ABSTRACT AND REFERENCES

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DEVELOPMENT OF A MATHEMATICAL MODEL FOR COST DISTRIBUTION OF MAINTENANCE AND REPAIR OF ELECTRICAL EQUIPMENT (p. 6-16)

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The research is devoted to the development of a model for cost distribution of maintenance and repair of electrical equipment when making decisions on the management of the electric power system state. The decrease in the reliability of electric power system operation, caused by the objectively existing aging of electrical equipment, requires consideration of equipment significance when planning the maintenance and repair. For this purpose, it is proposed to use the theory of fuzzy sets, Saati's method and Boolean programming method. The result of solving the optimization problem of multicriteria analysis is a vector of the best alternatives, built on the principle of dominance. The developed algorithm of complex simulation of the electric power system state and cost distribution of maintenance and repair for making decisions on the determination of priority of electrical equipment out of service allows for effective decision-making. The results of probabilistic and statistical simulation of electric power system states using the Monte Carlo method allow us to take into account the probabilistic nature of emergency situations in the electric power system when determining its weakest elements that require priority replacement. The advantage of the proposed approach is taking into account the technical condition of electrical equipment for risk assessment of the electric power system emergency situation. A comparative analysis of ranking results of electrical equipment based on the emergency risk assessment of the electric power system confirmed the high efficiency of the planning of electric power system states when solving the problems of preventive control. The developed model will be used for further research and development of the algorithm for making effective decisions regarding the operation strategy of the electrical equipment and preventive control of the subsystem operation of the electric power system. The obtained results of complex simulation of the electric power system state and technical condition of the electrical equipment give grounds to assert the possibility of software implementation of operation risk analysis of the electric power system for power supply companies.

Keywords: Saati's method, risk management, failure probability, maintenance and repair.

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DEVELOPMENT OF PROCEDURE TO CONTROL FLOW DISTRIBUTION IN WATER SUPPLY NETWORKS IN REAL TIME (p. 17-24)

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It is required to substantiate the method for determining the number of control nodes both during designing networks taking into consideration its supply, and in the process of its operation when hydraulic characteristics of the sections change. It is necessary in order to substantially reduce energy consumption of pumping equipment and to prevent significant leakage. The processes of formation of zones of insufficient head in water supply systems were explored. The method of flow distribution control in water supply network, which makes it possible to substantiate the necessary and sufficient number of control nodes and the place of their location, was proposed.

It was shown that the resulting decisions are coordinated with the existing methods for ensuring the necessary head in a network. This opens additional opportunities in flow distribution control, namely, specification of control nodes location in the water supply system during its operation.

As a result of the studies, the principle of determining the number of control nodes was proposed, which makes it possible, depending on the area of zones with insufficient head, to determine their necessary number when designing a water supply network and specify the location during operation.

According to the presented procedure of flow distribution control in water supply systems, hydraulic calculations for various modes of water pumping are performed, water consumption in the sections that are in operation at the time of measurement of piezometer in control nodes is determined. The actual node heads are determined, the nodes on the border of the zones with insufficient head, from which, if necessary, additional head control nodes are assigned, are established. At the stage of networks designing, a change in operation parameters of the network is modeled. Piezometric marks in the nodes are determined relative to supply nodes, where the head value is specified. The criterion for selection of the number of control nodes and their location places is the magnitude of minimum head in them and the dimensions of the zones with insufficient head.

There were developed the recommendations and supplements to existing practices of flow distribution control, which determine the number and location of control nodes at the stage of design and in the process of the operation of water supply networks. This makes it possible to maintain the necessary head in network nodes, prevent its exceeding, which helps to reduce leakage and power consumption costs at pumping stations.

Keywords: water supply network, flow distribution control, control procedure, zone of insufficient head, control nodes.

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CONSTRUCTION OF METHODS TO IMPROVE OPERATIONAL EFFICIENCY OF AN INTERMITTENT HEAT SUPPLY SYSTEM BY DETERMINING CONDITIONS TO EMPLOY A STANDBY HEATING MODE (p. 25-31)

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In the course of this study we defined conditions for the rational utilization of intermittent heat supply for public buildings of various types: administrative and educational institutions, and other public buildings. Known results of theoretical and experimental research do not take into consideration the dynamics of cooling a building and the appropriateness of employing a standby heating mode. And this is very important for a model of control over a heat supply system. We modeled mathematically a change in temperature indoors for various types of buildings under variable climatic parameters, of different levels of modernization and operating parameters of buildings, all of which defines the appropriateness of employing a standby regime. By cancelling a standby mode, it becomes possible to achieve an additional energy saving effect.

