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# HEAT AND POWER ENGINEERING

UDK 621.321

## WATER-CHEMICAL REGIME IMPROVEMENT OF THERMAL POWER PLANTS OF MEDIUM PRESSURE

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### Abstract

**Background:** Systems of water-chemical regimes in steam boilers at most thermal power plants with medium pressure cannot get steam with pH25 lower than 7,5 and exclude parking and operational corrosion of return condensate pipelines. Systems of chemical-engineering monitoring of these thermal power plants do not have effective diagnostic capabilities. It is possible to reduce corrosion corrosiveness of return condensate by means of water treatment facilities (ionite filters, deaerators).

**Materials and methods:** The laboratory research results of Purolite C104 and C 100 cationites as well as the data of industrial experiments are used.

**Results:** The quality influence of source water and regeneration conditions of co-flow dual-layer filters, which are full of Purolite C104 cationite and strong acidic Purolite C100 cationite, on the acids and salts and the filtrate quality unit discharges are researched. The authors proved that two-phase decarbonization of H/Na-cationite water or the equipment of DA-50 deaerator tank with submersible barbotage device is necessary. The authors define the necessity conditions for deaeration of return condensate of steam consumers. The possibility of indirect operational control of the corrosion rate of condensate pipeline on the basis of oxygen meters is shown.

**Conclusions:** The obtained results can be used to improve water-chemical regimes of thermal power plants with medium pressure and to increase the diagnostic capabilities of the system of chemical-engineering monitoring.

**Key words:** thermal power plant, water-chemical regime, water treatment, carboxyl cationite, deaeration, corrosion, oxygen meter.

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UDK 621.165

## MATHEMATICAL MODEL OF IONIC EQUILIBRIA OF BOILER WATER IN DRUM BOILER

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### Abstract

**Background:** Reliability, economy, and operation safety of power-generating units at thermal power plants significantly depend on the state of water chemical regime, which is standardized by the operational regulations and other normative documents. Decreasing acceptable phosphate excesses, specified in the 15th edition of Operation Rules, requires reliable monitoring, especially automated one.

**Materials and methods:** Laboratory and industrial experiments are held to confirm the calculations accuracy of the mathematical model of ionic equilibria of boiler water in drum boiler.

**Results:** The generalized mathematical model for ionic equilibria of water heat carrier is proposed. The particular cases of its solution for demineralized water, feed water, and boiler water are considered. It is shown that the proposed method allows to define indirectly the concentrations of standardized ionic impurities according to the normal devices of chemical control: conductometers and pH meters.

**Conclusions:** The developed mathematical models can be used as a part of the mathematical support of chemical-technological monitoring systems and allow to diagnose the deviations of the normal water chemical regime at an early stage of their development.

**Key words:** feed water, boiler water, conductivity, ionic equilibria of water, automated monitoring.

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UDK 621

## POWER TECHNOLOGICAL SYSTEM IMPROVEMENT OF EXTRACTIVE PHOSPHORIC ACID PRODUCTION

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#### Abstract

**Background:** Problems of energy saving are actual for all industries, housing, and communal services. One of the solutions to the energy-saving problem in industry is the usage of gravity forces on the basis of smooth-bore thermal pipes (thermosyphons) instead of pumps with the electric drive, which transport the intermediate heat carriers.

**Materials and methods:** Evaluation of energy losses in production of extractive phosphoric acid is made on the basis of thermal balance.

**Results:** In this article the power technological system of production of extraction phosphoric acid (ERA) is considered. The new power technological system with effective using of the regeneration process and secondary heat power resources (SHPR) is developed.

**Conclusions:** The complete thermodynamic analysis of all lines of energetic transformations, from the basic raw materials till the final product by ERA production, shows the considerable possibilities to reduce fuel and energy resources (PFR) on the basis of intensification of technological processes and improvement of thermal diagrams. The comparative analysis of thermodynamic efficiency of the initial and the developed power technological systems showed that 9,5 MW of the extracted heat and 15,65 MW of heat with secondary steam from the evaporating device can be efficiently used in the heat supply system at a factory.

