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DETERMINATION OF THE ENERGY EFFICIENCY OF GRANULATION EQUIPMENT BASED ON EXERGY ANALYSIS

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The object of research is the process of granulation of mineral fertilizers by applying rolling and pouring methods, as well as in fluidized and suspended layers with active hydrodynamics of flows. It is noted that the development of the main technological stages of the production of granulated fertilizers should be aimed at improving the hardware design of granulators, establishing the most rational regime and technological parameters of the process in order to increase its efficiency and reduce energy costs. It is noted that the main indicators of the efficiency of granulation plants using heat are economic costs, exergy losses, as well as reduced costs. The method of exergy analysis for the assessment of energy costs for granulation processes in different types of granulators is presented, which allows to justify the choice of rational parameters of the specified processes, taking into account energy costs and equipment efficiency. Equations are presented for determining the amount of exergy of material flows and exergy losses caused by heat exchange at finite temperature differences of technological flows at the entrance to the device and at the exit from it. The equation for determining the exergy efficiency, which characterizes the energy efficiency of the technical system, is presented. The smaller the temperature difference for the technological flows at the exit from the device, the smaller the exergy losses, the higher the value of the exergy efficiency. and, accordingly, the device will have greater energy efficiency. An exergy analysis of granulation processes in granulation towers without a cooler, in

granulation towers with a cooler, fluidized bed devices and multi-stage (shelf) devices was carried out. The analysis showed that the exergy efficiency for the specified granulation plants is equal to: 64 %, 71 %, 32 % and 96 %, respectively. The obtained research results can be applied in production conditions where granulation towers and devices of fluidized or suspended layers are used. Enterprises that plan to reduce energy costs and increase the environmental safety of their technological processes can implement improvements based on the proposed methods and equations. The application of research results will contribute to the selection of more rational indicators of the granule production process, which will increase the productivity and quality of the final product.

Keywords: granulation of mineral fertilizers, granulator, urea, filling, rolling, active hydrodynamics, granulation, exergy.

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ELECTRICAL ENGINEERING AND INDUSTRIAL ELECTRONICS

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MODELING OF THE TUNABLE PLASMONIC PROPERTIES OF SPHERICAL AND ELLIPSOIDAL SILVER NANOPARTICLES IN THE MATRIX OF AN ORGANIC SEMICONDUCTOR

pages 12–18

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The object of research is the tunable plasmonic properties of spherical and ellipsoidal silver nanoparticles in the organic semiconductor matrix. The average absorption cross-sections, scattering cross-sections, and optical radiation efficiency of spherical and ellipsoidal silver nanoparticles have been simulated. The long-wave statistical approach has been used to model the optical parameters of the assembled spherical and ellipsoidal nanoparticles. Statistical averaging is used here, where absorption and scattering are considered from an "effective" particle with statistical properties. This approach avoids complex calculations considering the details of the spectral characteristics of single nanoparticles of different shapes. Taking into account the fact that the nanocomposite matrix will contain ensembles of spherical nanoparticles of different sizes, the peak of their absorption and scattering cross sections will be shifted to the short wavelength region of the spectrum compared to ensembles of the same spherical nanoparticles. In addition, there is a slight increase in the absorption cross-section and a decrease in the scattering cross-section, confirming the presence of smaller nanoparticles. A study was made of a composite material containing a randomly dispersed ensemble of silver ellipsoidal nanoparticles of the same and different shapes and sizes in an organic semiconductor matrix. An ensemble of identical ellipsoidal nanoparticles is characterized by the presence of two plasmon peaks, which corresponds to the characteristics of a single ellipsoidal nanoparticle. A completely different situation is observed if to consider that the nanocomposite will contain an

ensemble of ellipsoidal nanoparticles of different shapes and sizes. Such nanoparticles will be characterized by a plasmon peak for both the absorption and scattering cross-sections. This can be explained by the fact that as the size of ellipsoidal nanoparticles decreases, the distance between the peaks responsible for the longitudinal and transverse modes of plasmon excitation decreases. An increase in the shape distribution leads to a broadening of the absorption and scattering cross-section spectra. The efficiency of the optical radiation increases as the size distribution increases. It is shown that a change in the refractive index of an organic semiconductor matrix mainly affects only the value of the scattering cross-section of an ensemble of ellipsoidal nanoparticles dispersed in it. This research is a preliminary step to studying the influence of these particles on the properties of organic light-emitting structures.

Keywords: silver, spherical and ellipsoidal nanoparticles, plasmon resonance peak, absorption cross-section, scattering cross-section, nanoparticles assembly.

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DEVELOPMENT OF THE MODEL AND IMPROVEMENT OF THE METHOD OF AUTOMATED CONTROL OF STEAM TURBINE PARAMETERS TO MINIMIZE THE POWER IMBALANCE IN THE ENERGY SYSTEM TO INCREASE ITS EFFICIENCY

pages 19–29

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The object of research is the process of regulating power imbalances due to automated control of steam turbine parameters. The work solves the problem of minimizing power imbalances in the electric power system by developing a model of automated control of steam turbine parameters. This will ensure high-quality regulation of frequency and power, increase the efficiency and stability of the electric power system, and provide a new management method for reliable power supply to consumers.