This paper shows the impact of enclosing structures of buildings on the dynamics of heating and cooling premises under variable climatic conditions for various operational modes. A mathematical model has been proposed for the basic operational modes when an intermittent heating supply is used. A structure of the mathematical model consists of two inertial links: low-inertial and highly-inertial. The first link reflects the process of heating air indoors. The second link reflects the process of heating a premise's enclosing structures. Parameters of the proposed model are the coefficients of the transfer of an object along the channel "heating power – change in air temperature", as well as the time constants for each of the links. The input variables for a given model are the ambient temperature and the premises' utilization mode (switch time of alternating regimes). The output change is a room temperature in accordance with the current mode. We have defined boundary conditions for employing a standby mode of an intermittent heating system for various types of buildings at different degrees of thermal modernization.

The results of this research could be used when designing new public buildings and while modifying heating systems at existing administrative and educational institutions. In this case, it is necessary to take into consideration the degree of thermal modernization of a building, the type of heating systems, as well as modes of utilization.

Keywords: intermittent heat supply system, mode boost, standby mode, power reserve, heat accumulator.

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PREPARATION AND PRELIMINARY ANALYSIS OF DATA ON ENERGY CONSUMPTION BY MUNICIPAL BUILDINGS (p. 32-42)

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Systematization of data on energy consumption by buildings of different purposes makes it possible to investigate processes from the standpoint of efficient use of energy resources in order to ensure comfortable conditions. This necessitates improvement of existing approaches, or search for the new ones, in order to analyze data on energy consumption by different buildings.

Based on a study into the process of preparing data on energy consumption by buildings, we have proposed a procedure of initial analysis. It takes into account the purpose of a building, as well as techniques for data acquisition, information on the indicators of absolute and relative electricity- and heat consumption, indicators of indoor and outdoor air temperatures. Using energy consumption by buildings of the educational institution as an example, we have verified the devised procedure for the preliminary data analysis.

Our study has made it possible to establish the correlation of energy consumption indicators and the indoor and outdoor air temperatures in the transition from general data to the data on a heating period. An analysis of spread diagrams has revealed the trends towards lower energy consumption, as well as the excessive consumption of energy resources by the examined objects.

Based on the developed software, we compared indicators of heat consumption by individual apartments and a maximum heating need in accordance with normative documents.

The results obtained could form a basis for developing applied information solutions for municipal energy management.

Keywords: heat supple to buildings, energy consumption data analysis, data preparation, monitoring of energy consumption by buildings.

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EFFICIENCY OF THE AIR HEATER IN A HEAT RECOVERY SYSTEM AT DIFFERENT THERMOPHYSICAL PARAMETERS AND OPERATIONAL MODES OF THE BOILER (p. 43-48)

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We have examined, for the plate heater included in a heat recovery system of the boiler plant, the influence of its thermophysical parameters on the losses of exergetic power under different operational modes of the heating boiler. A procedure for the calculation of losses in a given heat recovery unit is based on an integrated approach that combines exergetic methods with the methods of thermodynamics of irreversible processes. A mathematical model includes a differential equation of the exergy balance and an equation of thermal conductivity for an air heater under boundary conditions of the third kind. The differential equation of exergy balance has been solved jointly with the equation of thermal conductivity. The result of solving them is the obtained estimation dependences for determining the losses of exergetic power associated with the processes of heat transfer.

We have calculated losses of exergetic power in the examined heat recovery units at a change in the coefficient of thermal conductivity of the plate, in the heat transfer coefficient from flue gases and an operational mode of the boiler. The derived dependences on a thermal conductivity coefficient for the considered operating modes of the boiler have two distinct sections, along the first of which there is a relatively small increase in the losses of exergetic power while reducing the coefficient of thermal conductivity, along the second – the loss of exergetic power in a heat recovery unit increase relatively sharply. For the considered sequence of regimes of the boiler a transition from its maximum heat output to the minimal one is accompanied by a decrease in the losses of exergetic power. A similar character is also demonstrated by the dependence on a thermal conductivity coefficient of the relative contribution of losses of exergetic power in the heat transfer processes to their totals in a heat recovery unit. In this case, there are minor differences in the relative contribution of these losses under different operational modes of the boiler. The heat transfer coefficient from the side of flue gases within a framework of a single operating mode of the boiler affects less significantly, compared to the thermal conductivity coefficient of the material of a heat exchange surface, the losses of exergetic power in the heat transfer processes. We have established regions of change in the thermal conductivity coefficient, as well as operational modes of the boiler, in the range of which the losses of exergetic power in a heat recovery unit are minimal.

Keywords: loss of exergetic power, thermophysical exergetic parameters, heat transfer processes, boiler's operational modes.

