ABSTRACT AND REFERENCES

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DETERMINING ADDITIONAL POWER LOSSES IN THE ELECTRICITY SUPPLY SYSTEMS DUE TO CURRENT'S HIGHER HARMONICS (p. 6-13)

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The paper reports results of research into the influence of higher harmonics of the power source voltage and the load current on power losses in an electric network. The relevance of this study is predetermined by the ever-increasing number of the electric energy pulse consumers, which leads to an increase in the number of higher harmonics at power supply systems. In turn, higher harmonics cause deterioration not only in the qualitative indicators for electricity, but a significant reduction in energy efficiency as well. The study that we conducted has shown that existing analytical dependences of a network's active resistance on the higher harmonics' frequencies are mutually exclusive, contradictory, and inaccurate because they do not take into consideration the geometrical characteristics of the network conductors. Based on the first-order Bessel equations, we have obtained refined analytical dependences of a network's active resistance on the higher harmonics' frequencies, taking into consideration the geometrical properties of wires. It has been established that in addition to an increase in the active resistance value due to the influence of a skin effect, higher harmonics predetermine additional losses caused by an increase in the root-mean-square current value. We present the dependence of additional power losses and efficiency factor in the electric network as a function of values for the load current harmonic distortions coefficient and the coefficients for harmonic distortions in a power source voltage. It was established that the network current higher harmonics, caused by the pulse load, lead to the bigger losses in the network than the higher harmonics from the power source. The results obtained in this study could be used in the calculation of energy losses in electric networks due to higher harmonics and while estimating economic efficiency when introducing filter compensating devices.

Keywords: load current higher harmonics, power losses, harmonic distortions coefficient, skin effect.

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DEVELOPMENT OF PLANAR MESOSCALE COMBUSTOR WITH DOUBLE NARROW SLIT FLAME HOLDER AND VARIOUS ASPECT RATIOS FOR MICROPOWER GENERATOR (p. 14-23)

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We have investigated the effects of the aspect ratio of the rectangular mesoscale combustor with a narrow slit flame holder on the flame stability limit, flame behavior and uniformity of combustor wall temperature. The combustor was made of copper with a cross-section area of 6 mm^2. The combustor aspect ratio (A_R) was varied as 1, 1.5, 2.67, and 6. LPG and pure oxygen were premixed and the experiment was conducted at a limited flow rate. Pure oxygen is selected as an oxidizing agent with the intention of revealing in detail the range of flame stability within a very narrow quenching distance. All observed flames were inside the combustion chamber, not outside the channel. This research used a new type of flame holder namely double narrow slit flame holder as a flame stabilizer. The flame holder with double slit and a kind of bluff body in the center helps recirculate the flow and prolong the residence time to make the flame more stable. The use of double narrow slit flame holder successfully extended the stability map to a very lean equivalence ratio (ϕ), However, there was a dead zone near stoichiometry condition due to very high flame propagation speed. Aspect ratio had an important role for the non-circular combustor. The aspect ratio gave a great effect to determine the limit of the stability map that can be achieved at the rich mixture. The combustor with A_R=1.5 had the widest range of flammability limit, while A_R=6 had the narrowest flame stability limits. However, the latter reached the most uniform wall temperature, which is important to obtain high efficiency thermal to electric energy conversion. The results of this study can be used to determine the right fuel mixture on the mesoscale combustor as a heat source on the micro power generator/thermal electric system.

Keywords: flame stability limit, wall temperature, aspect ratio, double narrow slit flame holder, planar mesoscale combustor.

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RESULTS OF RESEARCH INTO EFFICIENCY OF A FLAT SOLAR AIR HELIOCOLLECTOR WITH A WAVY ABSORBING SURFACE (p. 24-36)

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A new design of the air collector with the airtight and warmed casing and the absorber with the wavy surface that can be used as an additional heating element of the low-temperature heat source was developed. We established a series of generalizing dependences for finding thermal effectiveness of the collector, specifically, the influence of the components of thermal balance of the collector on the drop of temperatures in the heat carrier flow in the collector and the insolation level on heating efficiency.