**Key words:** energy saving, power technological system, thermal diagrams, heat losses, thermosyphon, regenerative and external thermal using, efficiency of power usage, energy resources economy.

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# ELECTRICAL POWER ENGINEERING

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UDK 111.111

## ALGORITHM RESEARCH OF BLOCKING EQUIPMENT OF RELAY PROTECTION WHILE SWINGING

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### Abstract

**Background:** Blocking equipment while swinging is the important functional part of the relay protection devices. It provides the right devices functioning in external and internal faults accompanied with synchronous swingings in the electric power system. Microprocessor-based data and modern methods of digital signal processing give the opportunities to improve the present algorithms of relay protection blocking while swingings. The most effective method to research the blocking algorithms with swingings and to explain the settings of the starting units is the computer simulation method.

**Materials and methods:** Researches the blocking algorithms with swingings are held on the basis of mathematical models, developed in the Mathcad environment.

**Results:** The mathematical model for analyzing the swinging regimes in the electrical engineering system as well as for researching blocking algorithms for relay protection devices while synchronous swingings is developed. According to the results of the mathematical simulation the meanings of misbalance coefficients, characterizing the blocking sensitivity while swingings and further analyses were received.

**Conclusions:** The usage of the received results allows to enhance sensitivity and promptitude of blocking starting units in emergency conditions (short faults), as well as stability of failures in regimes without short faults but with synchronous swingings.

**Key words:** electrical engineering systems, swingings, relay protection, blocking equipment while swinging, emergency components, coefficient of misbalance, computer simulation.

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UDK 621.311.004.13

## INNOVATIVE APPROACH TO SOLVING REGIME PROBLEMS IN MANAGING ELECTRIC POWER SYSTEMS

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### Abstract

**Background:** EPS Mode control is an important task and the technological efficiency of energy companies depends on the principles and methods of its solution.

**Materials and methods:** Solution to regime problems are based on three main blocks: methodology, simulation and research methods which widely use the modern computer technologies allowing to create intelligent systems of planning regimes.

**Results:** The theoretical foundations of control problems of normal modes of power engineering system are suggested. Their application allows to increase the efficiency of power engineering industrial enterprises according to the power engineering market in Russia.

**Conclusions:** Numerical experiments on the test and practical examples for the working power engineering enterprises showed the appropriateness of scientific statements presented for solving application tasks.

**Key words:** management, methodology, cybernetic methods, intellectual computer systems, operational planning.

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# ELECTROMECHANICS

UDK 621.538

## USAGE OF MAGNETIC FIELD EDGE ENERGY FOR INCREASING MAGNETIC SYSTEMS EFFICIENCY OF ELECTROMECHANICAL DEVICES

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### Abstract

**Background:** At the present time the edge effect is not taken into account when the magnetic systems of electromechanical devices are designed. The edge energy redistribution of the magnetic field of poles allows to increase the efficiency and technical and economical indicators of most part of produced electromechanical devices. Near the poles edges of the magnetic systems of electromechanical devices there are areas with high density of magnetic field energy. As a rule, magnetic energy of these areas is not used in operation of electromechanical devices, that is why it should be redistributed by means of increasing the device net energy.

**Materials and Methods:** The mathematical simulation method of magnetic field of magnetic system based on the finite elements method is used to calculate the parameters and describe the distribution scheme of magnetic field of magnetic system in the angle-data transmitter of dynamically adjusted gyroscope.

**Results:** The author estimates the size of the edge effect in magnetic field of the specific electromechanical device. The influence of the edge effect on the device operation is analyzed. The author proves that it is necessary to account it at the designing stage of the device.

**Conclusions:** According to the numerical experiments it was proved that specific energy of magnetic field near the poles edge can exceed the average specific energy of field of the specific gap of the gyroscope magnetic system. The poles edge curving allows to decrease the edge energy of magnetic field and to redistribute it in favour of the specific gap energy. The increasing of the operational magnetic flow of the examined gyroscope by 4,8 % is received.

