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## SUMMARY. KEYWORDS

### MECHANICAL AND THEORETICAL ENGINEERING

**I. V. Boyarkina, E. V. Tarasov**  
**Rolling bearings with a small number of rolling elements performance in centrifugal pumps of oil refining**

For rolling bearings of centrifugal pump units in oil-processing the regularities of changes in its geometric parameters and vibration activity in the operation are obtained.

Keywords: rolling bearing, roller bearing, ball bearing, radial load, geometric characteristics of bearing, dynamic load capacity, centrifugal pump unit.

**N. S. Galdin, V. N. Galdin**  
**The analysis of the influence of design data hydropneumatic impact devices on power indicators of hydraulic pulse systems of building machines**

Creation of the new, perspective hydropneumatic impact devices providing effective work of hydropulse means of mechanisation is an actual problem. A research objective is perfection of mathematical modelling of power indicators of hydropneumatic impact devices. Research problems reveal the influence of design data hydropneumatic impact devices on its power indicators. The technique of research includes application of methods of imitating modelling on a computer. It is established that power indicators (energy, capacity of individual blow) hydropneumatic impact devices depend on speed mobile part and its such design data, as weight, course size mobile part, pressure of gymnastics of gas of the pneumoaccumulator. Functional dependences of speed, energy of blow on weight, course sizes mobile part, pressure of gymnastics of gas of the pneumoaccumulator are presented. The found functional dependences develop algorithms and an engineering technique of the automated modelling and calculation of hydropneumatic impact devices that will reduce terms of its designing.

Keywords: hydropneumatic impact device, speed mobile part, energy of blow.

**E. N. Eremin, T. V. Kovalyova, I. V. Mozgovoy**  
**Determination of strength and permeability of foundry molds of sand-resin mixtures**

Experimentally determined strength properties of sand-resin forms are obtained under conditions of simultaneous thermal impact and static loading. It is shown that the increase in pressure on the mixture of 0,03 ... 0,05 MPa during the shaping forms increases the strength decreases the surface roughness of castings.

Keywords: casting mold, strength, gas permeability, the mixture of resin.

**S. N. Litunov, V. S. Slobodenyuk, D. V. Melnikov, V. V. Fedyanin, N. S. Koshcheeva**  
**Review and analysis of additive technologies. Part 2**

Various methods and devices of 3D-printing are considered. The design of the printhead of 3D-printer is proposed, which uses the principle of inkjet printing. The head can be used for printing high viscosity materials and wax-based materials. A comparative analysis of 3D-technologies with their advantages and disadvantages is presented. The main trends of development of the industry in the near and distant future are depicted.

Keywords: additive technology, 3D-printing, an overview of modern 3D-technology.

**S. N. Litunov, N. I. Filenko, O. V. Chemisenko, N. S. Koshcheeva**  
**Preliminary determination of certain characteristics of print head for 3D printer**

There are proposed 3-D Printer Models for casting using printhead operating with electrohydraulic effect (EGE). To define one of the most important parameters of the head, the pressure in its body, there is made spun assembly and test stand. The circuit model selected is based on compositions paraffin and rosin. The optimum temperature of the printed composition is calculated. The relations of the pressure inside the spun-node from the model structure are obtained.

Keywords: casting, 3-D printing.

**F. N. Pritykin, V. I. Nebritov**  
**The study of size and shape of area in multidimensional space of generalized velocities defining permissible instantaneous state of android robot mechanism**

The area of admissible values of the vector of generalized speeds android robot arms are investigated for various positions in the synthesis mechanism motion on the velocity vector. Set theory is used for analytical set of the field of multidimensional space. This paper presents a method to reduce the synthesis of motion of the android robot manipulator.

Keywords: synthesis of motions of robots on the velocity vector motor redundancy manipulator mechanism, intelligent robot control system.

**V. N. Tarasov, I. V. Boyarkina**  
**Method of investigation of dynamic acceleration and braking working equipment boom machines processes in step-law with directional control valve**

There is performed a hydraulic study of the dynamics of working equipment of boom machines based on the proposed analytical solution of the differential equations of motion of the piston of the power cylinder of the boom, in which the input forcing is a function of control magnitude of walk-through the Windows of the control valve spool.

