ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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DEVELOPMENT OF THE GRAPHICAL-ANALYTICAL METHOD FOR CALCULATING ELECTRIC LOAD AT CIVILIAN OBJECTS (p. 4-9)

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The calculation method is proposed for electric load at civilian objects, whose novelty, in contrast to determining in line with the acting standards, is in the improvement of its determining accuracy. This will be made possible by developing chart models of the load of electrical receivers, their synthesis at the inputs of civilian objects. The original information for modeling is obtained in advance by measuring chart parameters of similar functioning systems of power supply. The implementation of the proposed method would bring down the cost of material and energy resources.

We constructed theoretical and actual mathematical models of their dynamics using the function «cspline (x,y)» embedded in MathCAD, extending the interpolation curve with a cubic parabola.

We evaluated the errors of theoretically calculated, relative to actual, specific electric load at civilian objects, under conditions of the city of Odessa.

Using the graphic-analytical method would improve accuracy in the calculation of electric load by 1.5–3.5 times compared with that determined in line with the standards. This could save energy resources, capital expenditures on the construction and operation of power supply systems.

Keywords: graphic-analytical method, housing and communal services, electric load, chart modeling, calculation error.

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IMPROVEMENT OF THE CONTROL SYSTEM OVER DRUM BOILERS FOR BURNING COMBUSTIBLE ARTIFICIAL GASES (p. 10-16)

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One of the promising directions in the development of power industry in Ukraine is the implementation of low-cost activities with a fast payback period, which would make it possible, without attracting significant funds, and in the shortest possible time, to bring down fuel and electricity consumption. Such activities could include the use of the new structural circuits of automated control at the existing steam generators running on organic fuel, which will allow, without a substantial equipment modernization, the use of combustible artificial gases as fuel.

A limiting factor for the combustion of artificial gases in energy drum boilers is their low calorific value and insufficient throughput of the regulating valve, which depends on density of the regulated medium.

We examined a possibility of burning artificial gases in energy boilers without considerable modernization of basic equipment (replacement of burners and controlling elements, installation of additional steam generating equipment) both for a single drum boiler and a group of boilers operating in the common steam line. In both cases, in order to increase the throughput, a gas compressor is employed. It was established that for the aligned work of the compressor with a heat load ACS of one boiler, it is necessary to define a transfer function of the communication device. To control a group of boilers, we synthesized multidimensional optimal ACS that would make it possible to improve the integrated quality indicators to regulate pressure and consumption of superheated steam.

The implementation of the obtained technical solutions will improve energy security and effectiveness of the industrial potential of Ukraine.

Keywords: drum boiler, automated control system, artificial combustible gases, technological section.

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EXPERIMENTAL STUDY OF HEAT TRANSFER AND HYDRAULIC RESISTANCE AT CROSS FLOW OF TUBE BUNDLE WITH INDENTATIONS (p. 17-21)

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The results are given on experimental study of heat transfer and hydraulic losses at the cross flow of a five-row tube bundle arranged in the staggered mode, the external surface of which is covered with conic-shaped dimples. The tube's spatially averaged heat transfer was measured by means of the melting ice technique. As a result, the heat transfer coefficients were determined both for separate tube rows and the whole bundle. The hydraulic losses of the tube bundle were also found for the same conditions in the form of the Euler number. The Reynolds number was defined on the external tube diameter and flow velocity in the minimal cross section of the bundle and was in the range of 3000...25000. In the heat transfer determination, the surface of a smooth cylinder was used without the surface of the dimple area. The heat transfer augmentation rate of 34...40 % at the pressure losses growth by 10...15 % was obtained. The Reynolds analogy factor (thermal performance) value is 1.17...1.27. The similarity relations for the Nusselt number and Euler number as a function of the Reynolds number were obtained. These relationships allow determining the coefficients of heat transfer and hydraulic resistance in the development of tube-type heat exchange equipment. The results of this study can be used for the development of compact tube-type heat exchangers with a high thermo-hydraulic performance parameter.

Keywords: tube bundle, cross flow, surface indentations, heat transfer coefficient, Euler number.

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EXAMINING A CAVITATION HEAT GENERATOR AND THE CONTROL METHOD OVER THE EFFICIENCY OF ITS OPERATION (p. 22-28)

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The cavitation heat generator for decentralized heating of industrial buildings and facilities was examined and implemented for actual operation. On this basis, a thermal system for decentralized heating of buildings was designed and studied. The circuit of the thermal system differs by the following feature: two connected cavitation heat generators are connected in series for heating of the liquid. At the same time, the heated liquid passes through a heat generator operating at high frequency, then through a heat generator operating at lower frequency. In the generator with high frequency, smaller cavitation embryos are excited, which increase in size in the generator with low frequency. This leads to increased impulses of cavitation pressure and increases the effect of cavitation.

