ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

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EXERGY ANALYSIS OF THE OPERATION OF A SOLAR DRYER (p. 4–11)

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The study considers the exergy analysis of rational ways to use and store thermal energy in a solar dryer in order to increase the exergy efficiency of the technological process of fruit drying at individual farms.

We analyzed the application of solar energy for the technological process of fruit drying in individual farms based on an exergy analysis of a solar dryer operation. We carried out full-time tests of a solar dryer at the latitude of the location of Rivne oblast (Ukraine), which has an average annual solar power of 3.41 kW·h/m^2 per day. Therefore, this makes it possible to obtain from 74.8 to 123.1 MJ of solar energy per day from 1 m^2 of an air collector area.

We improved the procedure of an exergy analysis of operation of a solar dryer, which is based on the simplified mechanism of calculation of an exergy balance of a plant depending on physical parameters of the environment relative specific territory of a farm.

The performed complex of calculation-quantitative studies confirmed the possibility of significant intensification of fruit drying process in a solar dryer. We established that heat losses during fruit drying in a solar dryer make up 3...3.7 MJ/kg, and the degree of intensification increases by 3.3...12 times. The exergy efficiency of a solar dryer without the use of a thermal battery is 87.6 %; with it – 89.8 % with the use of a thermal battery. The exergy efficiency of a solar dryer increases by 1.02 times. We achieved such results by using a flat mirror concentrator and a thermal battery in a solar dryer.

An applied aspect of using the results obtained is the possibility to increase the energy efficiency of fruit drying process based on exergy express-analysis of the efficiency of a solar dryer. It will reduce the cost of energy resources by using solar energy. It creates a prerequisite for the transfer of technological solutions for justification of exergy balances for various characteristics of fruit drying process in a solar dryer.

Keywords: exergy balance, solar dryer, solar energy, heat transfer, intensification, convective drying.

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IMPROVEMENT OF RELIABILITY OF FIRE ENGINEERING EQUIPMENT BASED ON A JET-NICHE TECHNOLOGY (p. 12–19)

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The obtained results address the solution to problems on enhancing the reliability and operation efficiency of fuel consuming equipment at industrial and power engineering facilities in the course of low-cost modernization through the introduction of effective fuel combustion technology.

Using statistical methods of experiment planning, regression dependences of boundaries of the detachment work of burners were obtained. Solving the optimization problems for the derived functions made it possible to select the values of fuel distribution parameters for natural and liquefied gases with the purpose of decreasing the operation technical minimum of FE loading. As a result, possibilities of starting the equipment at gas pressure P_{start}=10 Pa were achieved and minimally possible workload of FE was decreased up to 5...10 % of the nominal, which corresponds to the coefficient of working load regulation K_R>10. The presented results on improvement of starting characteristics of burners, as well as reserving of natural gas by liquefying will make it possible to ensure reliability of FE operation. A decrease in starting consumption minimizes the possibility of gas contamination of the furnace space (explosiveness) and decreases thermal intensity of FE elements, preventing the thermal «shock» on the heat exchange surface of the equipment.

Keywords: flame stabilizer, burner device, «poor» flame-out, fuel distribution, liquefied gas.

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RESEARCH INTO AERO ACOUSTIC CHARACTERISTICS OF TWO-ROW IMPELLERS OF THE AXIAL COMPRESSOR (p. 20–24)

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We have conducted numerical simulation of current in the axial impellers with a single-row and a two-row geometrically equivalent blade crowns with a density of blade crowns over average radius of 1...2.5. The pressure characteristics of impellers obtained at $q(\lambda)=0.45...0.8$ show that using the two-row impellers can improve the pressure of a stage over the entire range of operation. Under the flow-around modes that correspond to the maximum pressure, the degree of pressure rise increases by 10.5 %. The research results showed that the two-row impellers demonstrate the higher level of losses compared with the level of losses in the equivalent single-row impellers. We have obtained results of research into aero acoustic characteristics of subsonic two-row impellers of the axial compressor.

The research results showed that the use of two-row blade crowns in the impeller makes it possible to reduce the level of acoustic pressure in the range of operation $q(\lambda)=0.45...0.8$ by 0.5 dB to 3.2 dB at a density of blade crowns over average radius of 1...2.5. The replacement of a single-row blade crown in the impeller of a stage of the axial compressor with the equivalent two-row blade crown could ensure the enhancement of aerodynamic loading on the stage and reduce acoustic emission of the compressor.

Keywords: aero acoustic characteristics, two-row impeller, pressure, loss of full pressure.