Keywords: directional control valve, acceleration, braking working equipment, the reduced mass, stiffness coefficient.

**V. F. Mukhin, E. N. Eremin**  
**Using dynamic characteristics for classification of welding processes with periodic short circuits**

We consider construction of dynamic characteristics of a short-circuit for comparison and without separation of waveforms or advanced control algorithms and traditional short arc welding processes.

Keywords: short-circuit, short-arc welding, dynamic characteristic, waveform, power supply.

**Yu. F. Saveliev, N. Yu. Simak**  
**Vibration-proof device for railway rolling stock**

The paper presents the results of the search of constructive solutions for modernization for suspension of rolling stock with the aim of creating effective vibration protection. We propose a new constructive scheme that simplify known analogs and increase reliability.

Keywords: spring suspension, protection, optional devices, knife supports, design justification.

**I. A. Sysuev, E. A. Kobenko, M. F. Fedorchuk**  
**Evaluation of color reproduction inkjet printers**

The article considers issues that relate to reproduction of color images with inkjet printers. Criteria of estimation of color reproduction, in particular, color gamut are discussed. There are the results of the evaluation of the color gamut of the nine systems printing «inkjet printer—paper» using a variety of technologies for assessment. The features of color reproduction of modern inkjet printers are shown.

Keywords: inkjet printing, inkjet printers, print system, color gamut, volume of the solid color coverage.

**I. A. Sysuev, N. N. Kozina**  
**Perception of printed publications made on white and color substrates**

The article considers issues that relate to the creation of attractive external graphic image of regular pages of printed publications. There are provided data pertaining to the perception of the graphic image of pages with different contrast. The assessment of the perception of printed publications, made on white and colored substrates is done. There is examined the relationship between the rank of expert evaluation with contrast graphic image of the pages according to the color of the substrate.

Keywords: graphic image of page, printed publications, saturation of text set, contrast, color substrate.

**N. A. Matveev, A. P. Morgunov**  
**Improving specified properties of rubber selection of ingredients and their parts by accelerated method**

In manufacture of rubber products one of the main processes is the development of rubber mixtures. In the process of formulation of the structure of all accounting operations are performed manually, resulting in considerable complexity. In this regard, the task of automating processes through development and implementation of information technologies at the stage of formulation of the structure is relevant to modern businesses. The authors propose the developed software to carry out the selection of ingredients, specifying their quantity without the influence of the subjective factor, with high accuracy and minimal complexity, forming in this case the prescription database of the enterprise.

Keywords: receptors, algorithm, database, optimization.

**D. V. Emelyanov**  
**Defining characteristics force-torque machining holes depending on depth of drilling**

In this article, the author indicates and specifies how changes in the force-torque characteristics depending on the drilling depth of the hole. On the basis of theoretical and practical study, the authors proposed a method for designing spiral drills, stiffness which varies along the length of the drill, which allows more productive to conduct machining, reduces the number of rejects due to damage tool as well as reduces the consumption of the cutting tool, which is, of course, important in modern mechanical production.

Keywords: cutting tools, twist drills, drill point.

## ELECTRICAL ENGINEERING. POWER ENGINEERING

**A. V. Bubnov, A. N. Chetverik**  
**Features of use of pulse frequency-phase discriminator with advanced features when building modern systems of synchronously-inphase electric drive**

The synchronously-inphase electric drive widely used in thermal imaging and laser scanning systems due to the high accuracy characteristics in a wide range of adjustment of the angular velocity. The aim of the article is consideration of features of application of pulse frequency-phase discriminator with enhanced functionality to implement various methods of control of electric drive with phase synchronization and synchronously-inphase electric drive. The classification of methods of control of electric drive with phase synchronization and synchronously-inphase electric drive and functional diagrams are presented, during realization of that additional functional possibilities of impulsive frequency-phase discriminator are used: indication of modes of operation and the time change mode of impulsive frequency-phase discriminator.