We obtained analytical dependences for determining the components of thermal balance of the collector, distribution of the temperature field along the absorbing panel, which made it possible to improve the mathematical model of the heat exchange process in the developed air collector. The results of the research into the air collector allowed developing the program of numerical computer calculation of the temperature field of thermal flows.

It was established that application of the wavy absorbing surface of the absorber in the air heliocollector at the low level of insolation E=377 W/m^2 allows increasing efficiency up to η=58.3 %, and at high energy lighting of E=1,000 W/m^2, up to η=63.9 %. Performance of the collector was determined by the iterative calculation-quantitative method and made up more than 78–80 %. This is 10–20 % higher than that in flat collectors, and by 5–10 % higher than in cylindrical vacuumed collectors.

The obtained results can be used in the development and improvement of the technical facilities of fruit drying, for increasing the technological and energy effectiveness of the process.

Keywords: heliocollector, air heating system, absorber, heat flow, Rayleigh criterion, heating efficiency.

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INFLUENCE OF THE MEAN VOLUMETRIC TEMPERATURE OF A THERMOELEMENT ON RELIABILITY INDICATORS AND THE DYNAMICS OF A COOLER (p. 36-42)

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The paper deals with the influence of the mean volumetric temperature of a thermo-element branch on the basic parameters, reliability indicators and the dynamics of operation of thermoelectric cooler under different temperature changes at the assigned heat load, geometry of branches of thermo-elements for specific current operation modes. It was shown that the mean temperature of the thermo-element, which is a reference point when calculating the energy performance of the thermoelectric cooler, can be used only for calculations in the stationary operation mode. Its use in the dynamic mode leads to significant errors. It was proven that the mean volumetric temperature of a thermo-electric branch can be such a reference point for a dynamic mode. The ratio for assessment of the mean volumetric temperature depending on the relative operating current was determined. The relationships between the mean volumetric temperature of a thermo-element, the time required to enter a stationary mode, the required number of thermo-elements, the differences between the mean volumetric and the mean temperature, and a cooling coefficient, depending on the relative working current, were analyzed. It was shown that at an increase in the mean volumetric temperature at the assigned current operation mode and a temperature difference, exceeding 40K, the magnitude of operating current, the number of thermo-elements, consumption power, failure rate and time constant decrease and cooling factor increases. The time for entering a stationary mode during the transition from the mode of minimum failure rate to the mode of maximum cooling capacity decreases by 5 %, while the failure rate increases by 16 %.

The practical significance of the conducted research is both to improve the quality of design of coolers and to select the necessary modes of thermo-electric system for ensuring thermal modes of electronic equipment depending on the importance of dynamic or reliability criteria of control.

Keywords: thermo-element branch, mean volumetric temperature, reliability indicators, dynamics of cooler.

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SYNTHESIZE OF THE INTEGRATIVE TRIGENERATION SYSTEM FOR A «SOLAR HOUSE» IN THE MIDDLE EAST REGION (p. 43-50)

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This research aims to synthesize a trigeneration system for a "solar house" based on an autonomous small solar photovoltaic plant,

which could meet the year-round private consumers' needs for heat and cold supply.

The climatic data on the Middle East countries, such as Iran, Saudi Arabia, the United Arab Emirates, Turkey, Syria, and Iraq, were used. Day and night air temperatures in different regions of these countries throughout the year and the total daily radiation, which comes onto a horizontal surface area, were determined. The obtained results revealed that the entire territory of the Middle East is suitable for the development of solar power supply. Seasonal and daily temperature fluctuations require the year-round use of artificial cold for air conditioning and heating of premises. As a result of the analysis, the generalized circuit solution of the small integrated trigeneration system, based on the photovoltaic solar station, was synthesized. Additional solar collectors with a water heater-accumulator provide hot water supply. Air conditioning and heating are provided by a refrigerating machine. The time of modes change is determined by ambient temperature, which does not correspond to comfortable temperature in particular premises. The temperature mode in premises is maintained by the fresh air flow from the active ventilation system, cooled or heated in heat-exchanger of a machine. To harmonize the operation of all elements of the system, the toolkit for determining thermal loads and temperatures modes on premises and elements of the trigeneration system were developed. The study makes it possible to argue that "solar houses" can solve energy, environmental problems of regions, satisfy the social needs of the population in the Middle East countries.