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ANALYSIS OF POSSIBILITIES FOR IMPROVING ENERGY INDICATORS OF INDUCTION ELECTRIC MOTORS FOR PROPULSION COMPLEXES OF AUTONOMOUS FLOATING VEHICLES (p. 25–32)

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This study proposes additional possibilities to improve, at minimal efforts, a number of technical-economic indicators of three-phase standard industrial induction motors (IM). We suggest that such engines should be used in the propulsion complexes of modern autonomous floating vehicles (AFV). Such a task is to be solved because of the need to provide the propulsion complex of AFV with energy-efficient and inexpensive electric motors. It is proposed to apply four-pole electric motors, instead of bipolar electric motors, at an elevated rated power frequency (100, 150, 200 Hz). Employing the method of analogies of geometrically similar electric machines, it is substantiated to apply the shortened three-phase four-pole IM instead of bipolar IM. We have conducted a detailed analysis of the basic structural and energy characteristics of the modernized general-purpose IM. It was established that in the modernized four-pole IM of the AFV propulsion complex the weight and size parameters are significantly reduced (by approximately 15 %). This is enabled by a simple structural modernization. Given such a modernization, it is not necessary to manufacture new bearing assemblies, lids; in this case, mass of the utilized active materials decreases (by 10...17 %). The research results make it possible to meet the needs of modern AFV production in energy-efficient (power factor of modernized engines is approximately 0.56) and inexpensive electric motors for a propulsion complex.

Keywords: autonomous floating vehicle, three-phase induction electric motor, frequency converter.

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SIMULATION OF A GAS AND AIR FLOW EXHAUSTED BY PRODUCTION EQUIPMENT (p. 33–42)

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The paper provides the results of researching the influence of the gas and air flow at the exit from the pipeline of

the technological channel on the performance of a gas and air power unit. It has been determined that in order to obtain the maximum electrical energy by the gas and air power unit, it is necessary to take into account the influence of the gas and air flow. In this case, the location of the generator's propeller in the field of the gas and air flow has a significant effect. The energy parameters of the gas and air flow are influenced by the parameters of the fan, the generator, the process channel and the generator's propeller. A technique was developed to analyse changes in the speed of the gas and air flow at the exit from the pipeline. The physical equations included in the method characterize the processes occurring in the gas and air channel. In this case, the law of conservation of mass and the pressure balance in the form of a system of differential equations for a section before and after the propeller of the generator are used. The dependencies of the air flow rate variation on the output power of different types of fans are calculated. It has been shown that in order to increase the air flow speed at the exit from the pipeline, it is necessary to increase the output power of the fans.

A mathematical model was constructed to analyse gas and air flows before and after the propeller of the generator when changing its distance from the process channel exit, its parameters, and the parameters of the generator's propeller. The model includes equations on the conservation of mass, momentum, and energy of a non-stationary spatial flow. The equations are represented in the Cartesian coordinate system that rotates with an angular velocity around the axis passing through its origin. The model also includes equations on the kinetic energy of turbulence and the dissipation of this energy. The study provides the results of the computer simulation of the process of distribution of the gas and air flow blown by a fan of the working unit. The research was done using the SolidWorks Flow Simulation software environment. The article presents the simulation results that helped obtain the recommended limits of the best location of the generator propeller in the field of the gas and air flow to produce the maximum amount of electrical power by the gas and air unit.

The adequacy of the obtained results of the computer simulation of the process of air flow production by a fan has been verified by conducting experimental tests on the laboratory facility. It has been determined that the practical value of the results obtained is the possibility of using the proposed analytical dependencies to develop algorithms for controlling the performance of the gas and air power unit.

Keywords: gas and air power unit, gas and air flows, technological channel, electrical power, laboratory facility.

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IMPROVING POWER EFFICIENCY OF PNEUMATIC LOGISTIC COMPLEX ACTUATORS THROUGH SELECTION OF A RATIONAL SCHEME OF THEIR CONTROL (p. 43–49)

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The work addresses solving important problems that occur when using pneumatic actuators, namely energy saving and expanding the scope of its use by covering the zone of large inertial loads at a constant maintenance of the actuator's operability.

A rational structure of the pneumatic actuator based on a change in the structure of commutation links was determined. It ensures the following advantages over a discrete actuator:

– an optimal form of the transient and high braking effect in the PA which are achieved by simultaneous pressure growth in the exhaust chamber and pressure differential in the working chamber up to ensuring a constant negative pressure differential at which a constant negative acceleration during braking takes place;

– in the braking phase, not only transit working capacity but also potential energy of expansion of the compressed air in the working chamber is used;

– the compressed air from the braking chamber is not irrevocably transformed into thermal energy but is returned to the feed line through the opened return valve (recuperation mode is realized);

– the compressed air consumption for fixing the piston in the final position is significantly reduced;

– due to the minimum pressure p_k in the exhaust chamber at the initial moment of the piston motion, nonproductive work of ejection of the compressed air from the exhaust chamber is substantially reduced.

