ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

INVESTIGATION OF ENERGY CONSUMPTION IN THE COURSE OF PLASTERING MACHINE'S WORK (p. 4-11)

Bogdan Korobko

The study focuses on the operating principle of the hydraulic technological equipment set for finishing works. The main objective of the study is to determine the amount of energy consumed in the process of the set operation. This energy is spent on mixing the finishing mortar and on the work output of the mortar pump piston when it is acting on the mortar to create the required feed pressure in the pressure main. We consider a scheme of energy consumption of the operating equipment set and propose a method of calculating the specific energy consumption of the selected set components. The method consists in calculating the energy consumption of each component and the total energy input, which allows determining the required capacity of the power unit.

The research findings allow calculating the energy input in the process of operation and, thereby, estimating the energy balance of such unit. They can be used by design engineers to further improve the performance of the designed machines in terms of their rational energy consumption.

The proposed method allows analyzing the share of energy consumption of each element of the hydraulic equipment set and outlining steps to further improve the parameters of the hydraulic circuit.

Keywords: technological equipment set, hydraulic drive, mortar, pipeline, transportation, energy efficiency.

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AN ALGORITHM OF REGULATING AN ENERGY-EFFICIENT HOT WATER SYSTEM WITH THE OBJECT MODEL IN THE CONTROLLER (p. 11-18)

Oleksandr Stepanets, Anastasiia Andrasovych

The article presents a method of controling an energy efficient hot water supply system, a large amount of heat energy in which is supplied by the solar collector. The study proves importance of energy saving technologies and their use in everyday life and industry.

The study presents a generalized structure of the system of hot water supply as a control object. The devised analytical model of dynamics of the system individual elements is based on the equations of heat balance. The model is reduced to a form suitable for use in computer modeling of the dynamics of technological processes. Numeric values of the parameters of the model transfer functions are calculated for the selected model of the solar collector. The resulting model of the control object for a single-circuit system serves as a basis for the comparative studies of various controller structures and control methods that provide the minimum readjustment and the fastest transition process. The comparison is based on classical PID-algorithms and the IMC-approach. The article describes synthesis of the IMC of the temperature of hot water in the point of its supply to users.

It is found that the proposed approach to designing a control algorithm based on the object model allows the IMC provide better performance quality as compared to traditional algorithms. It is shown that the controller synthesis requires taking into account the work of the actuator, and the controller filter order directly affects the valve drive motion making it smooth.

We have considered the prospects of the proposed approach and possible options for upgrading the system.

Keywords: hot water system (HWS), control algorithm, internal model control (IMC), energy efficiency.

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CALCULATION OF ELECTROTHERMAL PROCESSES IN PULSE CONVERTERS TO PROVIDE THERMAL PROTECTION (p. 19-25)

Roman Baraniuk, Viktor Todorenko, Dmitry Ushakov

Power electronics and their thermal protection systems that are designed on the basis of modern methods of thermal calculations work efficiently under specified operating conditions in a particular operating range of temperatures and modes beyond which the form of the transition process can change. Consequently, the extent of oscillation in the transition process increases along with the initial voltage and current fluctuations. These changes are dangerous if the boundary values of the component parameters are underestimated due to heating.

The study suggests a method of integrated electrothermal calculation in order to ensure thermal protection of pulse converters for electric power by creating combined models of the circuit elements in the form of a system of differential equations. Analysis of the characteristic roots of solutions of the differential equations of the system state in the form of matrix exponentials gives an idea about the nature of the transition process. This allows setting a threshold value of fluctuations and a time frame of the transition process while enabling a heated device. It becomes possible to stabilize the transition process by heating the components and to choose magnetic materials of inductors, taking into account the thermal processes.

As a result of this approach, thermal protection of power transformers extends to providing trouble-free operation at non-stationary modes of the components and extreme temperatures; it becomes possible to reduce the complexity and rigidity of the requirements to establishing a time frame for restarting the device.

Keywords: equation of the system state, thermal impedance, matrix exponential, electrothermal modeling.

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ANALYSIS OF EXCHANGE PROCESSES DURING PARALLEL OPERATION OF WIND ELECTRIC UNITS (p. 26-32)

Sergii Denysiuk, Darya Horenko

Quality control of electric power is usually performed at the point of delimitation, and mutual influence of the elements of power systems and exchange processes between generators is not consid-

ered. But in the transition processes, transmission, accumulation or generation of exchange energy take place both between the supporting elements of the power system and between the generators. The influence of exchange processes on the load is compensated by special instruments and the quality of electricity from a consumer's perspective is almost not affected. However, mutual overflows of energy, even with full compensation, will produce electromagnetic effect on the equipment (for example, magnetic circuit oversaturation) that would cause deterioration in the operating modes of generators, increasing losses, etc. All the above-said predetermines the need for analysis of exchange processes directly in the intersection of generation.

So the calculations were carried out of the exchange capacity during the work of two generators with different modes of operation and the influence of perturbations during the work of one generator was studied. We constructed corresponding graphic dependencies of the exchange capacity on the phase shift angle using MathCAD and Excel software applications. By analyzing graphic dependencies, the conclusions were drawn. Even with an active load, the overflows of inactive power in the system are present. We also defined by the graphs the optimal value of the phase shift angle, at which exchange capacity equals zero.

The conducted studies make it possible to carry out analysis and optimization of energy processes in dispersed electric power systems with different energy sources, to identify and minimize unwanted energy flows between the elements of the system, as well as to compensate for the mutual influence of various-type electric power sources, both traditional and non-traditional.

Keywords: electromagnetic compatibility of generators, renewable sources of electric power, inactive power of Frieze, exchange processes, exchange capacity.

