ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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DEVELOPMENT OF AN INTELLIGENT SYSTEM FOR THE PROGNOSTICATION OF ENERGY PRODUCED BY PHOTOVOLTAIC CELLS IN SMART GRID SYSTEMS (p. 4-9)

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Solution of the problem of prognostication of the generated energy was proposed on the basis of mathematical apparatus of neural-fuzzy networks. The conceptual model of the household information system as a part of the common SMART GRID system was proposed. The main task of this system is continuous monitoring of the power net, prognostication of consumption of the energy consumed by domestic appliances and the energy produced by photovoltaic cell panels. Current and predicted data were obtained based on the use of current sensors and mathematical apparatus of neural-fuzzy logic. Importance and necessity of using SMART GRID technology for improving efficiency of power net operation was shown. Application of such systems can reduce energy costs and the environmental impact of energy systems. This effect is achieved by prognostication of the energy generated by domestic renewable energy sources, in particular photovoltaic cell panels which ensures more efficient energy management.

Also, the proposed model of the information system makes it possible to account produced and consumed energy which enables creation of an energy-efficient operation schedule of household appliances. Analysis of the dependence of the forecast accuracy on the choice of input characteristics was made. As a result, the optimal number of neurons in the inner layer was empirically set to 250 with a prediction error within 5 %. Influence of weather factors on accuracy of the resulting forecasts was considered. In particular, it has been found that quite significant differences between actual and projected data (up to 12 %) are due to the inaccuracy of local forecasts. The proposed information model can be integrated into existing or designed systems of the Smart Home type.

Keywords: neural-fuzzy network, SMART GRID, MICROGRID, photovoltaic cell panel, prognostication of produced energy.

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SUBSTANTIATION OF THE EFFECTIVENESS OF USING A FLAT MIRROR CONCENTRATOR IN THE SOLAR DRYER (p. 10-15)

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We propose a procedure for calculating geometrical parameters of a flat mirror concentrator of solar energy. The procedure describes construction of the path of rays between the mirror and the collector in the form of a system of degree coordinates α. We obtained analytical dependences for the course of illumination of air collector by the sum of direct and reflected flows $E_\beta(\tau)$ and a flow gain coefficient k. This makes it possible to estimate efficiency of a flat mirror concentrator for different azimuthal angles of orientation of parameters of the horizontal receiving surface of air collector S and the system of degree coordinates α.

The rational values for a dihedral angle (focline) α between the mirror and the collector are established, which are 90...120°. It was found that a gain coefficient of the flow of solar energy k is implemented with the least expenditures from 1.8 to 1.2.

We report results of experimental research into energy characteristics of work of the mirror concentrator in a combination with an air collector. It was established the application of a mirror concentrator in the solar dryer makes it possible, in the morning and in the evening, to improve annual average capacity of incoming solar radiation on the receiving surface of air collector by an order of 3.41 kW/m^2 during daylight. This enables receiving, amplifying, and directing to the absorber of AC from 1.5 to 2.3 kW·h of energy per day from 1 m^2 of FMC.

The results obtained could be used for design and improvement of technical means of drying, in order to enhance technological and energy efficiency of the process.

Keywords: solar energy, fruit solar dryer, mirror concentrator, receiving surface, air collector.

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DESIGN OF CONTROL ALGORITHM OVER TECHNICAL CONDITION OF HYDROGEN GENERATORS BASED ON HYDRO-REACTIVE COMPOSITIONS (p. 16-21)

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In order to describe the process of hydrogen generation, a system of differential equations is applied, which is matched with a transfer function of the hydrogen generator. A transfer function of the hydrogen generator is used for the transition to the frequency domain of research. We obtained an expression for the asymptotic logarithmic amplitude-frequency characteristic of the hydrogen generator. This characteristic is used to identify a simplified description of the hydrogen generator, which represents a model of dynamic link of the first order. Approximation error does not exceed 3.5 %. For such a model, we proposed a procedure for determining its parameter – the time constant. The magnitude of time constant is determined using a test-impact, which represents a change in the area of the outlet of hydrogen generator in the form of a pulse of the semi-sinusoidal shape.

In order to determine technical condition of the hydrogen generator, the test-impact is applied in the form of a change in the outlet in line with the harmonic law. The frequency of a test-impact is inversely proportional to the magnitude of time constant of the hydrogen generator. Based on the results of measurements of constant and variable pressure components in the cavity of a hydrogen generator, one determines a position of the figurative point relative to the assigned region on the frequency characteristic. Belonging of the figurative point to this region determines operational condition of the hydrogen generator.

Keywords: hydrogen generator, gas generator, technical condition, frequency characteristics, control algorithm.