Keywords: the electric drive with phase synchronization, synchronously-inphase electric drive, phase autoadjustment of frequency; logical comparator; of impulsive frequency-phase discriminator, the method of regulation.

**A. V. Bubnov, A. N. Chetverik**  
**Development of control methods of the electric drive with phase synchronization with improved dynamic characteristics**

The electric drive with phase synchronization widely used in thermal imaging and laser scanning systems due to the high accuracy characteristics in a wide range of adjustment of the angular velocity. The aim is to develop methods of control of the electric drive with improved dynamic indicators. The problems of building advanced electric drive with an unblocking logic comparator in the phase comparison mode, providing electric transfer in the closed mode with a decrease in errors in the angular speed to a predetermined value. The method of quasi-optimal for speed regulation of electric drive is proposed that allows the actuator to improve dynamic performance in transient synchronization modes.

Keywords: the electric drive with phase synchronization, phase autoadjustment of frequency; logical comparator; pulse frequency-phase discriminator, phase plane, the method of regulation.

**A. P. Popov, V. Yu. Sysolyatin, O. P. Kurakina**  
**Digital device for diagnostics of starter battery using Super-Cap backup (pseudocapacitor)**

The article discusses the digital device that allows to determine the performance of lead-acid batteries used as starter batteries based on the analysis of the results of measurement values: the internal battery resistance, short circuit current and open circuit voltage. In this case measurements are carried out in a simple

manner without the significant time and removal of batteries with regular place. The principle of operation of the device is the use of short-term discharge the battery to supercapacitor (ionistor). It is necessary to ensure the operation of diagnostic devices close to the start-up mode.

Keywords: a brief discharge the battery, ionistor, microcontroller, digital processing.

**V. I. Potapov, A. S. Gritsay, D. A. Tyunkov**  
**Spectral analysis of retrospective data of «Omsk Energy Retail Company» of power consumption**

Issues of building power consumption forecasting techniques paid a lot of attention because of it depends on many indicators of the effectiveness in an electricity retail company and, ultimately, the tariff for customers on the market price formed on the day-ahead market (DAM). The aim of research is the spectral analysis of retrospective data of «Omsk Energy Retail Company» at various intervals. Spectral analysis revealed the patterns of time-series data on power consumption.

Keywords: data mining, forecasting, power consumption.

**S. G. Shantarenko, V. F. Kuznetsov, E. V. Ponomarev, V. A. Taranenko**  
**Improving quality of current collection in touch «brush-collector» 2ES6 electric traction motor**

The efficiency of traction electric motor of a direct current is largely determined by the reliability of the collector-brush assembly. The results of the simulation of contact interaction «brush-collector» in the electric traction motors 2ES6. The influence of the design features of the brush holder, conditions and modes of operation in the contact area of the «brush-collector» and switching performance. On the basis of theoretical and experimental studies provide recommendations and technical solutions to improve the quality of current collection in touch «brush-collector» and ensure the operational reliability of the traction motors.

Keywords: traction electric motor of a direct current, collector and brush knot, area of contact, the quality of the current collection, brush holder design.

**P. A. Batrakov**  
**Analysis of hemispherical flow of radiant energy in furnaces of complex profile gas-tube boiler**

In solving complex problems, necessary pilot studies when the amount of physical knowledge about the process under study are not sufficient. For the research component of radiation heat flux it is presented developed a physical model of the process, developed a stand using specially manufactured measuring instruments with the calibration of them and carrying out experiments to further processing of the research results and their analysis.

Keywords: radiation-convective heat transfer, fire-tube boiler, furnace, experimental stand.

**O. A. Lysenko**  
**Torque load observer of asynchronous motor with double squirrel-cage of rotor**

The article describes the results of research and development of observer torque on the shaft and the state variables of asynchronous motors with double squirrel cage rotors or deep-slot-type rotors. Observers of the state variables are used for construct the sensorless control system of asynchronous electric. To estimate the load torque is used mathematical description based on the Luenberger observer complete order. The research methods: automatic control theory and electrical machines. The text gives the graphical results of numerical simulation and shows the efficiency of the developed algorithms and techniques.