**Key words:** edge effect, the magnetic field energy, mathematical simulation, finite element method.

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UDK 621.7.06

## RESEARCH OF PARTICLE INTERACTIONS IN MAGNETIC FIELD OF OPERATING SPACE OF MAGNETOABRASIVE DEVICE

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### Abstract

**Background:** The calculation method of particle interactions in magnetic field is necessary because of two reasons. First of all, while the magnetic tumbling the parts polishing is possible because of the impact of filler, moving with magnetic field, and workpieces. The magnetic

field as a means of operating effort transmission allows to control the filler flow, which moves in accordance with the configuration of the magnetic field induced by the permanent magnets. Therefore, a method for calculating the interaction of particles in the magnetic field.

**Materials and methods:** The authors apply the method of mathematical simulation of the magnetic field on the basis of the finite element method. The magnetic field around the filler particles and the workpiece are studied.

**Results:** The article describes the general structure and the principle of magnetic tumbling. The description of particle interaction of tumbling filler and a permanent magnet with magnetic tumbling is given. The calculation method of the interaction net force of the magnet on the filler particles is presented.

**Conclusions:** The presented calculation method of particle interactions in magnetic field allows to determine not only the direction of the magnetic interaction vector in the system of permanent magnet – particle of the tumbling filler, but also its module, the trajectory of a particle movement in the working volume of magnetoabrasive device, the volume of filler and filler efficiency on the operational surface of details.

**Key words:** tumbling, magnet tumbling, filler particle, permanent magnet.

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UDK 621.928

## RESEARCH OF ENERGY FLOWS FORMATION AND RATE OF MATERIAL WEAR WHILE BEING GROUND

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#### Abstract

**Background:** The materials being ground by means of attrition is traditionally designed separately from particles motion. However, it is the character of particles motion that determines the power supply towards the disturbing material.

**Materials and methods:** In order to describe the processes of particle motion, energy transfer and grinding of materials it is proposed to use the Boltzmann kinetic equation.

**Results:** A mathematical model of particles motion, energy transfer and size reduction in particle grinding by attrition based on the Boltzmann equation is developed.

**Conclusions:** Comparison of experimental and calculated data demonstrated the adequate description with the help of real process model.

**Key words:** particles motion, energy exchange, attrition, Boltzmann equation.

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UDK 621.313.8

## ANALYZING WAYS AND METHODS TO DECREASE EXTERNAL ELECTROMAGNETIC FIELDS OF INDUCTION MOTORS WITH SUPPLYING OF PULSE-WIDTH MODULATED VOLTAGE

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### Abstract

**Background:** It is reasonable to develop and numerically evaluate the ways and methods for decreasing the external electromagnetic fields of the induction motors because of the fact that the external fields of induction motors with supplying of pulse-width modulated voltage, which contain high frequency parts and influence negatively on the staff health as well as impair the electromagnetic operation compatibility of electrical and technical equipment, are studied not enough.

**Materials and methods:** The authors used the ways of motors parts shielding, magnetic shunts, methods of mutual compensation of external electromagnetic fields of induction motors group by the corresponding placement of motors and their phasing. For numerical evaluation the finite element simulation of electromagnetic fields is used.

**Results:** The external electromagnetic fields of the induction motors with supplying of pulse-width, modulated voltage, which contain high frequency parts, are researched.

**Conclusions:** It is revealed that at spatial triangular placement of motors the external magnetic field in the center decreases to two times, at optimum phasing of three-phase motors located in the line, the field intensity decreases by 30 %, when shielding the front parts of a stator winding the intensity of the external magnetic field of induction motors can be lowered by 50 %.

**Key words:** external electromagnetic fields, induction motors, pulse-width modulated voltage, electromagnetic compatibility.