The paper analyzes existing models and methods of power imbalance regulation, develops a dynamic model of automated control of K-300-240 steam turbines, which includes a mechanical-hydraulic system, a steam boiler and a steam superheater. As a result of the study, an improved power regulation method was proposed, which ensures efficient operation of the electric power system. The evaluation of the effectiveness of the regulation of imbalances was carried out on the basis of the proposed criterion of the efficiency of electricity supply and consumption, which is based on the convolution of partial criteria into the general criterion of the efficiency of electricity supply. The following criteria were proposed as partial criteria for electricity supply and consumption: volume criterion, quality criterion, and electricity supply efficiency criterion. The research results indicate the need for a reserve on each steam turbine in the amount of 10 % of its nominal power, which is explained by the assessment of the efficiency of electricity supply among the considered modes of operation of the systems. The presence of a power reserve on each steam turbine in the amount of 10 % of their nominal power ensures the most efficient power supply within the considered modes of operation of the power system, taking into account disturbances and as an imbalance of power generation and power consumption. The obtained research results can be applied in the strategy of primary regulation of power imbalances in the electric power system, thanks to the creation of a power reserve in the amount of 10 % of the nominal power on each steam turbine, and the organization of automated control of steam turbine parameters.

Keywords: electric power system, efficiency, reliability, quality, frequency regulation, disturbance, unbalance, steam turbine, primary regulation.

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TECHNOLOGY AND SYSTEM OF POWER SUPPLY

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MONITORING OF THE INERTIZATION OF CARGO TANKS OF LNG CLASS VESSELS

pages 30–37

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The results of monitoring the inertization of cargo tanks of vessels intended for the transportation of liquefied natural gas are given. It is determined that the mandatory stage of cargo operations in the port of unloading of liquefied natural gas is the inertization of tanks. It is noted that on gas-carrying vessels, the following sources of inert gases can be: flue gases of vessel's auxiliary boilers; gases generated in the inert gas generator during the burning of liquid fuel in them; directly chemically pure inert gas (usually nitrogen). It is also stated that the inertization of cargo tanks is carried out by one of two methods: either dilution of the gas atmosphere (which is the process of mixing two environments), or replacement of the gas atmosphere (in which the gases supplied to the tank form a dividing layer and gradually displace the residual vapors cargo). The stability and integrity of the dividing layer determines the inertization quality of cargo tanks. Control of the state of the dividing layer in the cargo tank is impossible with optical or visual means of control, which is caused by the opaque environment inside the tank. In this regard, it is proposed to determine the integrity of the separating layer, as well as the level at which it is located in the cargo tank, by measuring the concentration of inert gas in the volume of the tank. Research was carried out on a gas carrier with a cargo capacity of 42,563 m³. Inertization of the vessel's cargo tanks was ensured with the help of nitrogen, which was generated by an inert gas generator using the Pressure Swing Adsorption technology. Nitrogen concentration monitoring in the volume of the cargo tank was performed at levels corresponding

to 5 %, 20 %, 50 %, 80 % and 95 % of the tank depth. Research on determining the effect of nitrogen pressure entering the cargo tanks for their inertization on the stability and integrity of the dividing layer was carried out in the range of 0.95–1.05 MPa. The duration of the experiment was 210 minutes, fixation of nitrogen concentration values was performed every 30 minutes. As a result, optimal pressure values were established, according to which the inertization is ensured in the minimum time. The critical pressure values at which the separation layer breaks down were also determined.

Keywords: cargo tanks, inertization of cargo tanks, inertization using nitrogen, concentration of inert gas, gas carrier vessel.

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CONSTRUCTION OF A GENERALIZED MATHEMATICAL MODEL AND FAST CALCULATIONS OF PLANE-PARALLEL ROTATING MAGNETIC FIELDS IN PROCESS REACTORS WITH LONGITUDINAL CURRENTS OF CYLINDRICAL INDUCTORS ON A GRAPHICAL CALCULATOR

pages 38–49

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The object of research is a quasi-stationary rotating magnetic field (RMF) generated by cylindrical inductors with longitudinal windings in the working space of process reactors, in particular reactors designed to work with magnetic particles (MP). The RMF theory in the working space of reactors has not yet been sufficiently developed, which hinders the widespread introduction of the considered, rather complex technologies into practice. The RMF of

a specific reactor can be calculated accurately and completely using modern programs based on the finite element method, but it does not replace the general theory and theoretical analysis. In the literature, special cases of circular and elliptical plane-parallel RMF in reactors of the type under consideration have been studied, however, analytical formulas for a plane-parallel RMF for the general case of m -phase cylindrical inductors of external and internal design with symmetrical longitudinal windings are not presented.