Keywords: sensorless control; induction machine; Luenberger observer; estimation of load torque.

**V. A. Oshchepkov, A. O. Shepelev, N. S. Kapitonov**  
**Determining the level of overvoltage in networks with compensation of capacitive currents**

The technical condition of electrical networks significantly affects the economic performance of power transmission over networks. On transmission efficiency it also affects the neutral mode. This article considers the distribution network that works with capacitive current compensation. There are determined levels of overvoltage occurring on the elements of electrical network and capacitive current of the network and current of Peterson coil.

Keywords: simulation of transients, compensation of capacitive currents, single phase fault, Peterson coil.

**M. S. Balabanov, R. N. Khamitov**  
**The methodology for selecting FACTS devices for example ferroalloy production**

In order to optimize the choice of FACTS-devices for industrial and network objects there is developed software for computer security. In the article there are presented the results of testing the developed methodology to determine the optimal type of FACTS-devices for network and industrial facilities. Simulation implementation of various FACTS-devices ferroalloy plant is carried out in specialized software DigSILENT (Germany). It is proved that the filter-compensating device is the best type of FACTS-devices for operation in the power supply system of ferroalloy furnaces.

Keywords: FACTS-devices, ferroalloy furnaces, harmonic filter, synchronous compensator, shunt capacitor banks, static var compensator, active filter.

**A. V. Ded**  
**Mathematical modeling of calculation of losses of power in three-phase network at asymmetry of loading**

The way of calculation of increase in losses of power in four-wire networks with a zero wire, with the amplitude-phase asymmetry of loading is presented in the article. It is defined that for calculation of losses of power it is necessary to calculate current of the direct sequence in an initial (asymmetrical) operating mode of system and current of the direct sequence in the ambassador of the correcting actions.

Keywords: power quality, unbalanced load, the power loss.

**A. V. Ded**  
**Development of an algorithm of calculation of losses of power in four-wire three-phase network at asymmetrical loading**

The developed algorithm of calculation of losses of power in four-wire networks with a zero wire, in the presence of a long asymmetrical operating mode is presented in the article. The algorithm includes calculations of power parameters of the explored site of distributive network before holding an action for alignment (balancing) of level of the connected loading

Keywords: power quality, unbalanced load, the power loss.

**D. N. Shelkovnikov**  
**The prospective ice formations power lines protection system**

This article explores analysis of technical possibilities of overground power lines monitoring system that use weight sensors. These sensors allow user to monitor power lines' state being influenced by ice covering's weight. The article suggests a new way to separate ice covering from overground power lines, the main point of which is to pass high frequency voltage through the wires. The process leads skin effect to happen, and, as a result, a heightened temperature on the conductor's surface is produced, which is why ice formations cease to emerge.

Keywords: power lines, separation of ice covering from power lines, power lines diagnostics, overground power lines.

**INSTRUMENT ENGINEERING, METROLOGY AND INFORMATION MEASURING EQUIPMENT AND SYSTEMS**

**V. A. Arzhanov, A. A. Belousov, D. V. Sapozhnikov, D. V. Fedorov**  
**Ultra-wide band analog communication line of microwave range**

There is considered creation of ultra wide band analog communication links using microwave range of methods and tools of radio photonics. The characteristics of analog fiber-optic communication lines (fiber optic) are presented. There is shown the implementation of specialized analog of fiber optic link.

Keywords: analog transmission line analog signal, FOL, laser, microwave.

**M. E. Osinkina, V. P. Kismereshkin**  
**Some questions of design of printed circuit boards**

The method of electronic designing providing shielding of the alarm conductor with the inside continuous metallized potential layer in the multilayered printed circuit board is considered. Calculation of efficiency of shielding for magnetic is made, electric and electromagnetic water in the multilayered printed circuit board.

