ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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EXPERIMENTAL STUDY OF HEAT EXCHANGE AND HYDRODYNAMICS AT THE LAMINAR FLOW OF NANOCOOLANT BASED ON PROPYLENE GLYCOL AND Al_2O_3 NANOPARTICLES (p. 4-12)

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An experimental study of heat transfer coefficient and pressure losses coefficient under the laminar flow of nanocoolants in the pipe was carried out. The relevance of the studies is related to the possibility of intensification of the heat transfer process when using nanofluids as heat transfer agents and coolants without modernizing the equipment.

As the objects of the study, we used nanocoolants based on aqueous solutions of propylene glycol with the addition of Al_2O_3 nanoparticles in the amount of 0.53 and 1.03 % by weight. A technology for the preparation of nanocoolants by a two-stage method is described. Results of the aggregate stability of nanoparticles in the coolant are presented. Thermophysical properties of nanocoolants, necessary for evaluating heat-transfer coefficient and coefficient of pressure losses, were estimated experimentally (viscosity and heat capacity) and theoretically (density and thermal conductivity) in temperature range of 253–313 K. A schematic of the original experimental installation for measuring heat-transfer coefficient and pressure losses coefficient in the pipe is represented. Results of the calibration experiment with the use of water as coolant are presented. Experimental values of heat-transfer coefficients and pressure losses coefficient under the forced laminar flow of nanocoolant in the pipe are given. It was shown that the mean lengthwise and local values of heat-transfer coefficients for the nanocoolant are larger than those for the base coolant. At the same time, an increase in heat exchange intensity is not proportional to the concentration of nanoparticles in the coolant. An increase in the losses of head at the addition of nanoparticles to the base coolant was demonstrated.

The data obtained showed a possibility in principle to intensiy the heat transfer process under the forced motion of nanocoolant based on the aqueous solutions of propylene glycol and Al_2O_3 nanoparticles in the heat exchange equipment of refrigeration systems.

Keywords: coolant, nanoparticles, laminar mode, heat transfer coefficient, pressure losses, experimental installation.

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SUBSTATIATION OF THE CONSTRUCTIVE-TECHNOLOGOCAL PARAMETERS OF A SOLAR FRUIT DRYER (p. 13-19)

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A design of solar dryer for fruit drying is proposed, which includes the use of a flat mirror concentrator – to enhance the slanting flows of morning and evening solar radiation, and a thermal battery based on pebble for the accumulation during night time of excess heat from the reserve source of energy. This makes it possible to maintain a stable mode of drying the fruits over 24 hours and to increase the efficiency of drying process by 20 % under conditions of private peasant farms.

We devised a method for the substantiation of parameters of solar dryer that allows us to calculate its design parameters, to substantiate optimal technological regimes and parameters of heat carrier in the drying chamber, to describe the heat and mass transfer characteristics of the process of drying fruits, to take into account the impact of physical parameters of the environment on the technological indicators of the process.

A parametric series of five mini-solar dryers is proposed for the conditions of private farming and peasant farms and their structural parameters are substantiated, in particular, area of air collector and mirror concentrator; mass of thermal battery; inside volume of drying chamber.

The results obtained might be used when developing and improving technical means for the drying of fruits to enhance technological and energy efficiency of the process.

Keywords: solar energy, solar fruit dryer, mirror concentrator, thermal battery, drying chamber.

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ANALYSIS OF RESIDUAL OPERATIONAL RESOURCE OF HIGH-TEMPERATURE ELEMENTS IN POWER AND INDUSTRIAL EQUIPMENT (p. 20-26)

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The issues of taking account of damage caused by exposure to high levels of local temperatures of gases, local non-uniformity of temperature and reliable assessment of residual resource of high-temperature elements are relevant and will provide for a reliable and long-term operation of energy generating equipment.

A mathematical model is developed for the combustion process in burner devices with stabilizers based on the software complex ANSYS Fluent. We created a technique for determining the impact of levels of temperatures and their gradients on the assessment of residual resource of high-temperature elements of power and industrial equipment. Based on data on the work of industrial power equipment and results of physical experiments, we selected correct initial and boundary conditions that enabled adequate simulation of the influence of non-uniformity in the combustion products temperature field. Based on the software complex Solid Works, we performed calculation studies that take into account the gas-dynamics of gas flow that flows around the pipeline. The thermal and stress-strained states are defined and an estimation is conducted of operational lifecycle of pipeline in a boiler plant depending on the operating conditions of equipment.

It was established that the residual operation time of a pipeline in a boiler plant is 77.4 thousand hours at static damageability from long-term loads of 57 %.

Results of the research conducted might be used by implementing the recommendations proposed in large- and small-scale energy sector, industry and gas transportation system in Ukraine, as well as in other fields of science and technology.

Keywords: boiler plant, stressed-strained state, low cycle fatigue, damageability, residual resource.

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IMPROVING THE OPERATION MODES EFFICIENCY IN HEAT PUMP SYSTEMS OF HOT WATER SUPPLY WITH THE TWO-STAGE HEAT ACCUMULATION (p. 27-33)

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Here we propose circuit solutions for improving the efficiency of renewable energy sources using the two-step systems of accumulation. At the first step of accumulation, low-potential sources of heat are employed: heat pump, heat recuperation from the condensation contour of refrigeration unit, heliosystem (during winter). At the second step, temperature is brought to the required level through a high-potential source: heliosystem (in summer), gas boiler, solid-fuel gas boiler, etc. We substantiated theoretically and experimentally the rational techniques to connect renewable energy sources to the heat accumulators. A numerical CFD-simulation was performed of the distribution of temperatures in the volume of tank-accumulator under a two-step mode of accumulation; the visualization of temperature field is presented. This made it possible to choose rational modes of heat accumulators operation using the heat carrier connection by a cross circuit and to utilize in full the volume of tank in the combined systems of heat supply. We developed and implemented a pilot production-experimental installation of combined system of heat supply to one of the facilities at ONPU (Ukraine) with the use of heat pump and a reserve source of heat. Experimental study was conducted on experimental-production pilot installation, which confirmed the need for applying the two-step accumulation when using heat pump plants in the combined systems for the preparation of hot water. It was proven experimentally that at temperature of heat carrier in a heat pump plant above 45 °C, its efficiency falls (cost for energy is coming close to energy costs for traditional energy sources).

