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# HEAT AND POWER ENGINEERING

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УДК 621.187

## FOUNDATIONS FOR USING EMPIRICAL PARAMETERS AND CALCULATION ALGORITHM OF MATHEMATICAL MODEL OF BOILER WATER

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### Abstract

**Background:** The necessities of optimizing chemical control of water heat carrier of power-generating unit at thermal power-stations, including stations with drum boilers, decreasing the volume of human operational monitoring and increasing integrity and information capacity of the most reliable automatic devices such as conductometer and pH-meters, are the most urgent problems in power engineering. The development of a new method of automatic chemical monitoring is carried out by means of the simplified mathematical model of ion equilibria.

**Materials and Methods:** Laboratory and full-scale experiment were carried out to prove out the calculation accuracy of the mathematical model of ion equilibria of boiler water in salt box of extreme pressure drum boiler.

**Results:** Grounds for using empirical parameters and calculation algorithm of mathematical model of boiler water of extreme pressure drum boiler were presented. Block scheme of the calculation algorithm of ionic contaminant concentration of feed and boiler water was presented. The estimation of empirical parameters influence on the calculation of phosphates concentration of boiler water in salt box was made.

**Conclusions:** The developed algorithm allows to calculate the concentration of phosphates in boiler water within the limits of tolerate error according to the measurements of specific conductivity of the cooled hydrogen ion polishing samples of feed water and boiler water of salt box.

**Key words:** feed water, boiler water, electroconductivity, phosphates, automatic monitoring, algorithm, mathematical model.

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УДК 621.311.22

## ON THERMAL EFFICIENCY USE OF EXHAUST GASES OF RECOVERY BOILER WHEN BURNING ADDITIONAL FUEL

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### Abstract

**Background:** At present the principle of possibility and advisability of using the exhaust gases recovery boiler as an oxidant to burn additional fuel is considered. It is necessary to assess the effectiveness of combined cycle gas turbine in these conditions.

**Materials and methods:** The development of dependency is made on the basis of technical documentation for combined-cycle gas turbine and the calculation of boilers.

**Results:** With the usage of correlations conditions for effective use as an oxidizer the exhaust gases recovery boiler by burning additional fuel for it are defined. We received the equations that allow, depending on the additional fuel consumption, excess air ratio and the efficiency of gas turbine, to calculate the values of the boundary value temperatures for the gases recovery boiler, specific heat gas-water heat exchanger and the possibility of increasing the efficiency of power units.

**Conclusions:** The obtained dependences allow not only to quickly determine the regime characteristics of the combustion chamber the additional fuel and gas-water heat exchanger after recovery boiler, but also to predict their changes in the deviation of the initial conditions gas turbine.

**Key words:** combustion chamber of additional fuel, excess air ratio, the relative consumption of additional fuel.

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## EVOLUTION OF HEAT AND MASS TRANSFER INTERPHASE SURFACE IN BUBBLING LAYER

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### Abstract

**Background:** The processes of gas flow and heat transfer in the liquid bubbling layer are traditionally considered separately, although their mutual influence is of great significance.

**Materials and methods:** The authors propose the Boltzmann equation to describe the processes of heat and mass transfer in bubble stage.

**Results:** The authors present the mathematical model of motion, and heat and mass transfer based on the Boltzmann equation and numerical solution to the equation.

**Conclusions:** The authors propose a new approach for modeling the combined processes of heat and mass transfer in the liquid bubbling layer.

**Key words:** interphase surface, heat and mass transfer, evolution of the surface, the Boltzmann equation.

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# ELECTRICAL POWER ENGINEERING

УДК 621.321

## INFLUENCE OF CAPACITY BASIC INSULATION AND VOLTAGE OF TRANSFORMER ON STATISTICAL PERFORMANCES OF OIL CHANNELS ELECTRICAL STRENGTH

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### Abstract

**Background:** Nowadays to choose a basic insulation of transformer we have to take into account the dependence of oil channel electrical strength on its width. Specialists are discussing issues concerning basic insulation choosing with account of summarized factor – volume of oil channel. Solution to this problem depends in many respects on the level of knowledge of statistical performances of oil channels electrical strength with different volumes; and also the influence of nominal parameters of transformer on it.