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WAYS TO IMPROVE OPERATION RELIABILITY OF TRACTION ELECTRIC MOTORS OF THE ROLLING STOCK OF ELECTRIC TRANSPORT (p. 22-30)

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We found that the electrical equipment has a dynamics of failure rate growth according to the results of the processing of the statistical information of electric transport enterprises and analysis of the operating conditions of rolling stock systems and aggregates. We established that traction electric motor failures make up 20 % of all failures of electrical equipment. We analyzed the conditions of operation of traction electric motors and estimated the reliability.

The study of probabilistic and statistical characteristics of the functions of the distribution density of traction electric motors failure shows that some failures are approximated by an asymmetric distribution. In this regard, it is advisable to use a truncated normal distribution function N N{t; T; σ}, which will make possible tp increase the adequacy of models.

We established that the number of failures in the interval 0-t1 decreases significantly for large probability Q. We can consider the flow of failures in this interval as stationary for certain values.

We proposed a mathematical model for reliability evaluation (14), which, unlike existing models, is based on the system analysis of the probabilities of failure of subsystems, which are subjected to diagnosis (brush-holding unit, stator, anchor, collector), on a base of structural and functional diagrams of traction electric motor elements.

It makes possible to determine parameters of various elements of traction electric motors during operation. The model differs qualitatively from the existing ones by taking into account structural and electromagnetic characteristics and gibes possibility to optimize parameters of different units in relation to the requirements of the system of planned and preventive repair, when traction motors developed a given resource and continue to operate.

Thus, it is possible to estimate reliability parameters a traction electric motor of any type according to the results of the studies and the above calculations.

Keywords: electric transport, traction electric motor, diagnosis, operational reliability, probability of no-failure operation.

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THERMODYNAMIC ANALYSIS OF AIR-COMPRESSION REFRIGERATING MACHINE BASED ON THE EXERGY COST THEORY (p. 30-38)

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On the basis of the exergy cost theory, a procedure has been developed for carrying out an in-depth thermodynamic analysis of air-compression refrigerating machines and thermal pumps taking into consideration nonequivalence of exergy losses in various links of thermotransformation process and their effect on consumption of exergy supplied to the system. A thermoeconomic model of a single-stage air-compression refrigerating machine was proposed which takes into consideration structural and topological features of the process scheme and interrelation between its elements. For an equivalent mapping of structural and topological features of the refrigerating machine scheme, a parametric flow graph was developed. The procedure uses a matrix form of recording exergy balances which is the most convenient for representation of the thermoeconomic models. In order to obtain reference operating mode of the refrigerating machine, the principle of thermodynamic process idealizing was used. Application of the structural theory of thermoeconomics has made it possible to establish the portion of endogenous and exogenous destruction of exergy in the elements of the refrigerating machine.

Numerical implementation of the proposed procedure has made it possible to reveal influence of internal irreversibility in the cycle determined by non-isentropic compression processes in the compressor and expansion in the expander. A significant effect of efficiency of the expansion process in the expander on the exergy efficiency of the air-compression refrigerating machine was established.

Influence of the change of ambient temperature on the character of consumption of exergy by each element of the refrigeration machine was estimated. It has been revealed that even a slight change of the ambient temperature significantly affects consumption of "fuel" by each element of the system, while the dependence is linear.

Generalized dependences of exergy indicators on variable factors have been obtained which enabled finding of unfavorable operating conditions for equipment with increased energy consumption. It was established that the efficiency factor of the turboexpander has the greatest influence on the change of consumption of exergy of "fuel" in the system.

Keywords: thermo-economic model, exergy cost; thermodynamic analysis; air-compression refrigerating machines; heat pump systems.

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RESEARCH ON RESIDUAL SERVICE LIFE OF AUTOMATIC LOCKING VALVE OF TURBINE K-200-130 (p. 39-44)

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Calculations of non-stationary thermal and stress-strain state of the casing of ALV of HPC under combined effect of temperature gradient and operational internal steam pressure were performed. Temperature gradients and pressures were assigned by variables in time under starting operation modes in accordance with actual schedules of starts, determined by the power plant. In geometric modeling, valve's lid was taken into consideration. Taking into account the lid did not have a significant impact on durability of ALV of HPC.

The estimation of damage and residual service life of casings of ALV of HPC of the steam turbine K-200-130-3 showed that the total damage of metal of the casings of ALV of HPC is 84 %. The estimated residual service life of metal of the casing of ALV of HPC of the turbine K-200-130 will increase up to 164,383 hours when refining safety factors. This will make it possible to extend operation of casings of ALV of HPC by 50 thousand hours at the number of starts, equal to half the park number, that is 400 starts.

To increase reliability of the elements of the turbine, to decrease thermal loads and improve the quality of operation, it is necessary to optimize the number of starts from cold state in direction of a decrease. It is also necessary to refine safety factor of metal of casings of ALV of HPC by deformations n_ε, the number of cycles n_N, limits of fluidity n_f and safety by nominal stresses n_{ns}. To do this, it is necessary to conduct studies on the impact of ageing on changes in physical-mechanical properties of structural alloy steels under operational and elevated temperatures.

