ABSTRACT AND REFERENCES

ENERGY-SAVING TECHNOLOGIES AND EQUIPMENT

DOI: 10.15587/1729-4061.2020.195730

STUDYING THE INFLUENCE OF THE THERMOELECTRIC MATERIALS PARAMETERS ON THE DYNAMICS OF SINGLECASCADE COOLING DEVICES (p. 6–18)

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The effect of the variants of parameters of the original thermoelectric materials of the same efficiency on the operational dynamics of a single-cascade thermoelectric cooler has been examined. The variants differ by the coefficients of thermoEMF, electrical conductivity, and thermal conductivity. The study has been carried out in the range of changes in the working temperature, the rated heat load at the predefined geometry of thermoelement branches.

The analysis was performed for the characteristic current modes of operation: maximum refrigerating capacity Q_{0max}, maximum refrigerating capacity at the predefined current $(Q_0/I)_{max}$, maximum refrigerating factor $(Q_0/I^2)_{max}$, minimum failure rate λ_{min}.

We have established the relationship between the cooler dynamics and the basic parameters and reliability indicators for different current modes of operation. A possibility has been shown to reduce the time to enter a stationary mode of operation for a variant with the increased electrical conductivity of a material, by 9–10 %, compared to the basic variant calculated for the averaged electrophysical parameters. The minimum time to enter a stationary regime is achieved under a mode of maximum refrigerating capacity.

The economic feasibility of using the starting source materials with enhanced electric conductivity relates not only to the improved dynamic and reliable characteristics. Designing thermoelectric coolers is also associated with a decrease in the cost of a cooler by using materials that were considered substandard.

The rational design of thermoelectric coolers for the systems that enable the thermal modes of electronic equipment accounts for a set of restrictive requirements. These include energy consumption, weight, and size, performance speed, reliability indicators, etc., which are inherently contradictory. The proposed selection of compromise variants of the current modes of operation for different operating conditions allows the optimized design of thermally-loaded equipment.

Keywords: cooler, thermoelectric material, combination of parameters, electrical conductivity, dynamic characteristics, reliability indicators.

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DOI: 10.15587/1729-4061.2020.194330

DEVELOPMENT OF THE ENGINEERING PROCEDURE FOR THE THERMOTECHNICAL CALCULATION OF A BUILDING ENVELOPE WITH AIR CHAMBERS AND A HEAT-REFLECTING COATING (p. 19–27)

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The study has addressed the development of the engineering procedure for the thermotechnical calculation of a building envelope with thermal insulation in which air chambers with a heat-reflecting coating are formed.

The engineering procedure implied determining the average RSI-value of the building envelope based on the calculation of a temperature field in it. To find the temperature field, a one-dimensional heat conduction problem in a multilayer building envelope was considered. The thermotechnical heterogeneities caused by the presence of alternating air chambers and dividers of insulation material were taken into account in the mathematical model using the effective thermal conductivity of a corresponding layer. This coefficient takes into consideration the convective and radiant components of heat transfer through air chambers. An expression was obtained for determining its value depending on the temperature at the junction of corresponding layers with adjacent building envelope layers. The iterative procedure was proposed that makes it possible to use this expression for determining the temperature fields in the building envelope under consideration. The geometric and thermophysical characteristics of building envelope elements, as well as the values of indoor and outdoor temperature and heat transfer coefficients of the corresponding surfaces, were used as initial data.

The engineering procedure was verified by comparison with the results of three-dimensional CFD simulation, which takes into detailed account the free-convective motion in air chambers and the radiation heat exchange between thermally inhomogeneous walls of the air chamber. It was shown that the use of a one-dimensional mathematical model instead of a detailed three-dimensional one leads to errors not exceeding 2.5 %.

As a result of our comparative analysis, the effectiveness of the proposed thermal insulation material having air chambers with a heat-reflecting coating was shown in comparison with the conventional approaches to building envelope thermal insulation. Calculations were performed for the case of the coldest five-day period in the climatic zone of Shymkent (Republic of Kazakhstan).

Keywords: thermal insulation with air chambers, heat-reflecting coating, average RSI-value of the building envelope.

