ABSTRACT AND REFERENCES

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METHOD FOR DETERMINING A TECHNICAL RESOURCE OF THE POWER TRANSFORMER OF TRACTION SUBSTATIONS UNDER OPERATING CONDITIONS (p. 4-9)

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The goal of present study is to improve a method for determining a residual technical resource and expected life cycle of power transformer of the traction substations of electrified railroads under operating conditions with the influence of different factors. Solving this task makes it possible to use technical resource of the transformer in full, to decrease economic costs and labor expenses. It was established that even after a normative period of operation a substantial part of power transformers at the traction substations of railroads retains working ability under conditions of compliance with permissible load regimes, timely conducting of tests, diagnosis and maintenance.

We improved a method for determining a technical resource of power transformer by introducing the rate of change in the relative wear of insulation. The essence of improvement consists in the comprehensive account of the content of indicators of humidity in a solid insulation, the content of acids and oxygen in the oil, rate of an increase in their concentration in the calculation of technical resource and the remained time of operation of the transformer. The given method allowed us to increase the accuracy of calculation of the residual resource of a transformer by 10...12 %, which enables effective planning of the substantiated periodicity and the volumes of operations on the restoration of technical resource over entire life cycle.

Keywords: transformer, maintenance, life cycle, rate of relative wear of insulation.

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EXPERIMENTAL STUDIES OF TEMPERATURE CHANNEL EFFICIENCY FOR SOLAR ENERGY SYSTEMS (p. 10-16)

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The methods to improve the thermal test equipment and determine the efficiency of solar collectors are proposed. To improve the performance specifications of such equipment, it is proposed to use highly sensitive semiconductor sensors. Based on experimental studies, planar transistors are chosen and sensors that can be used in temperature channels of devices for solar system studies are designed. Series connection of several transistor diodes enables an increase in sensitivity while reducing technological variations and simplifying secondary devices.

The experimental studies have shown that the maximum temperature characteristics variation of the nine studied sensors does not exceed ±0.06 °C throughout the measuring range of 0 °C to +80 °C.

The structure of a digital temperature difference meter with the studied sensors is designed. The temperature difference meter circuit is based on two current-to-voltage converters, in the feedback of which temperature sensors are enabled. By using a single reference voltage source, the same currents will flow through the sensors. The output signals of both converters are equal to voltage drops on the sensors and are fed to the differential inputs of the ADC, which provides a source code proportional to the measured temperature difference. The meter calibration at any temperature in the measuring range while ensuring the temperature uniformity of both sensors is proposed. After calibration, the estimated error value of the temperature difference meter does not exceed ±0.1 °C throughout the measuring range.

The calibration method of precision digital thermometers with the designed sensors in two temperature points is proposed. At 0 °C, the thermometer additive error is determined, which is later used as a correction to all measuring results. The multiplier factor value is expedient to determine near the maximum measured temperature as the ratio of the nominal and the resulting values of the code that matches the calibration temperature. A method for adjusting a nonlinear error component in the whole measuring range is developed. It is based on determining the parameters of sensors approximating dependencies using experimental data. The logarithmic approximation temperature dependence of semiconductor sensors, whose value is equal to zero at both calibration temperature values is proposed. It is shown that this approximation dependence can be easily implemented in the modern microcontrollers base. After calibration, the acceptable error limit of digital thermometers in the measuring range from 0 °C to 100 °C does not exceed ±0.1 °C.

Keywords: solar collector, semiconductor temperature converter, temperature difference meter, thermometer calibration.

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ANALYSIS OF THE TEMPERATURE DISTRIBUTION IN A SPACE HEATED BY A DYNAMIC (FAN) STORAGE HEATER (p. 17-25)

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The experimental and research space heating system with a fan storage heater was introduced. The system contains a set of measurement tools, which allows studying the temperature distribution at several room points simultaneously. Temperature recording has begun since the heating season 2014–2015 and it is continued up to date.

Temperature measurement error in the range of 10...25 °C accounts for 6.8...2.8 %, respectively. The greatest errors in studies are from temperature sensors and the controller-logger unit, which records temperature values.

The regulation of the storage heater is performed using the values from two temperature sensors located in the same plane but at different heights. Depending on the temperature readings of the sensors, the storage heater fan was switched on and off.

During the research, the temperature change at different heights of the space depending on the fan mode was studied. The study found that when a fan is on, this leads to the formation of overheating zone. This fact negatively affects the comfortable conditions for people inside that space and results in overspending of thermal energy stored by a storage heater.

The study also showed that the lower the set room temperature, the lower the temperature gradient (along the height) and the duration of overheating periods. This fact creates favorable conditions for the construction of the algorithm for the storage heater automation system that would allow avoiding overheating.

