ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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DEVELOPMENT OF THE ANALITICAL METHOD FOR NONLINEAR CIRCUITS ANALYSIS WITH THE USE OF THE ADMITTANCE AND RESISTANCE ORTHOGONAL COMPONENTS (p. 4-12)

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A method for the nonlinear electric circuit analysis with the use of the orthogonal components of instantaneous admittance and resistance is proposed. The mechanism of the generation of the admittance orthogonal components of a nonlinear electric circuit is demonstrated. The analytical expressions for the components of instantaneous admittance and resistance are given and analyzed. The balance equations for the components of instantaneous admittance and resistance are analyzed. On their basis, the harmonic components of the current of the nonlinear electric circuit consisting of an active linear and nonlinear resistance, connected in series, are determined. The accuracy and adequacy of the developed method are proved by the comparative analysis of the current harmonic components calculated with the use of the proposed method and the ones obtained as a result of the numerical calculation of the researched circuit mathematical model. The advantages of the proposed method include its versatility in the use, the possibility to assess the circuit parameters influence on the current spectrum composition, good adaptation to the automation of the calculations in the frequency domain, the ability to obtain the predicted result independently of the degree of the approximating polynomial and the number of the analyzed harmonics.

Keywords: instantaneous admittance, instantaneous resistance, frequency domain, electric circuit, nonlinearity, analytical method.

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ANALYSIS OF RELATIONSHIP BETWEEN THE DYNAMICS OF A THERMOELECTRIC COOLER AND ITS DESIGN AND MODES OF OPERATION (p. 12-24)

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We examined a dynamic model of the relationship between basic parameters and indicators of reliability, taking into consideration the structural and technological elements, for a single-stage cooling device under various current modes of operation, thermal load at a temperature difference of 40 K. The ratios derived allow us to define the time required for a single-stage of thermoelectric cooling device to enter a stationary mode of operation, and the temperature of a heat-absorbing junction. The dependences take into consideration values of a thermal load, the number of thermoelements, current mode of operation, with respect to both the mass and heat capacity of the object, and the mass and heat capacity of structural and technological elements at heat-absorbing junctions of the module. It was found that the heat capacity and mass of structural and technological elements of the module affect not only the time required to enter a stationary mode, but the device's reliability indicators, reducing them by 2–3 times. The results of analysis of dynamic characteristics and energy indicators of a single-stage thermoelectric cooler demonstrated the possibility to control the time required to enter a stationary mode. Structural control, enabled by selecting the number and geometry of the cooler's thermoelements, and the mass and heat capacity of the load, makes it possible to reduce the time required for a thermoelectric cooling device to enter a stationary mode by up to 2.5 times. Operational control, executed by changing working current of the cooler, makes it possible to reduce the time required to enter a stationary mode by up to 3 times.

Keywords: thermoelectric cooler, stationary mode, temperature of heat-absorbing junction, reliability indicators.

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SUBSTANTIATION OF COUNTERVORTEX SPILLWAY STRUCTURES OF HYDROTECHNICAL FACILITIES (p. 24-32)

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The construction and reconstruction of waterworks sets a number of scientific and engineering tasks that require a new approach to their solution. One of the promising areas for solving these and a number of other problems is the use of swirling water flows in hydrotechnical facilities. The article presents the results of physical simulation of spillway counter-vortex systems. The model had a damping chamber diameter of 0.15 m and was tested at a head up to 8 mH_2O and a flow rate up to 0.11 m^3/s. As a result of the conducted experiments, the values of the flow coefficient of the entire system were obtained. The water-carrying capacity was determined for several modes of operation of the model by means of a combination of switching valves that brought water to the inlet nozzles of the model. In addition, a change in the mode of operation of the model was carried out by changing the vacuum in the near-vortex zone of the counter-vortex flow in a wide range.

A self-similarity of the flow coefficient by the head and the Reynolds number has been established. The physical modelling has made it possible to formulate a well-grounded approach to the hydraulic calculation of counter-vortex spillway systems. One of the most important issues studied experimentally in the process of the described hydraulic tests was the determination of the energy damping capacity of counter-vortex spillways, reflecting their effectiveness. The energy damping capacity was determined by the energy damping factor, reduced to the general head in the model. The article presents the main schemes of local water flow swirlers for the formation of a counter-vortex flow, which can be used in hydrotechnical practice. Some of their geometric and hydraulic characteristics are considered. A simplified scheme of hydraulic calculation of a counter-vortex spillway structure for various types of swirlers and constructive solutions of a spillway system (an open type or an underground tunnel) is proposed. The authors compared the efficiency of the proposed method for damping the energy of the spillway flow and the hydraulic scheme with a sudden expansion of the flow according to the Borda formula. The counter-vortex method of damping the energy of the transit flow has a much higher efficiency in comparison with sudden expansion. The study suggests directions for further research on complex counter-vortex flows.