Thus, the complex nature of reducing nonproductive energy inputs creates an energy saving effect that makes it possible to reduce energy inputs by 4–10 times in the rational scope of use of this actuator ($\chi < 0.2$ and $\beta < 2$).

The engineering procedure for solving the basic problem of functional and cost analysis was demonstrated on a specific numerical example: comparison of lump sum and operational costs in making a decision on the expediency of use of the new solution in practice.

Keywords: pneumatic actuators, braking, the structure of commutation links, growth of inertial loads.

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DEVELOPMENT OF THE ALGORITHM FOR THE AUTOMATED SYNCHRONIZATION OF ENERGY CONSUMPTION BY ELECTRIC HEATERS UNDER CONDITION OF LIMITED ENERGY RESOURCE (p. 50–61)

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A special feature of the proposed algorithm that automatically synchronizes operation of electric heaters is to divide the heaters into prioritized and non-prioritized ones, with subsequent synchronization of operation of the prioritized heaters in time so that the non-prioritized heaters would receive the maximum amount of excessive electric resource. The first condition for the prioritized heaters is the predictability of their modes of operation, when it is possible to predict the times of their turning on and off and to apply this information in order to synchronize operation of the heaters. The second condition is the maximal utilization of the proposed electric resource under condition of simultaneous connection of all prioritized heaters. The synchronization of operation of the prioritized heaters in time is based on two rules – in case among the non-prioritized heaters there are more heaters with a greater capacity, the prioritized heaters combine their work so that at moments of their simultaneous shutdown they would offer a resource to more powerful non-prioritized heaters. And when among the non-prioritized heaters there are more heaters with a less capacity, the prioritized heaters distribute their operation in time in order to constantly offer the resource to less powerful non-prioritized heaters. Such a coordinated work of prioritized and non-prioritized heaters in time makes it possible to use, at any time, the proposed electric resource for heating to the fullest.

Taking into consideration the amount of electricity used for heating the premises by the algorithm that automatically manages the allocation of power among heaters, as well as control over this parameter, allows the user to find a balance between a comfortable temperature at the premises and the amount of electricity consumed. This in turn is a precondition for the transition to energy efficient electric heating of buildings.

The result of study into the patterns of the process of allocation of power among electrical heaters based on the proposed algorithm confirmed effectiveness of the synchronization of operation of heaters at electric heating at premises. It was established that the duration of synchronization of heaters in time is between 1 to 2 minutes. Therefore, the procedure of change in the optimal combination of prioritized heaters and the synchronization of their operation makes sense only when the period over which other household appliances are connected to the grid exceeds 4 minutes. We also confirmed the possibility to control temperature regimes at premises by changing the limit of power for electric heating. It was established that when changing conditions of heating or power consumption, the period for the adjustment of thermal modes in heated zones due to a change in the power limit is 15–20 minutes.

The proposed algorithm that automatically synchronizes power consumption by electric heaters could be used in order to improve existing systems that manage energy supply in a house. As an additional feature of modern systems, it would allow private users to directly participate in the management of power consumption in their house in order to save electricity.

Keywords: electric heating, heater with a thermostat, power allocation, automated management of power consumption.

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DEVELOPMENT OF CLEANING METHODS COMPLEX OF INDUSTRIAL GAS PIPELINES BASED ON THE ANALYSIS OF THEIR HYDRAULIC EFFICIENCY (p. 62–71)

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The majority of gas and gas condensate fields of Ukraine are developed by pressure depletion, which makes it possible to stabilize production only in conditions of low working pressures at the wellhead. In turn, the working pressure values significantly depend on the pressure at the inlet to the gas gathering stations and pressure loss in the gas gathering and transportation process. Consequently, their reduction will lead to an increase in natural gas production from depleted fields.

The main idea of the work is to offer continuous monitoring of the gas gathering system in order to detect changes in the thermobaric operation mode. Such changes can signal the high probability of liquid accumulation, which will produce additional friction.

The results of monitoring changes in pressure, temperature, dew points and natural gas composition allow carrying out their complex analysis and evaluating the possibility of liquid mass formation in certain areas of the gas pipeline system with an acceptable accuracy, which at once excludes a more detailed recording of their presence by means of instrument equipment and human resources, as well as reduces the time of non-response to a problem. The works may be fully executed by the operations technician or the dispatch service. After detecting potentially hazardous places, they are analyzed for confirmation of the presence of liquid and the decision to clean them with one of the proposed methods is made.

This approach will be very interesting to large international companies, since natural gas reserves are constantly exhausted, and withdrawal of the remaining gas from depleted fields is an attractive target for producing companies. In addition, the use of simple pigging methods based on the analysis of the hydraulic efficiency of pipelines can significantly reduce both time and material resources.

Keywords: hydraulic efficiency coefficient, gas gathering and transportation system, pressure loss, breakaway emissions, pollution volume.

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