Results of the conducted research can be used to extend service life of locking and protective valves of steam turbines of large capacity in the energy sector.

Keywords: locking valve, stress-strain state, low-cycle fatigue, damageability, residual service life.

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STUDY OF THE THERMAL MODE OF A BARN FOR PIGLETS AND A SOW, CREATED BY COMBINED HEATING SYSTEM (p. 45-50)

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The present research addresses solution to the relevant problem of energy efficient heating supply of pig farms with barns of pigs and a sow by applying combined heating systems based on local heating of places for animal keeping.

A physical model is developed, which offered the possibility to carry out a complex of experimental studies on determining temperature mode in the barn for piglets and a sow. We established the patterns of influence of thermal capacity of individual heating devices, in particular the heating panel in the place of sow keeping, as well as the heating mat and the infrared heater, on the thermal condition of specific areas.

Assessment of the influence of the main factors of the research on its original characteristics was performed. We obtained the equation for determining relative air temperature in the zone of piglets and sow keeping, which depends on relative height of the operation area at a variable air velocity, as well as on incoming air temperature, influenced by the number of animals and background temperature in the premises.

Graphical dependences were constructed and empirical dependences were derived based on the conducted experimental studies that can be used in subsequent engineering calculations.

Based on the obtained results, we compiled recommendations on the choice of thermotechnical parameters of heating devices, particularly their geometric dimensions, material and method of location of heating elements.

Keywords: combined heating system, infrared heater, heating panel, heating mat.

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INVESTIGATION OF THE CARBON MONOXIDE POST-COMBUSTION FLAME IN THE WORKING SPACE OF A STEELMAKING UNIT (p. 51-57)

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In order to optimize thermal mode of the steelmaking process and to bring down energy consumption, we examined effect of ther-

mophysical parameters of the carbon monoxide post-combustion flame considering aerodynamic processes on the thermal-technological parameters during melting. Based on modern approaches and methods, we obtained data on the character of macro-physical processes that occur in the working space of the unit and in the reaction zone, taking into consideration the influence of aerodynamic processes in the bath of a steelmaking unit. We conducted a comparative analysis of the shape and temperature fields of the flame taking into consideration the influence of aerodynamic processes at different intensities of blowing the bath of a steelmaking unit with oxygen for different types of blowing devices.

It was established that the shape and magnitude of temperature fields of the drigted flame varies depending on the content of carbon (from 4 to 0.1 %) in the melt, the intensity of blowing the bath with oxygen (from 1,800 to 2,400 m^3/h), as well as design features of the blowing device (nozzle diameter and inclination angle). In this case, lances with an increase in the inclination angle of the nozzles to 50° and varying nozzle diameters from 10 to 20 mm, compared to lances of basic design (at the same inclination angles), make it possible to improve flame organization, to increase the length and temperature of the flame, to improve uniformity of the structure of flame, to increase heat exchanging surface between the flame and the bath, and to improve heating capability of the bath in a steelmaking unit.

The studies reported in the present paper are applicable to industrial steelmaking units with the intensity of blowing the bath with oxygen in a range of 1,800–2,400 m^3/h. The results obtained bring us closer to the development of a rational design of the blowing device to optimize the thermal mode of steelmaking process that will make it possible to reduce energy consumption in steel production.

Keywords: thermophysical parameters, thermal-technological parameters, flame, carbon monoxide post-combustion, temperature field.

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INVESTIGATION OF HEAT EXCHANGE IN A BLOWN DENSE LAYER OF GRANULAR MATERIALS (p. 58-64)

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Experimental studies of heat exchange between a dense layer of granular material and a stream of heated air have been carried out. As a granular material, claydite and gravel were used in a moving and a stationary layer. Temperature curves were obtained for the air flow and the solid component at the inlet and outlet of the installation. The shape of the curves indicates presence of two distinct zones with different heating rates. It was stated that it is expedient to set the heating period in the heat accumulators with a stationary bed within the first period which is characterized by a high heating rate. When calculating duration of the heating period, it is rational to take the value of the final material temperature 10–15 % lower than the temperature of the heating air at the inlet. It was established that the coefficient of intercomponent heat exchange depends on the gas velocity, the velocity of the bed motion, the gas temperature at the input to the installation and the process duration. It was found that the curves of the dependence of the coefficients of intercomponent heat exchange on the process duration are described by a sigma function.

Intensity of heat transfer for a moving layer in the investigated region was commensurable or somewhat higher than that for a stationary layer. It was shown that claydite is the preferred material for a granular packing. The time to onset of a stationary mode for a

moving claydite layer was reduced by 2.4 times in comparison with gravel layer and by 2.2 times for a stationary layer.

Keywords: heat exchange, granular material, moving layer, stationary, gas flow, temperature curves.

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