**Materials and methods:** A statistical model of evaluation of channels electrical strength performances with different volumes of transformer oil was used. To define oil volume in oil channels under voltage we used transformer constructive and electroinsulating parameters computational techniques.

**Results:** We suggested an evaluation technique of transformer oil volume changing in power high-voltage transformers basic insulation oil channels under voltage and electrical strength statistical performances of these channels with account of influence of capacity nominal parameters and transformers voltage. It was shown that degree of transformers technical performances influence on oil channels electrical strength statistical performances depends on the quality of transformer oil, which may change in different operation conditions.

**Conclusions:** It is proved, that the suggested technique may be used in the process of choosing parameters of basic insulation oil channels under voltage with account of transformer capacity and voltage nominal parameters influence.

**Key words:** transformer, transformer oil, oil channel, electrical strength, statistical performances.

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## CALCULATION OF IMPACT ACCELERATION WAVE PROCESSES IN EXTENDED EARTH LEAD AND SUBSURFACE PIPE LINES

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### Abstract

**Background:** Pulse current in earth leads and pipe lines appearing on discharge of atmospheric and frictional electricity, in transit mode of short-circuit in groundable circuit, while testing equipment with the use of magnetic cumulation generator and in a number of other situations create powerful electromagnetic and thermal fields which are of great interest in connection with problems of electrophysics and thermophysics, lightning protector of electromagnetic compatibility. Methods of position fixing diagnostics of points of fault in aerial and cable power network are based on the usage of weak current impulses.

**Materials and Methods:** The method of current and voltage allocation frequencies calculation in extended earth leads and pipe lines run in low conducting medium exposed to impulsive voltage and current is discussed. This method is based on the usage of frequency response characteristics obtained when calculating electromagnetic fields of earth leads in mode of simple harmonic current flow. A method of impulse parameters and wave processes calculation in extended objects is offered.

**Results:** Mathematical model of wave process in earth leads and pipe lines exposed to current impulse and voltage allowing to perform adequate calculation of input parameters and characteristics of these objects in impulse mode as well as current and voltage distribution longways is offered without falling back on the usage of some other essential simplifying assumptions.

**Conclusions:** In reference to media and objects with non-linear characteristics (leader lightning channel during wave propagation of general discharge, coronated wire or wire of power transmission lines in pulse conditions, earth lead, during sparkover of ground) the suggested mathematical model of wave process in earth leads and pipe lines exposed to current impulse and voltage can be used to obtain quite reliable evaluation results supposing further clarification in the course of the following iterations.

**Key words:** earth lead, pipe line, conducting medium, pulse current, frequency response curve, wave process.

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## INFLUENCE OF HYDRODYNAMIC MODE ON AIR SOLUBILITY IN TRANSFORMER OIL WITH OR WITHOUT SULPHUROUS CONNECTIONS

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### Abstract

**Background:** The main problem of modern power supply systems is an extension of operation terms of transformer oil in the equipment the operability of which depends on oil hydrocarbonic composition and on air concentration in it.

**Materials and methods:** The influence of hydrodynamic mode of air supply in oils of various hydrocarbonic structure on the amount of absorbed air with or without individual and oil sulphurous connections was studied.

**Results:** The influence of hydrodynamic mode on the amount of absorbed air by transformer oil with various content of aromatic hydrocarbons with or without sulphurous connections was considered. It is found that air absorption by oil under identical conditions with 0,5 per cent of individual and oil sulphurous connections proceeds more slowly than without them.

**Conclusions:** It is established that the application of bubbling and convective ways of air supply is equivalent and differs only in saturation time, both with and without sulphurous connections. This circumstance allows to reduce the speed of oil aging as the air belongs to the main catalysts accelerating oil aging in transformers.

