibirsk, Russia	523
BOGOMOLOV D.A., SYSOEV M.D., KARACHAKOV V.A., DAVYDOV A.A. Development of the university platform "My NSTU", Novosibirsk, Russia	527
MISHCHENKO P.V., KARNEEV M.A., BELOBORODOVA Z.E. The impact of memory effect on computing time, Novosibirsk, Russia	530
MISHCHENKO P.V., SILOV Y.V., BELOBORODOVA Z.E., LYKOV A.S. The interaction interface for the distributed computing system's nodes, Novosibirsk, Russia	534
ITKINA N.B., MARKOV S.I. Determining an effective permeability tensor in anisotropic media, Novosibirsk, Russia	538