Keywords: solar house, photovoltaic station, trigeneration, compressor refrigerating machine, active ventilation.

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EFFECT OF BACKWARD FACING STEP ON COMBUSTION STABILITY IN A CONSTANT CONTACT AREA CYLINDRICAL MESOSCALE COMBUSTOR (p. 51-59)

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This experiment investigates the effect of backward facing step size variation on combustion stability in the cylindrical meso-scale combustor with the constant contact area. The backward facing step was varied by changing the combustor inlet diameter while the combustor diameter at the combustion zone was kept constant, i.e. has a constant contact area. Butane gas (C_4H_{10}) was used as fuel with air as an oxidizing agent. The result shows that the backward facing step has an important role in the combustion stabilization mechanism. Stable flame could be stabilized inside the meso-scale combustor with the backward facing step. Without the backward facing step, the flame blows out, then stable at the combustor rim. Recirculation flow occurs in the area behind the backward facing step. The increasing backward facing step size leads to an increase in reactant inlet velocity, recirculation flow size and shear stress in the area near the backward facing step. At large backward facing step size, the high reactant inlet velocity together with the large shear stress quenches the flame while the heat recovered by recirculation flow is less sufficient to stabilize

flame so that the flame drifts to the downstream position. Hence bigger backward facing step size causes narrower flame stability limit area. The smaller the backward facing step size the wider the flame stability limit which shifts more toward lower equivalence ratio and high reactant velocity regions. Decreasing the backward facing step size decreases the reactant velocity into the combustion reaction zone as well as decreases the recirculation flow and the shear stress, so that the quenching effect decreases. The smaller recirculation flow has a better function for the flame holder to increase flame stability inside the meso-scale combustor. Therefore, small backward facing step size has a very important role in recovering heat energy stabilizing the flame in the meso-scale combustor.

Keywords: backward facing step, cylindrical meso-scale combustor, constant contact area, flame holder, flame stability limit.

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IMPROVING ENERGY EFFICIENCY OF COAL TRANSPORTATION BY ADJUSTING THE SPEEDS OF A COMBINE AND A MINE FACE CONVEYOR (p. 60-70)

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The object of this research is the process that forms the weighted specific energy consumption for the transportation of rock mass by a coal face scraper conveyor at intensive coal mining under conditions of the non-uniform movement of a cleaning combine. The subject of this study is the regularities in the influence of uneven feed speed of a cleaning combine on energy indicators for the transportation of breakage face by a scraper conveyor under conditions of intensive coal mining. The aim of this work is to substantiate a technique to improve energy efficiency in the operation of the system "Cleaning combine – mine face conveyor" under intensive coal mining conditions. We have statistically processed the results of experimental research into feed

speed of the cleaning combine KDK500 at the eastern coal face No. 23 of deposit c_{11} at the mine "Yuzhnodonbasskaya" (Ugledar, Ukraine) of GP "Donetskugol", undertaken by the Institute "Dongiprouglemash" (Ukraine). We have constructed the structural and mathematical models of the process that enables the output cargo flow of breakage face and forms specific energy consumption for the transportation of rock mass by a coal face scraper conveyor. A mathematical model of the operating process takes into consideration the impact of the magnitude and non-uniformity of the feed speed of a cleaning combine on energy consumption at cargo transportation. We have established significant non-uniformity in the speed modes, in the productivity of a cleaning combine, caused by the mining-geological conditions and the nature of the technological process, by existing procedures for harmonizing the operational modes of mining and transporting equipment at breakage faces. The influence has been established of speed modes and efficiency of the combine on specific energy consumption for the transportation of cargo by a coal face scraper conveyor. The result is the high irregularity of a cargo flow both along a coal face and along further transport chain, which leads to a significant increase in energy consumption for cargo transportation. We have examined the effect of speed modes during operation of a combine, consequently its efficiency, on energy indicators for the process of coal transportation and the distribution of a cargo flow. It was established that increasing the feed speed of a cleaning combine and decreasing the speed of a scraper conveyor bring down specific energy costs for the transportation of discharged rock mass along a coal face.