Keywords: shielding, efficiency of shielding, multilayered printed circuit board, potential layer, magnetic field, electric field, electromagnetic field.

**M. E. Osinkina, V. P. Kismereshkin**  
**About technological coatings when developing printed circuit boards**

The article discusses the impact of technological coatings on the impedance of printed circuit boards containing the microstrip transmission line. There is calculated the error of performance of wave resistance taking into account technological coatings.

Keywords: technological covering, printed circuit board, wave resistance, microstrip line.

**I. S. Kudryavtseva**  
**Method of evaluation of characteristic function statistical properties**

Determination of numerical values of facilities under condition monitoring with characteristic function parameters is an urgent task. The paper is aimed at developing the method of calculating the theoretical distribution function by the experimental data. I propose a method of constructing the empirical and theoretical distribution functions and of the density probabilities of the characteristic function's parameters of instant values of vibro-acoustic signal, that had been calculated for the different states of the diagnosed facility. The approximation validity estimation is carried out by calculating the multiple determination coefficient. These formulas of theoretical distribution functions of module characteristic function for various technical state of the facility and different parameters of characteristic function values allow the statistical methods of decision-making to calculate numerical criteria for assessing the state of facilities by the characteristic function parameters. These results were obtained for the first time in formation of the defining criteria of faults by the characteristic function parameters.

Keywords: characteristic function, diagnostics, technical condition, diagnostic feature, vibro-acoustic signal.

**INFORMATION TECHNOLOGY**

**V. N. Zadorozhnyi, T. R. Zakharenkova**  
**Minimizing the risk of lost messages in networks with fractal traffic**

The problem of improving the quality of information service in telecommunication networks with fractal traffic is considered. The research aims to develop techniques providing a low probability of message loss. The problem of optimal configuration of networks with fractal traffic is formulated and solved in terms of queueing theory. To solve this problem the necessary theoretical analysis is conducted and the simulation experiments are carried out. The effective method of optimal channel distribution over network nodes is provided. The application example of the developed method is given.

Keywords: telecommunication networks, queueing theory, fractal traffic, structural optimization.

**A. A. Kolokolov, A. V. Artemova, A. V. Adeshin, I. E. Kan**  
**Complex products design on base of models and algorithms of discrete optimization**

The article presents the continuation of the development and research of models and algorithms of discrete optimization with logical, resource and other constraints for complex products design. These models are based on the MAX-SAT problem and its generalizations. Particular attention is paid to the questions of design of series of products using special constructions («kernels»). The results of computational experiments that point at the prospects of the approach are presented.

Keywords: discrete optimization, integer programming, maximum satisfiability problem, logical constraints, computer-aided design of complex products, consumer goods industry.

**V. I. Potapov, O. A. Gorn**  
**Mathematical models and software system for analysis of functional readiness of dynamic system of man-machine in conflict situation**

The task is targeted and there are developed mathematical models to calculate the operational readiness of the technical system with its preparation for confrontation in a conflict situation and restoring health after the failure of components in the process of confrontation with the ultimate reliability of preparation and recovery taking into account the human operator reliability. A software package for the numerical solution of the problem is developed. The technical system is considered as the man-machine complex taking into account the human factors (errors and failures of the human operator).

Keywords: mathematical model, a conflict situation, a human operator, confrontation, software system, man-machine dynamic system.

**V. I. Potapov, O. A. Gorn**  
**Mathematical model and method of solution of software for search and research the optimal strategy of behavior in conflict situations of two dynamic systems**

The task is targeted and developed a mathematical model and numerical algorithm of confrontation between two dynamic, restored after the failure, hardware-redundant technical systems involved in a conflict situation, subject to the limitation on the resources of offense and defense, and system setup time, after the failure of the corresponding block and replace it with a serviceable. There is designed convenient for practical use software to solve this problem on your personal computer, which is reduced to a differential game between the two conflicting systems. The program allows you to explore and find the optimal strategy of behavior of the opposing dynamic systems in the process of conflict.

Keywords: mathematical model, numerical method, the conflict situation, the confrontation, the software.