Keywords: hydraulics, hydraulic spillways, swirling flow, swirler, speed/velocity, flow rate.

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ADVANTAGES OF USING CHANNELS WITH DIFFERENT CORRUGATION HEIGHT IN THE PLATE HEAT EXCHANGERS (p. 33-38)

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In the case when there is a difference in consumption on the side of the cold and hot heat carriers, the use of channels with the same corrugation height in one heat exchanger leads to a decrease in velocity of the heat carrier on the side with low consumption.

Low velocity contributes to appearance of deposits on the heat transfer surface, which leads to disruption of operation mode of the apparatus and a forced clean-up stop. In case of using channels with a different corrugation height (cross-section area), velocities in the channels are aligned and intensity of emergence and growth of contamination falls sharply. It also allows us to reduce the heat transfer surface area of the apparatus and fully implement permissible pressure losses on the sides of the heat exchanger. For designing of heat exchangers of this structure, the authors developed the mathematical model that allows making calculations of heat exchangers for assigned operation conditions with the use of geometrical data of the plates, thermophysical properties of heat carriers and criterial equations for plates of the selected type.

The calculation algorithm involves determining of the ratio between corrugation heights. Practical value lies in the fact that the proposed approach makes it possible to extend the service life of the heat exchanger prior to a maintenance stop. This enables provision of continuity of the technological process and decreases operation costs. Calculation of the heat exchanger of hot water supply by the parallel scheme of attachment to heating networks and the heat exchanger of stage 1 of the two-stage hybrid scheme was presented. Calculation data indicate a decrease in the heat transfer surface area compared to heat exchangers with channels of equal height, full realization of pressure losses and their alignment in the channels, which facilitates an increase in resistance to contamination of the plates' surface.

Calculation showed the advantage of using apparatuses with channels of different cross-section area. The higher the ratio between consumption of heat carriers in the channels, the stronger this advantage.

Keywords: plate heat exchangers, corrugation height, heat transfer analysis, resistance to contamination, hot water supply.

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THEORETICAL AND APPLIED ASPECTS OF USING A THERMAL PUMP EFFECT IN GAS PIPELINE SYSTEMS (p. 39-48)

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Based on the classical method for calculating parameters of gas pipelines using electrohydraulic analogy, a mathematical model of the object, the process of gas transmission in an industrial pipeline, has been developed. The study subject was the change of gas temperature after its passing through a throttling device which brings about thermal pump effect in the receiving strand of the gas pipeline. It was proposed to use gas-dynamic thermal pumps to minimize the risk of plug and hydrate formation in the gas pipeline of Kharkivtransgaz Co. It was shown that the change of the ground body temperature by ±10 °C in the 20 km long gas transmission section of the multi-strand pipeline system causes a change of gas pressure by 5–15 %. A theoretical-empirical formula for determining the Joule-Thomson coefficient was derived which allows one to estimate the thermal pump effect on the energy and thermobaric parameters of nonstationary gas transmission processes. It was determined that the integral coefficient of performance (COP) for the network system of multi-strand pipelines including gas-dynamic thermal pumps varies within the range of 1.00–1.09 depending on the ambient temperature (0–20 °C). The principles of constructing the topology of the diagram of the gas pipeline with bridges and branches which, due to the use of the thermal pump effect, ensures a minimal risk of plugging and hydration consist in activation and regulation of the energy-transforming and heat exchange processes in the sections of the network system. This is achieved by introduction of additional throttling devices in front of the bridges and branches of the pipeline and by checking for proximity and bordering with critical temperatures of plug and hydrate formation.

Keywords: gas transmission system, inter-strand bridge, throttle effect, thermal pump, electrohydraulic analogy, mathematical model of gas transmission in pipelines.

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MODELING OF ENERGY EFFICIENT SOLUTIONS REGARDING THE HEATING SYSTEM AND THE FACADE HEAT INSULATION IN THE IMPLEMENTATION OF THERMOMODERNIZATION (p. 49-57)

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We substantiated design and construction-technological solutions for increasing the energy efficiency of thermomodernizable buildings and structures based on the conducted calculation-and-experimental and numerical studies. We investigated effective structural parameters and material of examined elements of a thermomodernization system of residential buildings and structures, which started their operation before the 90-ies of the last century. We proposed a number of innovative design and construction-technological solutions for the thermomodernization of residential buildings and structures that provide simultaneous modernization of a system of central water heating and facade insulation. Distribution of the temperature field inside a building structure, temperature on the surface of a facade thermal insulation at variation of its thickness by different forms of making of new indents, where new pipelines of a two-pipe system of a central water heating are located, were investigated. In particular, we established that such placement of pipelines makes it possible to reduce heat losses from these pipelines significantly (by up to 74 %) comparing with the placement in a layer of facade insulation at the side of a wall. We investigated the dependence of the cooling time of a heat-transfer agent temperature to 0 °C at the complete cessation of its flow through pipelines on the thickness of a thermal insulation. We determined experimentally the minimum thickness of a facade insulation layer, which is 50 mm, for the studied temperature mode and operating conditions, as well as for characteristics of the materials used, the geometry of pipelines and the facade insulation.