**Key words:** transformer oil, air concentration in oil, hydrodynamic mode, sulphurous connections, bubbling and convective ways of air supply, air solubilization in oil.

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# ELECTROMECHANICS

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## DEVELOPMENT OF DYNAMIC MODEL OF ASYNCHRONOUS MACHINE WITH THE USE OF FINITE-ELEMENT CALCULATION RESULTS

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### Abstract

**Background:** Technology development of parallel computing techniques give a rebirth of the numerical experiment, in particular, methods for calculating the processes in electromechanical devices using a combined model that combines the calculation of the magnetic field and electric circuit. This allows you to use the results of the finite-element calculation of the quasi-stationary magnetic field for the simulation of transient processes in electromechanical devices.

**Materials and methods:** To calculate the magnetic field in the asynchronous machine is used finite element method. To calculate the dynamic modes of the induction motor used in a method of loop currents.

**Results:** Consider using the results of finite element calculation of the magnetic field to simulate the transients in the asynchronous machine. From those of field methods for calculating the dynamics of induction machines this method of performance is different.

**Conclusions:** The developed method of dynamic simulation of the asynchronous machine promotes calculation accuracy typical for field models at calculation speed that is equivalent to calculation speed of chain models, and can be used to simulate electric drive with the integrated electric machine of unconventional construction.

**Key words:** CAD, asynchronous engine, finite element model, dynamic model.

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УДК 621.538

## STUDY OF FRICTION TORQUES IN SPECIFIC GAP OF SEALERS WHEN USING DIFFERENT TYPES OF MAGNETIC FLUIDS

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### Abstract

**Background:** Nowadays when designing magnetic systems of electromechanical units with different undulation levels of the surfaces contacting with magnetic fluid of different types, the influence of this characteristic on friction torques of magnetic fluid unit is not taken into account.

**Materials and Methods:** the research was done by using the parts which form the specific gap of the magnetic fluid unit, made from different types of steel with the different undulation levels and contacting with magnetic fluid of different types. The study was made on the base of a special unit.

**Results:** In the result of the experiment it was determined that friction torque of magnetic fluid units depends on the undulation level of polar terminal and sleeve contacting with magnetic fluid of different types.

**Conclusions:** Using sleeves with the low undulation level in specific gap allows to increase the effectiveness and technical-and-economical indexes of most part of produced magnetic fluid units.

**Key words:** undulation level, magnetic field energy, friction torques, magnetic fluid unit.

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## PARAMETRIC MODEL OF INDUCTION MACHINE WITH SOLID ROTOR IN TRANSIENT REGIMES

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### Abstract

**Background:** At the present time, given the trend of development object-oriented electro-mechanical systems, there are considerable practical and scientific interest in the induction motor with solid rotor, which determines the relevance of research related to the development of tools and techniques for the design and study of such machines.

**Materials and methods:** When developing a parametric model of an induction motor with solid rotor using the classical theory of transients in induction machines. To test the adequacy of the parametric model used a model based on finite element modeling of electromagnetic fields.

**Results:** A simple parametric mathematical model of the induction motor with massive rotor in steady-state and transitional regimes was developed. The calculation results were put in correspondence with field model.

**Conclusions:** The developed model allows to quickly and qualitatively evaluate steady-state and transitional regimes of the induction motor with massive rotor under different working conditions including abnormal ones.

**Key words:** mathematical model, induction motor, massive rotor, parametric model, the field model.

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УДК 621.7.06

## STUDY OF MAGNETIC TUMBLING PROCESS IN MAGNETIC ABRASIVE UNIT

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### Abstract

**Background:** Existed constructions of magnetic abrasive units do not allow to perform their reconstruction by using the way of changing the location of permanent magnets on the surface of the spinning disk and on the frame.

It is necessary to develop new constructions of these units and to study the process of polishing these parts.

**Materials and methods:** while polishing the parts magnetic fields produced by means of permanent magnets of different configuration made from different materials, and of metal-cutting compound of different structure, are used.