Keywords: storage heating, storage heater, fan storage heater, dynamic storage heater, room temperature.

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EVALUATION OF ENERGY EFFICIENCY OF SOLAR ROOFING USING MATHEMATICAL AND EXPERIMENTAL RESEARCH (p. 26-32)

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A relevant issue today is the principle of energy efficiency and rational use of energy resources. At present, solar heating systems with conventional solar collectors are quite expensive. Given this, we designed and patented a solar roofing, which combines the functions of a solar collector and a metal corrugated part of the pitched roof. The feature of solar roofing is that its heat absorber is made of the corrugated roofing material of the building. This makes it possible to significantly reduce the cost of the solar system, improve its strength and simplify the design.

Comprehensive solution of the issues of fixing solar collectors directly to the elements of the roof has broad prospects because, in this case, the possibility of replacing a part of the roof with them can be implemented. This eliminates additional load on the carrying structures and reduces the cost of solar heating in general. We developed a mathematical model of the work of a solar roofing in the heating system, which is a dependence of calculation of heating temperature of the heat carrier in the tank-accumulator on intensity of the heat flow and period of radiation. It was established that at changing incident angles of the heat flow from 90° to 30°, effectiveness of solar roofing reduces insignificantly compared with the flat solar collectors.

We improved dependences of change in the efficiency of solar heating systems using a solar roofing on the direction and velocity of the air flow. It is established that energy efficiency of a solar roofing is larger affected by velocity of air flow, while its direction is less important.

Keywords: solar roofing, heat supply system, energy efficiency, solar system, solar collector, solar energy.

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APPLICATION OF ELECTROMAGNETIC FIELDS FOR INTENSIFICATION OF HEAT AND MASS EXCHANGE IN COMBINED GAS-LIQUID PROCESSES (p. 33-39)

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To date, thermal rectors with submersible combustion devices with efficiency of more than 100 % relative to the lowest heat of combustion are known. This method of heating is more universal and energy efficient due to the absence of heat losses in transportation and maximum utilization of the carrier heat. This opens up broad prospects for the use of these energotechnological facilities in residential gas heating systems.

This work has studied the effect of electromagnetic fields having intensity gradient in the direction of motion of the contacting phases on the process of mass transfer between counter-current-moving gas and liquid phases. It was shown that the optimal method of intensification of heat and mass transfer in the submerged combustion devices is oscillation of the contacting phases under action of an electric spark discharge. Design solutions were proposed for intensifying the heat and mass transfer process and increasing the energy efficiency of operation of thermal reactors with the submersible combustion devices.

To evaluate the effect of magnetic and electric fields upon their application, it was proposed to use the developed vibrofrequency measuring transducer with a cylindrical-type resonator. Application of such control method makes it possible to measure total frequency-modular oscillations of the contacting phases. In this case, there is no need to control characteristics of magnetic and electric fields and assess their individual effects on the intensity of oscillations in the contacting gas-liquid phases.

Keywords: intensification of heat and mass exchange processes, magnetic and electric field, cylindrical resonator, induction receiver.

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INVESTIGATION OF FLOW STRUCTURE AND HEAT EXCHANGE FORMATION IN CORRUGATED PIPES AT TRANSIENT REYNOLDS NUMBERS (p. 40-45)

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The problem of convective heat transfer in the initial section of a pipe with a corrugated section was considered at transient Reynolds numbers. Influence on the intensity of heat exchange and the magnitude of hydraulic resistance of geometric parameters (wavelength and amplitude) of the corrugated insert, variability of the thermophysical properties of the heat carrier and the direction of the heat flow was estimated. Threshold value of the corrugation wavelength ($L/R_0>0.6$) was determined for the Reynolds number range under consideration for which there was a significant growth of heat exchange. Influence of the gradient of the dynamic viscosity coefficient on flow stability and intensification of heat exchange in internal flows was demonstrated. Influence of Reynolds and Prandtl numbers on local heat transfer, hydraulic resistance and flow structure was determined. It was established that the use of corrugated surfaces is ineffective at Reynolds numbers less than 2000. It was shown that heat exchange in a pipe can be raised to 30 % with an increase in hydraulic resistance of 1.05 times in the range of Reynolds numbers $2\cdot10^3...1.4\cdot10^4$ with the use of a nonencumbering corrugation.

Keywords: corrugated pipe, inlet pipe section, heat transfer intensification, hydraulic resistance, vortex structure.