On this basis, a heat system for decentralized heating of buildings was designed, and studied, with its energy efficiency. To increase energy efficiency of the thermal system with cavitation heat generators, their sequential installation was proposed. The heated liquid must pass successively through a heat generator operating at high frequency, then through a heat generator operating at lower frequency.

The efficiency of the system developed exceeds 18 % compared to the system of centralized heating by natural gas, which is a convincing prospect of use.

A method for effective control over the cavitation process during operation of a heat generator was developed, based on the suppression of waves of oscillatory energy of the object. The method is based on direct measurements of vibrations – a parameter characterizing the process of cavitation. Approbation of the method for control over effectiveness of the cavitation process was carried out by measuring the vibrations at various temperatures of liquid at the outlet.

Keywords: cavitation, rotary-impulse device, cavitational heat generator, compensation of oscillatory energy waves, dynamic vibration compensator.

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ANALYSIS OF THE MODEL OF INTERRELATION BETWEEN THE GEOMETRY OF THERMOELEMENT BRANCHES AND RELIABILITY INDICATORS OF THE CASCADE COOLER (p. 29-39)

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We examined influence of the geometry of thermoelement branches and the distribution of thermoelements in cascades of the two-cascade thermoelectric cooling devices on the reliability indicators. An analysis was conducted for the operating range of temperature difference, nominal thermal load under the mode of maximum refrigeration capacity at preset current. A mathematical model was constructed, connecting reliability indicators of the cooler and the geometry of thermoelement branches, distribution of thermoelements in the cascades, temperature differential and operating current in the cascades, and thermal load.

We ran an analysis of the model, which showed that the failure rates and the probabilities of failure-free operation demonstrate clearly pronounced extrema that can be applied when designing the two-cascade thermoelectric cooling devices with enhanced reliability. The analysis of the obtained model revealed that the variation of the geometry of thermoelements and their distribution in the cascades could be employed to achieve a two-time reduction in the failure rate of a thermoelectric cooler and a corresponding increase in the probability of failure-free operation.

Keywords: two-cascade thermoelectric cooling device, geometry of thermoelement branches, reliability indicators.

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INVESTIGATION OF THERMO-AERODYNAMIC CHARACTERISTICS OF BANKS OF TUBES WITH PUNCHED SPIRAL FINNING (p. 40-48)

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An application of tubes with punched spiral-tape finning is promising for heat exchange intensification in convective heating surfaces of boilers and boilers-utilizers. Results of experimental research into thermo-aerodynamic characteristics of specified heating surfaces are presented. As a result of research, heat exchange intensification by 17...32 % due to fin punching was established. Heat transfer increases at an increase in the Reynolds number and a decrease in the degree of finning. Dependence of heat transfer on the accepted parameter for characterizing the bank geometry – relative to longitudinal pitch of tubes – is extreme with peaks in domain of variability relative to longitudinal pitch of 2.7...3.5. Efficiency of punched finning was determined. Results of the study of aerodynamic resistance showed its increase by 18...40 % due to the punching of fins. Resistivity increases at an increase in reduced length of the extended surface, and decreases at an increase in ratio of transverse pitch of tubes of the bank to longitudinal pitch and in Reynolds number. Results of experiment were generalized and formulas for engineering calculations of heat exchange and aerodynamic resistance of in-line tube banks with punched spiral finning were proposed. The formulae hold in domains of variability of defining parameters: finning coefficient ψ=6.01...9.012, relative longitudinal pitch of tubes in banks σ_2=2...6, Reynolds numbers Re_d=6·103...4·104 and Re_e=5·10^3...4·10^4, ratios of tube pitches S_1/S_2=0.4...2.5 and reduced length of extended surface – H/F= =4.58...30.45. We established the intervals variability in ratio of pitches of tubes, in which thermo-aerodynamic efficiency of in-line and staggered tube banks is maximal, respectively: 1.0...1.5 and 2.0...3.0. Within these intervals, values of the Kirpichov criterion are, respectively, E=125...150 for in-line and 75...80 for staggered banks. Formulae establish relationship between Nusselt and Euler criterion with geometric characteristics of banks and Reynolds numbers.

We determined thermo-aerodynamic efficiency of in-line and staggered banks of tubes with punched spiral finning by results of experimental studies. In-line banks have higher efficiency. As a result of calculation research into thermo-aerodynamic efficiency of four types of heating surfaces of a powerful boiler-utilizer, in-line tube banks with punched spiral finning turned out to be more efficient by this parameter. The Kirpichov criterion for these tube banks, located in one shell, is 319, for staggered tube banks with punched finning – 228.8, for staggered tube banks with continuous finning – 223.8, and for staggered bare-tube banks – 143.0.