**Results:** general structure of the unit and the principle of magnet tumbling of parts are considered in the article. The results of finishing treatment of the parts from non-ferrous metals are given.

**Conclusions:** the given method of finishing treatment of the parts from non-ferrous metals allows to greatly improve the quality of their surfaces.

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

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# AUTOMATION CONTROL SYSTEMS

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## ANALYSIS OF SIGNAL DEFORMATION IN OUTPUT OF DIGITAL VOLTAGE REGULATOR

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### Abstract

**Background:** The currently applied methods of thyristor voltage regulation make a major distortion in the electrical network.

**Materials and methods:** The waveform simulation in output of the voltage regulator and the calculation of its spectral composition in the MatLab programming environment.

**Results:** The analysis of signal deformation as a result of different methods of effective voltage regulation was performed. The regulators designed on the basis of sectionalized transformers were considered. The dependence of deformations coefficient with the regulator parameters and features of control was given.

**Conclusions:** The obtained characteristics are reasonable to be applied in the design of voltage regulators with controlled spectral composition.

**Key words:** deformation coefficient, effective voltage, control, pulse duration modulation.

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УДК 621.313

## RESEARCH OF THEORETICAL MODEL OF SELF-EXCITED ASYNCHRONOUS MACHINE

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### Abstract

**Background:** Most modern variable-speed induction motor drives are working in conditions when the machine is running as a generator. These modes are poorly studied. For an accurate assessment it is necessary to clarify the known theoretical self-excited models and to make their comparative analysis with the real object.

**Materials and methods:** The theoretical model is based on common base of two-phase induction motor model with the introduction of the system of equations for a capacitor that is connected to the stator winding and the magnetization curve, which is obtained by the experimental method.

**Results:** The results of numerical and physical modeling showed that the model describes the dynamic and static modes of self-excitation of induction machine with reasonable accuracy.

**Conclusions:** it has been proved that for generative modes of the asynchronous electric drive the basic two-phase model of the asynchronous machine can be used.

**Key words:** self-excitation of asynchronous machine, asynchronous machine.

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# METHODS OF MATHEMATICAL SIMULATION

УДК 621.929

## CELL MODEL OF LIQUID DIFFUSION IN POROUS BODY SUBMERGING INTO IT

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### Abstract

**Background:** The problem in question can be used, for example, for calculation of absorption of the oil film from water surface by porous granules after escape of oil. Its physical essence is diffusion of impurity into a porous body, which is submerging into the liquid while it absorbs the liquid. Analytical calculation of the process kinetics is impossible as the boundary conditions are non-linear and not steady-state. Therefore, the calculation is based on labor and time consuming experiments.

**Materials and methods:** The proposed mathematical model is based on the theory of Markov chains. The cross section of a porous body is presented as a two-dimensional array of cell, transition probabilities between which consist of probabilities of diffusion and convection transfer, and boundary conditions are set on the boundary that varies while the body is submerging into the liquid.

**Results:** A mathematical model of absorption of liquid by floating on its surface and submerging into it porous body is developed. The features of liquid absorption by a porous body and its submerging at different values of the Peclet number are found. It is shown that a submerging granule absorbs liquid faster than a stationary floating one.

**Conclusions:** The proposed model can be used as theoretical and calculated base to describe liquid film absorption by porous body from the clear water surface (for example, oil film in case of oil emergency discharge).

**Key words:** porous body, cell model, transition matrix, concentration distribution, kinetics of absorption, submerging into liquid.

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## OPTIMAL CONTROL OF INTERPHASE SURFACE IN BUBBLING STAGE OF ATMOSPHERIC DEAERATORS

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### Abstract

**Background:** The processes of gas flow motion, heat transfer and deaeration in a layer of bubbling liquid traditionally are considered separately, although their interference is of great significance.

**Materials and methods:** A new approach to combined description and optimization of heat and mass transfer and deaeration in a stage of bubbling based on the kinetic Boltzmann equation is proposed.