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# METHODS OF MATHEMATICAL SIMULATION

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## MATHEMATICAL MODEL DESIGNING OF STEADY STATE MODE OF POWER ENGINEERING SYSTEM

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### Abstract

**Background:** The existing calculation methods of steady-state mode, based on solving the system of nonlinear equations by using the iteration method in case of analysis of an electric power system, differ by very big volume of produced computing and significant costs of computer time.

**Materials and methods:** Designing the mathematical model for the calculation of the possible set mode is based on the Z form of accordance task of a network and reservation restriction type of inequalities, imposed on the modules of voltage and reactive powers of the independent station knots.

**Results:** The mathematical model for the analysis of the possible set mode in the large electro-power system is offered. Recommendations on the mutual transition from the station knots of  $P-U$  type to the  $P-Q$  station knots and back, providing accordance of the voltage modules and reactive powers of the possible limits, turned to the proper achievement of the possible set mode of the electro-power system.

**Conclusions:** The usage of the offered model helps to diminish the number of iterations and to increase the convergence when solving the equalizations system, describing the set mode in the electric power system.

**Key words:** model, capacity, parameter, station, knot, matrix, loading.

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## SHEAR STRESS CALCULATION ON WALL IN GAS-LIQUID MEDIA

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### Abstract

**Background:** At the present time the shear stress in the flows with two-phase media is calculated experimentally or by using the semiempirical expressions. As a result, it is important to develop the theoretical approaches on the basis of the mathematical models and equalizations of friction velocity (shear stress) in the channels in dependence of gas velocity, liquid and gas content for calculating two-phase media.

**Materials and Methods:** Dynamic velocity is calculated by using the average flow velocity, dissipation of energy and the momentum transfer coefficients.

**Results:** Different mathematical methods to calculate dynamic friction velocity (shear stress) in two-phase system liquid-gas depending on liquid and gas concentrations and gas velocity are overviewed.

**Conclusions:** It is shown that the best agreement with the experimental data is obtained from the method used the thickness of the boundary layer and the coefficient of the momentum transfer. The above mathematical models give results which agree well with the experimental data, and can, therefore, be used in engineering calculations.

**Key words:** dynamic speed, energy dissipation, the coefficient of momentum transfer, the thickness of the boundary layer.

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UDK 614.8

## CALCULATION METHOD OF PREFERENCE PARAMETERS OF ACTION VERSIONS FOR DISASTER RESPONSE ON POTENTIALLY DANGEROUS OBJECTS

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#### Abstract

**Background:** The actions control system for disaster response on potentially hazardous installations (power plants) including the power engineering units aims to achieve several goals simultaneously, and therefore it is difficult. Decision-making process in such case is based on consideration of several efficiency indicators that characterize the achievement degree of specific objectives by the management system. Therefore, when developing options for emergency response to potentially dangerous objects it is necessary to use formal procedures for multi-criteria selection.

**Materials and Methods:** The methods of multicriteria optimization were used in the research.

**Results:** Based on a general mathematical model taking into account substantiated information about the relative importance of criteria in multi-criteria selection process the additive method of modification of the vector criterion for finding the best solution is developed.

**Conclusions:** The developed procedures in the multi-criteria selection are used on the planning stage for emergency response, as well as on the analysis stage of the disaster occurred with the aim of collecting operational information which is necessary for the effective usage of the units involved.

**Key words:** emergency, decision making, multicriteria optimization.

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## ECONOMICS

UDK 001.892

### LABORIOUSNESS ESTIMATION APPROACH OF RESEARCH, SCIENTIFIC AND DEVELOPMENT WORKS IN POWER ENGINEERING WITH FUZZY EXPERT JUDGMENTS

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#### Abstract

**Background:** The expert estimation problem of research, scientific and development works laboriousness in power engineering in consideration with its innovation components is actual for estimating costs of research projects.

**Materials and methods:** Expert judgments are expressed by linguistic variables. The mathematical apparatus of fuzzy set theory is used for this processing.