Keywords: coal combines, specific energy consumption, mine face scraper conveyers, cargo flow characteristic, direction of combine's motion.

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DEVELOPMENT AND INVESTIGATION OF THE REDUCED MATHEMATICAL MODEL OF THE PROCESS OF BAKING CARBON PRODUCTS (p. 70-78)

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The development of optimal control of the process of baking carbon products involves consideration of the influence of characteristic zones of the furnace and uniformity of the temperature field of workpieces. This statement suggests the development of a distributed-parameter mathematical model of the furnace. It is known that the calculation time of such models is quite large, and then their application in real time is impossible. According to the above, for further development of the optimal control system of the baking process, there is a need to reduce the full mathematical model providing the necessary calculation time.

The reduced mathematical model of the baking process, which differs from the known models in shorter calculation time was developed and investigated in compliance with accuracy requirements.

It is found that for cases of using n>15 first basis vectors, the restriction on the permissible error of approximation of the values of Fourier coefficients is fulfilled. The possibility of choosing the optimal structure of identification models determines the possibility of obtaining temperature images of the reduced mathematical model with the necessary accuracy.

The results obtained allow flexible selection of the reduced mathematical model in accordance with the technical capabilities of computing equipment.

Given that in the process of baking carbon products, the defining temperatures are workpiece temperatures, only control points of workpieces were selected for the quality study of reduced models.

Since the process of baking carbon products consists of three main stages, three reduced mathematical models of these stages were implemented for adequate modeling of such a process.

The study of the accuracy of reduced models included comparisons of temperature values calculated by the reduced model with temperatures calculated by the initial model, which in this case was considered as a generator of experimental data.

Keywords: baking process, temperature fields, variable separation method, carbon products.

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ASSESSMENT OF EFFICIENCY OF DRYING GRAIN MATERIALS USING MICROWAVE HEATING (p. 78-85)

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We present results of experimental work on studying the drying of a dense layer of grain using microwave heating. We investigated a series of techniques to supply heat to grain to assess energy efficiency of a microwave field. We studied the following ways of drying: a microwave method, a pulsating microwave method, a microwave-convective cyclic method with blow of a layer with heated air flow and air without preheating, simultaneous microwave-convective drying method.

Studying the kinetics of drying in a microwave field showed that we can divide the process into heating periods (zero drying rate), constant (first drying rate) and falling (second drying rate). These periods are characteristic for drying of colloidal capillary-porous

bodies at other methods of heat supply. We obtained empirical relationships for the drying rate and the average temperature of grain in the first period based on the generalization of experimental data on the study on drying of grain of buckwheat, barley, oats, and wheat. We presented kinetic dependences in a dimensionless form. They summarize data on the studied grains. The aim of comprehensive studies of various methods of heat supply during drying was determination of the optimal method and rational operational parameters, which ensure high intensity of the process and the required quality of the finished product with minimal energy consumption.

All studies took place under identical conditions and for the same grain (oats) to ensure the accuracy of the comparison. We determined that the most preferable method is a simultaneous microwave-convective energy supply without air preheating, which minimizes specific energy consumption. Experimental studies on drying using a microwave field made possible to select the required process parameters: power, heating rate, mass, and form of loading. We plan to develop a technology for drying of grain using microwave energy based on the study data.

Keywords: microwave heating, microwave-convective, moisture content, temperature, drying rate, optimal method.

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