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ENTROPY-BASED METHODS APPLIED TO THE EVALUATION OF A REAL REFRIGERATION MACHINE (p. 49-56)

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The aim of the research is the thermodynamic analysis of a real refrigerating machine with solid fouling on the heat-exchange surface of an air-cooled condenser with the help of entropy methods such as: the entropy-cycle method, the entropy-statistical method and the entropy generation minimization method. The experimental data of the refrigerating machine with solid fouling in the form of dust on the external surface of the air-cooled condenser was used for the thermodynamic analysis.

The influence of irreversible losses in separate elements of the refrigerating machine caused by the presence of external solid fouling on the external heat exchange surface of the air-cooled condenser was determined according to the entropy-cycle and entropy-statistical methods. The entropy-cycle method has estimated the absolute value of energy losses in each element. The entropy-statistical method was used to determine the excessive consumption of work in the real cycle in comparison with the theoretical compression process in the compressor.

The irreversible losses associated with aerodynamics and heat transfer during air motion through a finned surface in an air-cooled heat exchanger were estimated by using the entropy generation minimization theory. The influence of growing fouling on the thermal and mechanical components of the total entropy generation in the heat exchanger was determined. In addition, the fouling mass that determines the time of its cleaning was defined.

Application of entropy methods for analyzing the real refrigerating machine at the design stage allows minimizing irreversible losses associated with operating conditions. Moreover, it allows predicting a maintenance schedule which contributes to energy saving.

Keywords: entropy methods, real refrigeration machine, air-cooled condenser, solid fouling.

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DEVELOPMENT OF THE CONVERTER STRUCTURE THAT ENABLES POWER SUPPLY TO TRACTION INDUCTION MOTORS OF MINE ELECTRIC LOCOMOTIVES FROM DIFFERENT LEVELS OF VOLTAGE (p. 57-64)

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We have proposed an adjustable structure of the converter of energy of electric drive in the electrotechnical complex of a mine electric locomotive from power sources with different voltage levels – from a contact network and a battery of traction accumulators. A characteristic feature of the converter is the presence of inverter units that can be connected either sequentially or in parallel. When powered by a low-voltage source, inverter units are connected in parallel over the entire range of change in the output voltage. When powered by a high voltage source, inverter units are connected sequentially in the range of low output voltages and in parallel in the range of high output voltages. Such an approach makes it possible to align the power voltage levels of traction asynchronous motors of a mine electric locomotive at a lower level. The expected alignment of voltage levels is carried out at a lower level compared to a standard circuit of the three-phase bridge autonomous inverter and is achieved by controlling the paired bridges in the power circuit of traction induction motors. Given this, the frequency of voltages of width-pulse modulation does not change, which is important for the process of reducing dynamic losses of power in the drive's elements.

It has been confirmed that an increase in the output voltage distortion coefficient in the IGB-transistors of the inverter with the minimal level of energy losses in the electric drive's elements is achieved by modulating the voltage at a constant switching frequency at different voltage levels. We have proven the fact that the best indicators for the harmonic coefficient were obtained at frequencies about 30 Hz, which are the working ones, so the converter operating mode is most effective at these frequencies. The result of analysis of the classical scheme of the inverter has revealed that increasing the frequency of pulse-width modulation by three times significantly increases electrical losses in the windings of traction electric motor. In the proposed circuit of the voltage inverter of engine's power, at leveling the voltage at low level, there is no need to increase the frequency of pulse-width modulation, which does not lead to a growth in the electrical losses in a traction motor.

Keywords: induction motor, autonomous voltage inverter, pulse-width modulation, electric losses, harmonics coefficient, mine electric locomotive.

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EXPERIMENTAL RESEARCH INTO AERODYNAMIC CHARACTERISTICS OF A NACELLE WITH THE ENABLED SYSTEM OF ENGINE THRUST NEUTRALIZATION (p. 65-73)

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We have conducted an experimental study into aerodynamic characteristics of the structural scheme "wing – two-circuit engine nacelle". The data were acquired in the course of work of a promising system for the neutralization of a two-circuit engine's thrust of a large by-pass ratio at aircraft landing. The relevance of the conducted study relates to the improvement of operational performance of a passenger aircraft. Based on the analysis of functions and principal schemes of reversible devices at cargo and passenger airplanes, we have proposed a promising method to neutralize the thrust of a two-circuit engine with a high by-pass ratio. Physical essence of the method for neutralization of the engine's thrust is to substantially restrict an airflow into the engine by a technique to rotate working blades of the fan at the time of landing. We have devised a specialized procedure for conducting a weighting and drainage experiment with a model of the nacelle of a turbojet two-circuit engine in a wind tunnel. The obtained experimental data make it possible to evaluate the limits of the investigated method for neutralizing the thrust in order to shorten the length of aircraft run. By conducting a drainage experiment and applying a tuft flow visualization technique, we identified the detachment of a flow at the outer surface of the nacelle's model with a completely closed entrance. The presence of the flow detachment predetermined an increase in the frontal drag of the nacelle model by approximately 2.5 times, revealed by the weight experiment. In the course of the weight experiment it was established that the existence of a screening surface (while the engine's nacelle approaches a runway) increases frontal drag of the nacelle model by approximately 14 %. The drainage experiment found that such an increase in the frontal drag was due to a significant redistribution of pressure at the surface of the nacelle model. The study has shown that the idea of closing the entrance to the engine that has a large by-pass ratio at the time of aircraft landing is one of the promising methods for shortening the run length of the aircraft.