In this paper, a mathematical model is constructed and generalized analytical formulas for magnetic induction are obtained, linking the characteristics of a plane-parallel RMF in the working space of reactors at idle speed with the main parameters of external and internal cylindrical inductors with an m -phase symmetric longitudinal winding. A physical analysis is carried out and the adequacy of the model is confirmed. Using the proposed formulas and a free, easy-to-use Desmos graphical calculator, quick trial calculations and analysis of RMF in several reactors with two-pole external inductors and various windings for three phases (for 6 and 42 slots) and for six phases (12 slots) are carried out. The calculation results are consistent with experimental and literary data.

New analytical formulas, as well as the demonstrated methods of quick evaluation calculations, analysis and experimental studies are recommended for practical implementation in the research, development and operation of reactors of this type. To carry out the calculations, it is enough to have a laptop or smartphone connected to the Internet, the time costs are insignificant. The results of the work will be useful to technologists, engineers and developers of both the reactors of the type under consideration and other devices with a similar purpose with an RMF.

Keywords: rotating magnetic field inductors, circular and elliptical magnetic field, magnetic drive of small particles, reactors with magnetic particles.

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CONSIDERATION OF WAYS TO IMPROVE THE EFFICIENCY OF DEEP WELL DRILLING

pages 50–56

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The object of the research is the composition of the bottom of the drill string when installing screw amplifiers. One of the biggest

problems is the place of installation of the screw amplifier in the arrangement of the bottom of the drill string and its influence on the dynamic properties of the rock-crushing tool.

The results of the study of the influence of the use of a screw amplifier on the efficiency of drilling deep wells were obtained. According to the results of research, it was determined in particular that the imposition of vibrations often causes a change in the nature of the interaction of the bit with the hole rock, therefore, the installation of the amplifier at different points of the layout will have different effects on the drilling performance. It is shown that the kinetic energy accumulated by the weighted drill pipes, when the amplifier is installed above the bit, is transmitted through the screw mechanism to the rock-destroying tool (bit) and is an operation that leads to an increase in drilling performance.

Thanks to the conducted research, it has been proven that the property of the drill string elements and the disturbances of the oscillatory processes of various nature acting on them are related to the dynamic loading of its elements due to the installation of the amplifier in different places of the layout of the bottom of the string. This is due to the fact that the proposed screw amplifier is used with a friction fuse, which causes the rotary movement of the screw under the action of the torque and the translational movement of the nut together with the overbit mass attached to the bit.

In most practical cases, especially during deep drilling, bits fail due to the destruction of the rolling bearings of the roller bit, which leads to jamming of the roller bit and leaving them in the holes. For practical use, the proposed design uses a friction fuse, which connects the bit to the drill pipe column through an elastic element. Analytical studies and performed calculations show that this screw amplifier will effectively ensure the destruction of any rocks, especially during overloads without slippage of reaches and be used for the construction of wells in native mining and geological conditions.

Keywords: well, drilling, dynamic state, screw amplifier, mechanical speed, deepening per run.

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SELECTION OF THE OPTIMAL FORMULATION OF THE BIOPOLYMER SYSTEM FOR THE STIMULATION OF PRODUCTIVE FORMATIONS

pages 57–61

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The object of study in this paper is the biopolymer system "X" – a complex composition that includes a biopolymer, salts and a thermal stabiliser intended for use in drilling fluids at high temperatures. The components of the formulation include complex reagent "X" for regulating structural, mechanical, rheological and filtration properties, as well as inhibitors (sodium and potassium chloride) and filler. Components of the biopolymer system (sodium chloride, organo-mineral colmatant thermal stabiliser) increase its thermal stability. One of the most problematic areas is the mechanism of sodium chloride's thermal stabilising effect. It is associated with an increase in the overall mineralisation of the drilling mud, which leads to a certain conformation of biopolymer molecules, accelerates gelation processes and counteracts the temperature dilution of the system.

The results obtained can be explained as follows:

- an increase in the concentration of sodium chloride leads to an increase in the ionic strength of the solution, which contributes to a change in the conformation of biopolymer molecules, enhancing intermolecular interactions and, as a result, increasing the viscosity and stability of the system;
- the organo-mineral colmatant heat stabiliser promotes the formation of a filtration crust on the well walls, which prevents fluid loss and reduces rock permeability;
- all components of the system interact with each other, affecting the properties of the solution. The optimum ratio of components allows achieving the required rheological characteristics and ensuring the stability of the system at high temperatures.

As a result of processing the information on technologies for tapping productive horizons, the disadvantages and advantages of each of them were noted. The existing drilling fluid systems used to tap productive horizons at high temperatures were considered. However, more attention was paid to the selection of a new optimal formulation of the biopolymer system, in accordance with the specified rheological and structural and mechanical properties for further implementation in practice. This ensures the possibility of obtaining predictive parameters of the drilling mud.

The proposed system has a number of advantages over similar ones, namely:

- the system retains its properties at high temperatures;
- the system provides the required values of viscosity, filtration and static shear stress;
- due to the use of an optimal formulation, high efficiency is achieved at a relatively low cost.

Keywords: biopolymer system, drilling mud, colmatant, filtration, well, rheological parameters, regression model.

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