Keywords: heat exchange intensification, aerodynamic resistance, punched spiral finning.

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INFLUENCE OF ENERGY CHARACTERISTICS OF SURGE ARRESTERS ON THEIR SELECTION (p. 48-55)

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For analysis of thermal processes occurring in SA under conditions of presence of overvoltage of different nature in the electric network, it is necessary to conduct research using volt-ampere characteristics. Thus, energy, released in SA, has to be determined. This approach is essential for correct selection of parameters of SA not only in terms of protection of electrical networks, where it is installed, but also to provide proper operation of a protective device itself. This approach will allow choosing parameters of SA at a design stage, which greatly reduce emergency rate throughout the entire period of operation.

Presented results of calculations show that at standard pulse of atmospheric overvoltage, SA maintains thermal balance at values of current of lightning of up to 75 kA. Design lightning currents for electrical networks are about 30 kA. However, it should be noted that this approach cannot be applied to the selection of SA

in the assigned network, because it may be different in values of amplitudes of lightning currents, rates of increase and the number of lightning strikes in one channel (as we know, there may be 10 of them). All presented parameters will influence thermal balance of SA, and, at some values, they can lead to its disturbance, which will cause the failure of SA and the damage to equipment of electric network. This conclusion emphasizes the need for detailed analysis of overvoltage that may occur within the network when selecting parameters and the place of SA installation. Taking into account the magnitudes and composition of overvoltage will make it possible to provide serviceability of SA throughout the entire period of operation.

Keywords: non-linear overvoltage limiter, volt-ampere characteristic, thermal modes of voltage limiter, overvoltage energy.

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DEVELOPMENT OF ENERGY-SAVING TECHNOLOGY TO SUPPORT FUNCTIONING OF THE LEAD-ACID BATTERIES (p. 56-64)

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Based on mathematical and logical modeling, a technological support system for changing the battery capacity based on the prediction of voltage variation in measuring the temperature of electrolyte in the volume of the batteries was developed in the composition of a technological system for battery operation. The developed technology makes it possible: to control operational capacity of the accumulator battery in order to obtain a functional assessment of change in the total charge and discharge voltage; to obtain an integrated reference estimation of change in the charge and discharge volt-age; to develop an integrated system for assessing a change in the voltage of the battery, which enables maintaining capacity of the accumulator battery when measuring the temperature of electrolyte at the input to the battery. The limiting temperature change of electrolyte, – 35 °C, was determined at charging with direct current supply and a limit-ing voltage change for a further charge and discharge was established with a change in the consumption of electric energy. The use of an integrated system for the estimation of voltage change obtained based on the alignment between electrochemical and diffusion processes of discharge and charge makes it possible to take timely decisions on recharg-ing to prevent recharge and unacceptable discharge. Coordination of the electrochemi-cal and diffusion processes that accompany charging and discharging of the battery makes it possible, for example under conditions of functioning of a wind power plant with a capacity of 10 kW, to reduce the cost of production of energy and the payback period of the wind power plant by up to 25 % due to a reduction of the charge period and prevention of gas formation.

Keywords: lead-acid accumulator, mathematical and logical modeling, decision making.

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ANALYSIS OF OPTIMAL OPERATING MODES OF THE INDUCTION TRACTION DRIVES FOR ESTABLISHING A CONTROL ALGORITHM OVER A SEMICONDUCTOR TRANSDUCER (p. 65-72)

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The study addresses determining optimal operating modes of the induction traction drive. We identified optimal operating modes of the autonomous voltage inverter at different temperatures of windings of the traction motors for a tram carriage and a diesel locomotive.

The identification is carried out of optimal parameters in the operating modes of autonomous voltage inverter of the traction drive of a tram and a diesel locomotive. We obtained dependences of performance efficiency and electromagnetic torque of the induction traction motor on the rotation frequency and temperature of the windings for the following modes: acceleration, recuperative braking, and maintaining preset speed.

We determined operating modes of induction traction drive of the tram Tatra T3 VPA and the diesel locomotive 2TE25A over the entire range of motors' rotation frequency at spatial-vector and one-time pulse-width modulation of the semiconductor inverter for different values of temperature of the motor's windings. A technique was devised for this purpose, which is based on solving a problem on the optimization of parameters of the traction drive using a combined method that employs genetic algorithms and the Nelder–Mead method.

It was established that dependences of change in the transition point from the spatial-vector to the one-time PWM on the temperature of traction motor for a tram and a diesel locomotive are not similar. Different level of the location of this point is predetermined by the different load in magnetic circle of the motor, by different level of saturation coefficient. The difference in saturation coefficient is 0.15–0.4 r.u.

Keywords: traction induction motor, identification of optimal operating modes, performance efficiency of traction drive.

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