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MODELING OF THE PROCESS OF OILSEED MEAT COOKING IN A MULTI-VAT COOKER DURING PROCESSING OF OIL RAW MATERIALS (p. 46-54)

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A new method for determining design and technological parameters and the number of cooker vats for the moisture-thermal oilseed meat treatment has been proposed. The peculiarity of this technique is that the set values of the mean and mean-square oilseed meat moisture were taken as the criteria for the validity of the calculated data.

A mathematical model of hydrodynamics of motion of the oilseed meat particles in the cooker vat was developed as a single process of motion of the oilseed meat fluxes along the horizontal concentric circles and along the vertical (meridian) ones traversing the vat axis. The basis of the model is the differential equation of particle motion along the blade rotating around the axis over the heated bottom of the cooker vat. The equation takes into account the design features of the stirrer, speed of blade rotation, length of the blades and physical characteristics of the oilseed meat expressed in terms of friction coefficients. Solution of the equation makes it possible to determine velocity of the particle in the direction of the blade and the circumferential velocity, the time of motion along the blade. This is the initial data for the axial movement of the oilseed meat. The time of passage of the oilseed meat along the agitator blade makes it possible to justify conditions of conductive heat exchange. The time of passage along the vat axis makes it possible to justify the conditions of convective heat exchange.

A discrete model of the moving contact layer of the oilseed meat at the hot surface of the vat bottom was developed. Moisture content of the oilseed meat was described by a matrix in which the number of rows is equal to the number of elementary layers and the number of columns is equal to the number of elementary time intervals. The mass of the dry oilseed meat substance is determined by the row vector of the matter mass in the thick layer.

Thermal balance of conductive and convective heat and mass transfer of the oilseed meat drying process has been compiled taking into account the heat spent for removal of the bound moisture from the solid phase which will ensure more accurate calculation of the technological conditions of cooking.

Keywords: cooking model, stirring hydrodynamics, conductive and convective drying, multi-vat cooker.

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RESEARCH INTO TECHNOLOGICAL PROCESS OF CONVECTIVE FRUIT DRYING IN A SOLAR DRYER (p. 55-63)

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We proposed a generalized procedure of convective fruit drying, which takes into account comprehensive combination of thermal-physical and physical-chemical properties of fruit with their kinematic heat and mass exchange characteristics.

We developed a mathematical model of heat, moisture and mass exchange for convective fruit drying, which considers moisture-yielding velocity of the dried material in the operation zone of the heat carrier under conditions of diffusion process of moisture transfer in the dried material. The given model allows us to determine heat and mass exchange characteristics and intensity of the drying process.

We proposed the systems of differential equations of heat and moisture transfer in the process of convective fruit drying for parabolic and uniformed original distribution of temperature and moisture content. As a result of the solution of a system of differential equations, we obtained appropriate dependences to determine the energy of bound moisture, moisture content on the surface and in the center of the material, difference of moisture content between the surface and central layers, as well as critical moisture content.

The obtained results may be used when predicting the heat and mass exchange processes, for improvement of technology and equipment for fruit drying in the solar dryer, for increasing technological and energy efficiency of the process.

Keywords: solar energy, solar fruit dryer, diffusion, moisture content, heat and mass transfer, intensification, convective drying.

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DEVELOPING THE MULTITEXTURE OF HYBRID STRUCTURE OF A SOLAR CELL (p. 64-71)

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Here we demonstrated the prospects to create effective and profitable organic multitextures for the frontal surface of the hybrid structure of solar cells by using a sol-gel method on macro- or mesoporous silicon. A problem of obtaining the desired size and depth of a macrotexture was investigated by using the additions of organic origin (organic acids, ketones, alcohols) in etchants. In the course of the present study, we managed to experimentally determine optimal conditions for receiving macro porous surface macro texture of silicon substrates. Formed by chemical methods of treatment, the surface of a silicon substrate of solar cell makes it possible to attain several significant advantages, the main of which is the existence of relief, enabling conducting the subsequent technological stages (fabrication of an organic multilayer stack using the sol-gel technology), which, if combined, can create on the surface of a silicon substrate a high quality optical system to capture luminous flux. Development of the technological process for the synthesis of sol-gel method was carried out using a low-molecular polymer and applying an AR coating, which represents spatial-crosslinked condensation structures of organosilicon gel – xerogel of polyorganosiloxane. This will make it possible to create a multifunctional organic multitexture for the frontal surface of a solar cell using hybrid technologies for obtaining PS, with a reduced cost of production, relatively large efficiency and simple technological process of the synthesis, which can be applied over large areas. Parameters of the multifunctional organic multitextures, which were created at the macro surfaces of substrates for SC, were explored using the method of mass spectrometry.

Keywords: solar cell, porous silicon, hybrid structure, sol-gel coating, multifunctional multitexture.

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