We obtained the optimum thickness of a facade insulation layer, which is 100 mm. It provides up to a 100 % freeze protection of pipelines even when a heat-transfer agent movement stops for more than 24 hours. We established that an increase in the thickness of a facade heat insulation contributes to the additional drainage of a building structure, which leads to improve-

ment of thermal characteristics of the thermomodernized building. The study showed that the developed innovative design and construction-technological solutions lead to a significant reduction in the energy consumption of existing buildings and structures of the housing stock, which has been in operation for longer than 30 years, and contribute to maintaining comfortable living conditions.

Keywords: thermomodernization of buildings and structures, facade, energy efficiency, thermal insulation, water heating system.

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EFFECT OF THERMAL FIELD DISTRIBUTION IN THE LAYERED STRUCTURE OF A HEATING FLOOR ON THE TEMPERATURE OF ITS SURFACE (p. 57-63)

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We propose a method for creating optimum temperature microclimate modes at livestock facilities of different functional purpose by using a multi-layer heating floor. A structural mathematical model was constructed that makes it possible, under a preset operation mode of m-tiered tubular heaters, with respect to thermal conductivity of each layer of heat-generating modules, to define structural heat engineering parameters. We have obtained a general solution to the boundary value problem on determining the distribution of a steady temperature field in the multi-layered structure of MEHHS in the form of a prism with randomly arranged tubular heat sources.

The respective mathematical model of MEHHS that was developed solves the task on the optimization of formation of temperature parameters of the heating floor surface with an accuracy to 0.5–1 °C. We have studied the model of automated MEHHS for effectiveness of resource-saving electrotechnology and for techniques for creating optimal thermal parameters of the heating floor surface in technologically-active zones (TAZ) at a livestock facility. It is proposed to substantiate parameters of MEHHS systems in terms of creating automated means to form the microclimate at PF in the agricultural sector that would enable structural-functional control over energy fluxes of power to STH of MEHHS under the mode consumer-regulator, which could ensure preset levels of temperature at the heating floor surface at livestock facilities of different functional purpose.

Keywords: temperature fields, heating floor, heat-generating modules, tubular heaters, layered structure.

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RESULTS OF RESEARCH INTO TECHNOLOGICAL PROCESS OF FRUIT DRYING IN THE SOLAR DRYER (p. 64-73)

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The work addresses the issue of solving a scientific-applied task on the substantiation of operation modes of the solar fruit dryer in order to improve energy efficiency of the technological process of fruit drying for small amounts of fruit processed at private farms.

We have explored the use of solar energy for fruit drying at the latitude of the location of Rivne oblast, Ukraine, which has the average annual solar radiation power of the order of 3.41 kW·h/m^2 per daylight. This makes it possible to receive from 1.5 to 2.3 kW·h of energy per day from the air collector area of 1 m^2.

The series of analytical and experimental studies that we conducted has confirmed the possibility for a significant in-

tensification of the process of fruit drying in the solar dryer. Compared with modern convective drying devices, the specific energy consumption when drying the fruit in the solar dryer is reduced by 3...3.7 MJ/kg. The degree of intensification grows by 3.3...12 times compared to drying devices of the mine and tunnel types. Such results were achieved by implementing the proposed design of a flat mirror concentrator, to enhance the slanting fluxes of morning and evening sun irradiation, and a heat accumulator, based on pebbles, for accumulating at night the excessive heat from the reserve source of energy.

It was established that regardless of a blanching technique for fruit raw materials, the duration of drying in the solar dryer varies depending on physical parameters of the environment. In the process of drying, the experiments were carried out at a temperature of 289.15...333.15 K, and the duration of drying was from 50 to 74 hours. We have analyzed the effect of operational parameters on a change in the chemical indicators and quality of the dried fruit. Specifically, the content of vitamin C, which was 5.2 mg/% for pear, and 4.3 mg/% for apple. The acidity was 0.29 % for pear, and 0.46 % for apple. The content of dry nutrients was 87.5 % for pear, and 85.9 % for apple. The sugar content of fruit raw materials was 59.36 % for pear, and 57.8 % for apple.

Keywords: solar energy, solar dryer, temperature-humidity fields, heat mass transfer, intensification, convective drying.

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