Keywords: thrust reverse, thrust neutralization, fan, nacelle, two-circuit engine, wind tunnel, run distance.

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RESULTS OF RESEARCH INTO KINETIC AND ENERGY PARAMETERS OF CONVECTION FRUIT DRYING IN A SOLAR DRYING PLANT (p. 74-85)

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We have improved a procedure for calculating the kinetic and energy parameters of the convection fruit drying process in a solar drying plant, based on which it is possible to analyze enhancement in the effectiveness of the technological process of drying and to reduce the cost of energy resources through solar energy.

We have examined the kinetics, dynamics and intensity of fruit drying in a solar drying plant, in particular for apples cut in slices with a thickness of 8 mm, treated with a sugar solution, exposed to blanching, and without treatment. We have determined such kinetic characteristics of the process: duration of drying the apples treated with a solution of sugar or exposed to blanching was 27 hours, without treatment – 33 hours. In this case, the intensity of drying apples with a moisture content from 2.89 to 0.24 kg wet/kg of dry matter is 1.57÷0.18 kg/(m^2·s).

We have established the effect of energy parameters on the technological parameters of a heat carrier and the plant's efficiency. Specifically, over a single drying cycle from 1.5 m^2 of the air collector's surface, a solar drying plant consumed solar radiation energy in the range from 723 to 800 W/m^2. It has been established that this energy was converted into heat energy (2,368.2 kJ), absorbed by a heat carrier (1,984.9 kJ) and used to heat the product (836.3 kJ) and moisture evaporation (756.7 kJ), with a part absorbed by the heat accumulator (356.9 kJ). We have determined the efficiency of a solar drying plant, which ranged from 23 to 60 % depending on a change in the density of solar energy arrival, which ranged in the morning period (from 7:00 to 10:00) from 456 to 965 W/m^2 and in the evening period (from 17:00 to 20:00) from 734 to 223 W/m^2.

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

Keywords: solar drying plant, convection drying, kinetics, activation energy, intensity of drying, heat-and-mass exchange, moisture content.

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THE RESULTS OF STUDY INTO THE EFFECT OF AIR-STEAM BLAST ON THE LOW-GRADE FUEL GASIFICATION PROCESS (p. 86-96)

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The design of a highly efficient gas generating plant with a direct-flow gas generator was proposed for gasification of low-grade fuels. The design includes a gas-air recuperator and an evaporator for preliminary preparation of air-steam mixture. The gasification process is fully controlled since operation of the evaporator is coordinated with operation of the blast gas supply system due to which humidity of the mixture fed to the gasification zone is programmed 10 mm pellets produced of rape stems were used as fuel.

Two-factor experiments have been carried out to estimate the effect of volume and humidity of blast air on the lower heat value of the generator gas and the mass fuel consumption in the gasification process. The effect of air volume and humidity on temperature of the air-steam mixture required for the gasification process was also investigated.

It has been established that the optimum temperature of the air-steam mixture was 550...570 °C and was achieved at the volume of blast gases entering the gas generator in the range of 37...42 m^3/h and air humidity of 55...65 %. Under these conditions, the lower calorific value of the generator gas was 12.3 MJ/m^3, which was 15.1 % higher

than that of the gas obtained without the use of air-steam blast in the gasification process.

Consumption of pellets for the gasification process was reduced by 14.7 % and the volume of gas produced from a kilogram of pellets increased by 18 % to 3.2 m^3/kg.

The total energy efficiency of using the given flowsheet in production of generator gas from pellets produced of rape stems was 23.5 %.

The innovative procedure of compiling heat balance for the process of air-steam gasification of plant materials was presented. According to the results of experimental studies, a heat balance has been compiled for the developed design of the gas generating plant. This balance has demonstrated high efficiency of the process of air-steam gasification. Efficiency factor of the direct-flow gas generator was 79 % and that of the gas generating plant as a whole was 74.6 %.

The presented studies can be used as a basis for modernized methodologies of thermal calculation of mobile and stationary gas generating plants.

Keywords: air-steam gasification, gas generating plant, generator gas, heat of gas combustion, heat balance.

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