**Results:** A mathematical model of processes of heat and mass transfer and deaeration of water in a bubbling layer based on the Boltzmann equation is formulated, and the problem of optimal control of deaeration in bubbling stage is solved. A new approach to modeling combined processes of heat and mass transfer and deaeration is proposed.

**Conclusions:** The obtained results can be used to provide maximum energy saving in a stage of deaeration.

**Key words:** energy saving, deaeration, stage of bubbling, heat and mass transfer, the Boltzmann equation, optimal control, interphase surface.

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## MODELING OF HEAT EXCHANGE IN REACTORS WITH POLYDISPERSED FLUIDIZED BED

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### Abstract

**Background:** Calculation of fluidized bed boilers requires information of fuel particles and filling distribution over the bed height. Engineering calculation of fluidized bed must be based on mathematical models of the process that takes into account all basic features of fluidization on the one hand, and are simple enough to have a reasonable computational time, on the other hand. These requirements can be met by the models based on the theory of Markov chains, in which transitions probabilities must be agreed with the process physics. The objective of the study is to build such a model.

**Materials and methods:** The proposed mathematical model is based on the theory of Markov chains. A bed is presented as two parallel chains of cells. One chain is for description of particle motion, another one describes the upstream gas flow. If interphase heat exchange occurs, portions of heat are transferred between corresponding cells of the chains. This process is accompanied by longitudinal heat transitions along the chains.

**Results:** A mathematical model of fluidization of binary mixture of particles is proposed. The model allows calculating interphase heat exchange in the bed.

**Conclusions:** Regularities of interphase heat exchange in a fluidized bed that take into account non-homogeneity of different size fractions distribution over the bed height are found.

**Key words:** fluidized bed, binary mixture of particles, Markov chain, interphase heat exchange, convection transition, diffusion transition, concentration distribution, temperature distribution.

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# COMPUTER SCIENCE AND INFORMATION TECHNOLOGIES

УДК 004.9:65

## QUALITY MANAGEMENT INFORMATION SUPPORT OF CONSUMERS' HEAT SUPPLY

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### Abstract

**Background:** Currently, it is paid not enough attention to the assessment of the quality of the consumers' heat supply and there are only standard methods of thermal energy distribution. It is necessary to develop a methodology for assessing quality of specific cities heat supply.

**Materials and methods:** The author used materials of the "Utility Technology" company, which were processed by cluster analysis. The author used calculation method for the evaluation of quality indicators and method of decision tree to display the options.

**Results:** The analysis of heat supply quality indicators and standards was carried out. The method of heat supply quality assessment was suggested. The information support for a particular company was developed. An example of the algorithm implementation was considered.

**Conclusions:** The proposed method of heat supply quality assessment can be used for the analysis of the heat supplying organizations work and managing the process of customers' heat supply.

**Key words:** information support, heat supply, clusterization, decision making.

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## APPROACH TO TECHNICAL CONTROLLING ON THERMAL ENGINEERING FACILITIES

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### Abstract

**Background:** Non-effective management, runout of main equipment and heat networks, lack of funds that result in energy tariff rates growth cause necessity of a system approach to management of the area in question. Power-generating facilities monitoring and assessment based on informational analytical systems allow us to make a system view of the subject to management, to distinguish problem zones and to plan program activities aimed at energy efficiency increasing on a well-grounded basis. It should be noted that power facilities "spot" audit don't provide assessment of heat-and-power generating facilities in general and can serve just as a basis of local energy saving programs within separate subjects of the regional heat-and-power engineering network.

**Materials and methods:** The multi-alternative (where alternatives mean objects of heat-and-power engineering network) assessment approach was designed based on multi-attribute utility theory method combined with analytical hierarchy process.

**Results:** We carried out an informational support technology for decision making on target organizing and forming of a technical activities set, that makes a basis for regional and municipal energy saving and energy efficiency enhancing programs.

**Conclusions:** The obtained results are used to increase decision making efficiency in the field of regional energy saving.

**Key words:** energy saving, technical controlling, decision making support, informational analytic system, power-generating facilities assessment.

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