Research results are relevant because they allow a more efficient use of renewable energy sources in the combined systems of heat supply. It was substantiated that the compactness, ease of installation and low investment, adopted as a priority in the creation of alternative systems of heat supply, often lead to a decrease in their operational efficiency.

Keywords: accumulation of heat, heliosystem, heat pump, combined systems of heat supply, phase transition.

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PERFORMANCE EFFICIENCY ANALYSIS OF ELECTRIC POWER SUPPLY SYSTEMS (p. 34-40)

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Predetermined by the need to increase effectiveness of electric power supply and electric power consumption, the interconnected problems of effectiveness of these processes were explored. The object of present study is effectiveness of operation of electric power systems and the subject of the study is the processes to increase

their effectiveness. The problems are caused by energy-consuming technologies, unstable consumption of electricity and out-dated organization. On the one hand, it is the variable system of electric power consumption, on the other hand, the unstable system of electric power supply. It was established in the work that these systems could be balanced by their constant optimization. All operative factors of influence are established for this. Based on this, the processes of electric power consumption and supply are optimized with the help of the diagram of cause-effect interrelations. All factors, which influence effectiveness of electric power consumption and electric power supply, are represented by the Ishikawa Kaoru diagram and are divided into four groups: organizational, technical, technological and economic with their specific definition. It was followed by an analysis of their influence with separating 7–9 basic factors in each group. The establishment of the optimum variant of EPS and EPC is classically reduced to determining characteristic of distributive function, strategy and modes at minimization of effectiveness indicators. It is simpler to establish the optimum structure of electric power supply and electric power consumption, using, to describe them, directed graphs, the vertices of which correspond to the elements of the structure, and arcs correspond to relationships between them. For further mathematical processing, this directed graph is described by the system of matrix equations and the task is reduced to the search for minimum or maximum paths in the directed graph.

Keywords: electric power networks, effectiveness, electric power consumption, electric power supply, factors of power process, simulation, directed graph.

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IMPROVEMENT OF COMPENSATION METHOD FOR NON-ACTIVE CURRENT COMPONENTS AT MAINS SUPPLY VOLTAGE UNBALANCE (p. 41-49)

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The necessity and topicality of the problem of improving the efficiency of compensation for power consuming asymmetrical equipment negative influence on the low-voltage mains have been demonstrated. That is why the ways of improvement of the compensation system have been offered on the basis of the analysis of the processes of compensation for currents non-active components in a three-phase power supply system under the conditions of supply voltage unbalance. The analysis was performed in an analytical form in the frequency domain. An instantaneous power cross-vector theory was used to generate active and reactive power instantaneous components and also to determine compensation currents in the analyzed power supply system. Improvement of the method consists in exclusion of voltage asymmetrical components, caused by the mains distortions, from the algorithm of generation of compensation currents. It was realized with the use of the designed blocks of separation and balancing of the supply mains voltage signals. The latter improved the efficiency of operation of power supply systems and the speed of operation of the compensation system. The significance of the presented paper consists in the fact that the offered method provides correct operation of the compensation system under the conditions of unbalance of the supply mains voltages. This makes it possible to improve power indices of the power supply system, to reduce the value of reactive power, voltage drop at the mains resistances, unbalance coefficient and the coefficient of distortion of currents sinusoidality and supply mains voltages. In the future, the presented method will be applied to compensation for currents non-active components in industrial power supply systems to which nonlinear and asymmetric equipment, characterized by a sharply changed operation modes, is connected.

Keywords: active compensation, cross-vector theory, balancing block, unbalance, frequency-domain.

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THE DEVELOPMENT OF AN ARTIFICIAL ENERGOTECHNOLOGICAL PROCESS WITH THE INDUCED HEAT AND MASS TRANSFER (p. 50-57)

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The study justifies the importance of developing "artificial" energy technology processes. The "start-up" of these processes under natural conditions does not meet the conditions for the processes that are truly natural. For "artificial" processes, it is common that at least one or more parameters or properties of the system can have no "affinity" with the environment. The system properties may acquire the equilibrium value only after overcoming some energy activation barrier. One of these new artificial processes is a process of an induced heat and mass transfer (InHMT). The aim of the study is to determine the necessary and sufficient conditions as well as to develop balance equations for technical applications of the InHMT process, based on generalizing theoretical and experimental data obtained so far. The phenomenon of the "artificial"

energy technology process of InHMT is observed in a thermostat. The InHMT process consists in inducing an intensive removal of the liquid phase from the thermostat volume as well as in an intensive dissipation of heat while the system in moving from an unstable equilibrium to a stable equilibrium.

Balance equations for the InHMT effect have been developed on the basis of the observed facts in the case of fluctuations in the concentration of particles in a continuous gaseous medium inside the thermostat due to fluctuations of the concentration of particles in the volume of the obturator under the impact of an external continuous gas medium. These equations have helped determine that the heat, which is dissipated during the InHMT process due to the removal of the mass flow into the environment, depends on the physical properties of the liquid, the way of filling the thermostat volume, and the structure of the obturator.

Keywords: artificial energy technology process, thermostat, obturator, the effect of induced heat and mass transfer.

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