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DEVELOPMENT OF MATHEMATICAL MODELS AND THE CALCULATIONS OF ELEMENTS OF CONVECTIVE HEAT TRANSFER SYSTEMS (p. 33-41)

Yosyf Mysak, Igor Galyanchuk, Marta Kuznetsova

Despite the considerable number of papers on elaborating the methods of mathematical modeling of thermal power systems, at present little attention is paid to the development of methods of analysis of the influence of different factors on the performance indicators of work of an energy unit. In this article we substantiated principles of selection and mathematical modeling of the simplest elements of heat transfer systems, which clearly reflect the essence of processes in these systems and are convenient in terms of their mathematical modeling. The use of selection and mathematical description of elementary heat exchangers, mixers and dividers of flows may describe a variety of heat transfer system of any energy plants.

These methods allow comparing various modes of operation of the equipment, its design peculiarities and their possible combination significantly faster and economically efficient. A proposed mathematical model of the elements of HTS in the form of a temperature characteristic provides unification of models of all elements, subsystems and HTS as a whole, as well as the clarity and convenience of the description of connections of elements. The calculations of heat transfer systems may be efficiently used for analysis of the work and different types of design and checking calculations of heat transfer convective surfaces. The use of generalized dimensionless parameters makes it possible to perform calculations based on different parameters of the initial information and to improve efficiency of analysis of the work of heat exchangers.

Keywords: mathematical model, heat transfer system, thermal energy unit, heat carrier, heat exchanger, thermal energy parameters.

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A MODEL OF HUMAN THERMAL COMFORT FOR ANALYSING THE ENERGY PERFORMANCE OF BUILDINGS (p. 42-48)

Valerij Deshko, Nadia Buyak

Despite numerous studies devoted to a comprehensive analysis of buildings as complex energy systems and, in particular, human thermal comfort, an attempt to combine these two aspects to solve the problems of energy conservation and comfort has been made for the first time. The designed comfort model serves to determine the structure of the human body exergy balance and calculate the minimum exergy consumption and comfortable air temperature. The paper presents a structure of the exergy balance in winter and summer, the dependence of the human body exergy consumption on the mean radiant temperature and room air temperature in winter. We have analyzed various models of human thermal comfort and devised a model of a comprehensive analysis of the system "heat source – human being – building envelope". We have calculated the standard deviation of comfortable room air temperature for different values of the mean radiant temperature, for the exergy model of thermal comfort and the model for which the Predicted Mean Vote (PMV) index of human sensation equals to zero. It is found that the standard deviation equals to 1.4 °C. Using thermal comfort models in a comprehensive analysis allows constructing buildings with low energy or exergy consumption and with high-quality thermal comfort.

Keywords: thermal comfort, energy efficiency, building, exergy, human body exergy consumption.

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MODELING OF IMPACT OF HYDRAULIC FRACTURES ON THE PROCESS OF FLUID DISPLACEMENT FROM LOW-PERMEABILITY SEDIMENTARY ROCKS (p. 49-55)

Andriy Bomba, Alesya Sinchuk

Mathematical modeling of fluid displacement from low-permeability (shale) sedimentary rocks in the pattern waterflooding elements considering the impact of hydraulic fractures is performed. Based on numerical methods of comprehensive analysis (quasiconformal mappings), numerical algorithms for the calculation of filtration characteristics: saturation field, velocity quasipotential, time of the displacing fluid breakthrough to the production well and its complete waterflooding are developed. The algorithm also allows determining the coordinates of the critical "suspension" points and their quasipotential values, fluid interface position at different time points, the overall filtration rate of the production well, the dependence of oil fraction in it. For an effective analysis of the research, calculations of the volume of the displaced fluid in the reservoir within a certain time and the volume of the remaining fluid in the reservoir at an arbitrary time are performed. This allowed predicting the rate of waterflooding of production wells and identifying the features of operation under the projected arrangement of wells and hydraulic fractures on them. It was found that the "transverse direction" (with respect to injection wells) of hydraulic fractures accelerates the time of the displacing reagent breakthrough to the production well (although provides some growth of oil withdrawal values at the initial stages), and their "longitudinal" direction reduces the number of oil stagnation zones.

Keywords: numerical methods for quasiconformal mappings, hydraulic fractures, pattern waterflooding, nonlinear problems.

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EXPERIMENTAL RESEARCH ON THE SEALING ABILITY OF BOREHOLE PACKERS (p. 56-62)

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With the use of a full factorial experimental design based on a Box-Hunter rotatable central composite plan for second order response surfaces, it was possible to obtain a statistical mathematical model of the impact of the diametrical tension, the test pressure, and the radial clearance between the thrust bush and the casing as well as the shear modulus of the material on the amount of contact pressure, which is represented by a polynomial of the second order. The research was carried out on the laboratory model of the PJSC "Ukrnafta" (Poltava, Ukraine). The analysis of this model shows that an essential impact on the sealing ability of the self-sealing ring (the value of contact pressure) is made by the following series of factors: the test pressure, the diametrical tension, the radial clearance, and the shear modulus of the compaction material. Moreover, the test pressure factor is characterised by nonlinearity, which manifests itself in intersections of the hypersurface response.

The study has experimentally determined the patterns of distributing contact pressure along the length of the conjugate surface between the ring and the casing, characterized by a decreasing contact pressure from the edge of the working bite to the supporting section of the ring.

The research has demonstrated that it is possible to manage directly the sealing ability of borehole packers, particularly by changing the geometric parameters of the packer compaction.

Keywords: borehole packer, self-sealing ring, contact pressure, blowout preventer, wellhead equipment, shear modulus.

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