**Results:** Two methods of research and development project costs estimation in power engineering are described. The possibility of fuzzy logic application of implementation of expert approach to the problem is proved. The method of fuzzy expert judgments formation is proposed for estimation of complexity differences between a project under consideration and a benchmark project.

**Conclusions:** The proposed method allows to estimate costs of a research and development project in power engineering even in case of significant complexity differences compared to existing benchmarks.

**Key words:** scientific and research works, development works, laboriousness, fuzzy logic, expert judgments.

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### ORGANIZATION AND SEPARATE ACCOUNTING OF INCOMES AND EXPENSES ACCORDING TO ACTIVITY TYPES OF POWER ENGINEERING ENTERPRISES

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#### Abstract

**Background:** At the present time, there are many requirements on the organization and management of energy companies for separate accounting of income and expenses in terms of production and financial-economic activities. In the Russian Federation there are legal and sub-legal acts, long-term programs, which regulate the organization and management of separate accounting of income and expenses. They require the system generalization and analysis.

**Materials and methods:** The problem is analyzed on the basis of present legal and sublegal acts valued in the Russian Federation, long-term programs, which regulate the organization and management of separate accounting of income and expenses. They require the system generalization and analysis.

**Results:** The authors suggest the peculiarities of the organization of separate accounting of income and expenses in the conduct of economic activity by the energy complex enterprises. The article considers the positive and negative aspects of the implementation of this procedure.

**Conclusions:** The organization of qualified accounting of incomes and expenses makes it possible to achieve tax risks reduction, the requirements implementation of the existing laws, the implementation of company's disclosure policy and improvement the rating of investment attractiveness.

**Key words:** separate accounting of income and expenses, method of separate accounting, production and transfer of thermal energy, accounting policy of the organization, the rating of investment attractiveness.

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## STRUCTURIZATION AND AGGREGATION IN SYSTEM ANALYSIS OF TERRITORY RESOURCES SUPPLY

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#### Abstract

**Background:** It is necessary to consider a large number of objects and factors and existence of difficult structure of interactions and the interferences between them which have various physical and social and economic nature when administrative decisions on rational placement of the enterprises are accepted. It is connected with the considerable methodical and technological problems. Therefore, the existing techniques consider, as a rule, only some of the most essential factors that do not allow to solve the spatial tasks with sufficient accuracy.

**Materials and methods:** The system technology of determination of territory properties by means of models of spatial influence of objects is applied. The mathematical apparatus of the theory of sets is used for formation of logic structure of multiple-factor spatial model. Geomodelling methods are used for graphic interpretation of results.

**Results:** The technique based on the usage of library of functions of spatial influence and formation on their basis of models of spatial influence is offered.

**Conclusions:** The concretion and accuracy of the spatial analysis, and its practical value considerably increase as a result of application of this technique. It can be defined not only the general condition of the territory, but also a contribution of separate components to resource security of the territory (for example, power security, transport availability, etc.) when using offered technology of modeling.

**Key words:** system technology of an assessment of territory properties, geomodelling, spatial analysis, functions of spatial influence.

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## PECULIARITIES AND MANAGEMENT PROBLEMS OF HEAT-POWER ENGINEERING IN IVANOVO REGION

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### Abstract

**Background:** Heat supply is one of the most important social processes of population sustenance and the most fuel capacity sector of the region economy. Heating supply questions in Ivanovo region is not sufficiently developed.

**Materials and methods:** The methods of system analysis and statistical processing of data are used. Review of the problems of heat and power engineering in Ivanovo region with the analysis of statistical data are presented.

**Results:** The author considers the peculiarities, problems of functioning and heat supply system control in Ivanovo region as well as the serious delay of the regulatory system which define the permissions of the constituents of the Russian Federation in the engineering field; unsolved issues of separation powers and responsibilities of the owners, managers and staff in heat power engineering; low qualification of the staff and absence of quality systems.

**Conclusions:** The identified problems require intent attention for a number of actions to improve the state of the heat supply system in Ivanovo region.

**Key words:** heat power engineering, heat supply, region, thermal energy, heat power engineering system of a region.

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