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DOI: 10.15587/1729-4061.2020.192828

INVESTIGATION OF THE INFLUENCE OF THE GAS PIPELINE TEE GEOMETRY ON HYDRAULIC ENERGY LOSS OF GAS PIPELINE SYSTEMS (p. 28–34)

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CFD simulation investigated turbulent flows in equal gas pipeline tees, in which the gas flow completely moves from the main line to the branch. The study was performed for tees of different geometry – stamped with different bending radii of the transition from the branch to the main line and weld, where the main line and branch connection is made at right angles. The outer diameter of the tees varied from 219 mm to 1420 mm, the bending radius of the transition from the branch to the main line from the minimum permissible to the maximum possible, the pressure in the gas pipeline at the tee location from 3 MPa to 7 MPa.

The mathematical model is based on the solution of the Navier-Stokes and energy transfer equations closed by a two-parameter high-Reynolds k–ε Launder-Sharma turbulence model. To describe the processes occurring at the wall, the wall function was used.

It was found that the bending of the transition from the branch to the main line, the increase in the bending radius lead to a decrease in the intensity of flow separation at the bending point and a decrease in turbulence kinetic energy in recirculation areas. The velocity field of the gas flow after it moves from the main line to the branch becomes more uniform. All this greatly affects the magnitude of hydraulic energy loss of the gas flow in the tees. In this case, the greatest energy losses were observed in the tees located at the lowest pressure points in the gas pipeline system. An analysis of the results showed that if the ratio of the bending radius of the main line and branch connection to the outer diameter is more than 0.25, then the influence of such a tee on the energy loss of the gas pipeline system is minimal. Local resistance coefficients of equal gas pipeline tees are calculated and the resulting equation for their calculation will be useful for specialists designing gas pipeline systems.

Keywords: hydrodynamic pressure, local resistance coefficient, pressure loss, bending radius, turbulent flow, Navier-Stokes equations.

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DOI: 10.15587/1729-4061.2020.194938

BUILDING A TECHNOLOGICAL MODEL OF THE EXHAUST GAS ENERGY RECOVERY DEVICE FOR THE DIESEL ENGINE ON A SMALLSIZED VESSEL (p. 35–42)

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Recuperation systems that utilize the energy of exhaust gases from existing diesel engines are designed for large and medium-sized vessels. There is a need to develop an appropriate system to recover the energy of exhaust gases for small-sized vessels.

We have designed a technological model of the recuperation device for small vessels in the form of a thermoelectric generator (TEG) that operates on the exhaust gas energy. Technical conditions for the TEG arrangement on a vessel have been analyzed and the components of its design have been defined. We have proposed technical solutions for improving the process of energy heat transfer from gas to a TEG, namely: the use of thermoelectric modules (TEM) with an operating temperature above 1,000 °C; the application of a square shape of the pipeline cross-section, and the arrangement of a spiral-type cylinder inside the generator pipeline.

Based on the theoretical calculations, we have examined a thermal model of the thermoelectric generator and estimated the technological parameters for using TEM in order to ensure maximum value of efficiency for a TEG. The need to divide the generator into three constituent sections has been identified, which operate as separate generators. We have shown a possibility to receive up to 0.8 kW of electric energy when using a TEG provided the rotation speed of the diesel engine shaft is 1,500 rpm.

An optimal technique for utilizing the generator electric energy has been proposed, which implies the application of a motor-wheel. A motor-wheel function is to transform the excess electrical energy from a TEG into mechanical energy (to support the main engine) within a comprehensive increase in the fuel utilization efficiency. An appropriate circuit to connect a motor-wheel to the vessel's power system has been given.

We have identified ways to improve the efficiency of a thermoelectric generator and extend the scope of its application on small vessels.

Keywords: energy recuperation, diesel engine, small-sized vessels, thermoelectrical generator, exhaust gases.