**V. N. Ivanov, A. V. Ivanov**  
**The concept of evolution of systems of the Internet of things**

The increasing place in society life is occupied with systems of the things united by means of the Internet. The quantity and possibilities of such systems is rapidly growing, and modern technological possibilities allow drawing a conclusion that this growth will not stop in the near future. In the article the concept of the development of systems of Internet of things is stated, the primary goals of a society in this sphere and the ways of overcoming of the outlined problems of development, both from the acceptance of such systems by consumers, and the choice of directions of new workings-out from manufacturers, are revealed. The special attention is given to the psychological aspects of human life and a society in the environment changed by such systems. Stages of the development of systems of Internet of things are resulted. On the basis of the analysis of these stages, one of the basic directions of the further development is seen the increase in the systems based on network use of things that transform the material world. Possibility of mass remote use such devices in the near future puts before a society a number of questions, reflected in this article, to answer on which it is necessary already today.

Keywords: Internet of things, the development of gadgets, information system, remote control, consumer preferences.

**O. V. Batenkina**  
**Methods of user's satisfaction testing for assessment of usability of information systems**

User satisfaction is an important characteristic of the quality of software products, the measurement of which is a complex process due to the lack of standardized methods to assess it. The article presents the methods used in the process of usability testing to evaluate user satisfaction, as well as the example of the developed tests, suitable for testing user satisfaction when working with websites. The use of these tasks provides a multicomponent evaluation of user satisfaction with the interface of websites.

Keywords: Usability testing, user satisfaction, testing methods of satisfaction of information systems, website.

**R. H. Zaripova, M. N. Rasskazova, B. I. Starikov**  
**Using EPC-diagrams for modeling business processes, production and marketing activities of small enterprises garment industry**

There are built and analyzed models of business processes of small clothing enterprises in solving production problems under uncertainty. For model development we used EPC notation. Built models allow in future to conduct simulation experiment to study business processes in dynamics.

Keywords: process approach, analysis of business processes, the EPC notation, functional diagram, production services, garment enterprise.

**D. V. Kalekin, A. P. Zagorodnikov, V. S. Kalekin**  
**A software tool for design of piston engines and aggregates**

The paper presents a modular approach to mathematical modeling of reciprocating machines using specially developed for this purpose software tool. In contrast to the previously created computational analogues for reciprocating compressors, the proposed software tool can be used in the design and creation of designs not only compressors and air motors, expanders and aggregates based on them, because it allows you to simulate and calculate both stationary and non-stationary work processes piston machines, the dynamics of their motion mechanisms to conduct multi-factor optimization.

Keywords: mathematical model, software tool, piston machine, air motor, automatic valve, multi-factor optimization.

**A. D. Kushnerov, Shmuel (Sam) Ben-Yaakov**  
**Unified algebraic synthesis of generalized Fibonacci switched capacitor converters**

A unified algebraic approach to the synthesis of generalized Fibonacci switched capacitor converters (SCC) has been developed. The proposed approach reduces the power losses by increasing the number of target voltages. It is shown that the binary and Fibonacci SCC are special cases of the proposed approach. Furthermore, the proposed generalized SCC is built around the same switch network as the binary and Fibonacci SCC. This feature is extremely beneficial, since it provides the option of switching between the different target voltages, thereby increasing the resolution of attainable conversion ratios. In the case of three flying capacitors, six new conversion ratios were introduced, in addition to the 13 that had already been realized. The theoretical results were verified experimentally.

Keywords: charge pumps, circuit topology, DC-DC power converters, energy efficiency, switched capacitor circuits.

**A. S. Shchegoleva, E. T. Gegechkori**  
**The role of information technologies in conduct of business process reengineering**

Currently, new technologies are being created every day, more sophisticated, more complex to understand. Business interacts directly with the new information technologies. Every company has its own IT service department. Business owners have become, increasingly, wondering how to increase the efficiency of IT services. The latter applies effective methods of management tools — business process reengineering (BPR).

Keywords: reengineering, process approach, business processes, project.