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DOI: 10.15587/1729-4061.2020.194642

DETERMINING THE TECHNICAL AND ECONOMIC PARAMETERS FOR DESIGNING HYBRID POWER UNITS FOR THE BUDGET SEGMENT (p. 43–49)

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The paper addresses the issue of designing environmentally friendly and energy-efficient vehicles in a budget segment based on determining the technical-economic parameters. The fuel efficiency and environmental friendliness of cars have been improved and substantiated through devising a hybrid power system based on the chosen rational technical-economic parameters. We have constructed three-dimensional dependences of energy, consumed by the unit of traction rechargeable batteries, and a relative travel range, on the mass and steady speed. Recommendations have been made on selecting the energy intensity of the unit of traction rechargeable batteries for hybrid vehicles of different mass and the desired travel range under an electricity-only mode. We have established the travel range under an electricity-only mode per a single charge of traction rechargeable batteries within 20 km to 50 km. The choice of a hybrid vehicle has been proposed depending on the expected average daily mileage and the energy intensity of traction rechargeable batteries. This would make it possible for a consumer to make a decision about the choice of a hybrid vehicle based on the individual planned average daily mileage.

Conceptual solutions have been developed to construct hybrid power units based on the economic principle of their design. The scientific results have been confirmed in practice using an

experimental hybrid concept based on the ZAZ Lanos Pickup. Such an approach makes hybrid vehicles more competitive and economically attractive.

Keywords: hybrid vehicle, hybrid power unit, traction rechargeable battery, energy intensity.

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DOI: 10.15587/1729-4061.2020.195203

DETERMINATION OF THE KINETICS OF THE PROCESS OF PUMPKIN SEEDS VIBRATIONAL CONVECTIVE DRYING (p. 50–57)

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Experimental studies of the drying process of high-moisture pumpkin seeds in a vibrating dryer are carried out. The research is caused by the need to solve the problem of fast and high-quality post-harvest treatment with minimal cost. Existing technologies and equipment do not ensure high performance of the drying process in the post-harvest period or carry it out with significant expenses of time and resources. The main objective of the study is to determine the rational parameters of the process and equipment for drying pumpkin seeds.

As a result of the experimental studies of the kinetics of pumpkin seeds vibrational convective drying, rational process parameters were obtained, i. e. the maximum allowable temperature of the drying agent is t_{da}=50 °C, which corresponds to the maximum allowable heating temperature of seeds t_{h2}=46.7 °C. At this temperature, the grain retains conditional values of germination ability and energy. The maximum allowable temperature is 0.3 °C lower than the maximum allowable heating temperature for pumpkin seeds.

The results of the study of the intensification of vibration exposure indicate a direct relationship between the vibration frequency of the drying chamber and drying duration: the higher the frequency, the greater the intensity of vibration-convection

drying, as well as a reduction in drying duration with increasing vibration amplitude.

The obtained results confirm the feasibility of using a filtration-convective vibrating dryer, which ensures compliance with rational drying parameters, i. e. temperature and speed of the drying agent, amplitude, frequency, and filling of the working chamber. The combination of these parameters allows drying the seed material with minimal cost and maintaining its high quality.

Keywords: pumpkin seeds, vibratory fluidized bed, drying speed, drying agent, vibrational and convective dryer, rational parameters, convective drying.

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DOI: 10.15587/1729-4061.2020.196763

CREATING A MICROCLIMATIC THERMAL MODE BY THE MULTILEVEL SYSTEM FOR HEATING INDUSTRIAL STRUCTURES (p. 57–63)

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A heating system for predicting the thermal state, to control and regulate the heating of technologically active zones of production facilities has been proposed. This makes it possible to ensure a high-quality level of compliance with the standards of the thermal mode at production facilities through the use of energy-saving multifunctional systems of a multi-level heating system. At the same time, the heating devices of the resistor type

are located below the floor level and their heaters are powered by traditional and non-traditional renewable energy sources.

Modeling of thermal processes in the heating system, which was reduced to solving the problem of heat conductivity in the flat layer system, was carried out. A constituent part of this solution is to determine the floor surface temperature as a functional series, which establishes a relationship between the standards of floor surface heating and the power of energy flows in a multilevel heating system. This approach makes it possible to ensure the structural and functional control of energy flows and at the same time ensure the responsiveness and accuracy of compliance with the set standards of the thermal parameters of the microclimate of the technologically active area of industrial facilities for various functional purposes.

Keywords: forming the predefined microclimate mode, electrothermal processes, thermal conductivity, heating floor, tubular heaters.

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