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SUMMARY and KEYWORDS

POWER AND CHEMICAL ENGINEERING

J. A. Shostak, N. K. Nikulin, P. A. Shostak, G. T. Tsakadze, E. V. Svichkar
Study of interstage channel of hybrid turbomolecular pump

The calculation is based on the use of Monte Carlo method (method of test particle), which consists in the statistical modeling of processes. The article describes an algorithm to construct a mathematical model step by step. The article defines both a probability for gas molecules to pass through the interstage channel of a hybrid turbomolecular pump in forward and backward direction. The effect of the movable walls limiting the channel is taken into account. Results and, accordingly, recommendations, given in the article, can be used in designing a flow passage of the hybrid turbomolecular pumps. The dependencies of a probability for gas molecules to pass through the interstage canal on the relative parameters determining the geometry and dynamics of the channel walls are given.

Keywords: turbomolecular pump, probability, conductivity, mathematical model, Monte-Carlo method, pumping performance.

A. M. Kalashnikov, A. A. Kapelyukhovskaya, I. D. Obukhov
Analysis of application of heat loss recovery system using organic Rankine cycle for drive of process equipment

The analysis of heat exchange processes during cooling of the heated surface of the process equipment is carried out on the basis of the equations contained in the ANSYS Fluent package. When modeling heat exchange processes, the following boundary conditions are adopted: the temperature of the heated surface; the coil heat exchanger is located at a distance from the heated surface of the process equipment. From these results, we can draw the following conclusions: the increase in the temperature of the heated surface leads to the increase of the heating zone of the refrigerant with high capacity and, hence, to increase heat capacity; increasing the refrigerant flow rate, the lower the temperature of the refrigerant at the exit, but increases the thermal capacity; increasing the pressure of the heated refrigerant increases the thermal; this design of the heat exchanger allows you to achieve the necessary power for the operation of the drive by: changing the flow rate of the refrigerant, the excess pressure of the refrigerant, the number of elbows, as well as by installing a heat-reflecting casing.

Keywords: heat energy, heat recovery, heat exchanger, mechanical engineering.

V. I. Karagusov
Experimental and computational studies of radiation panels of life support system

Environmentally friendly and renewable energy sources are currently relevant and in demand. One of such energy sources is solar radiation, which can transmit up to 1,5 kW of thermal energy per square meter of the earth's surface. This energy can be converted into electrical energy using solar panels, which have several disadvantages. The main one are low efficiency and short service life. Another way to harness solar energy is by using solar collectors, which convert the sun radiation into thermal energy.

Keywords: life support system, radiation heater, solar radiation, heat flux, renewable energy sources, thermal performance, insolation.

M. I. Sokolov, Yu. V. Kozhukhov
Investigation of applicability of Peng–Robinson and GERG-2008 equations of state of real gas for calculating properties of Freons for refrigeration machines and compressors

A study of real gas state equations Peng–Robinson and GERG-2008 with respect to calculation of Freons R404A, R408A and R410A has been carried out. Four Freon parameters are calculated during the study:

saturated vapor pressure at the saturation line at some Freon temperature, Freon density at saturation pressure and some temperature, enthalpy and entropy at the same pressures and temperature. The data obtained from the calculation of Freon by the above equations are compared with the experimental data for each of the above Freons. As a result of this work, data have been obtained to evaluate the accuracy of the Peng–Robinson and GERG-2008 equations of state for each of the three CFCs, to evaluate the effectiveness of these equations, and to provide recommendations for the calculation and application of these equations in the design and mathematical modelling of refrigeration machines.

Keywords: Freon, real gas, equation of state of real gas, thermodynamic calculation, refrigeration engineering, refrigeration compressor.

M. Grieb, A. Brümmer
Investigation into the effects of surface condensation in steam-driven twin screw expanders / trans. from Engl. M. A. Fedorova

During the operation of twin screw expanders with slightly superheated vapours or even two-phase fluids, surface condensation on machine parts occurs during the filling period and the expansion phase when the working fluid is in contact with cooler inner surfaces. This heat exchange from the working fluid to adjacent machine parts effects the working cycle and the efficiency of these machines. Short time scales and the periodicity of the process indicate the condensation process is best described by models for dropwise condensation. In this paper the effects of surface condensation on the operation of twin screw expanders are initially discussed in a simulation-based investigation. Chamber model simulation coupled with a thermal analysis is used for the thermodynamic simulation, whereby heat transfer coefficients are systematically varied. It is found that during the inlet phase condensate emerges on the inner surfaces of the machine being substantially cooler than the working fluid. This results in a higher mass being trapped within the working chamber and, thus, an increasing mass flow rate of the machine. An increase in power output is, however, not observed. The results obtained from chamber model simulations are finally compared against experimental data of a screw expander prototype.

Keywords: twin screw expanders, surface condensation, heat exchange, working fluid, thermodynamic simulation.
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AVIATION AND ROCKET-SPACE ENGINEERING

V. Yu. Kudentsov, A. V. Kudentsov
The position of liquid fuel residues in tank of worked-off rocket stage during ballistic descent

The results of modeling the behavior of liquid residues of the rocket fuel component in the fuel tank of the worked-off rocket stage on a ballistic trajectory are presented. The simulation is carried out for the following variants: during the controlled descent of the rocket stage and when using the technology of evaporation of liquid rocket fuel residues in the tanks of the spent stage. It is established that during the controlled descent of the spent rocket stage along the ballistic trajectory at the site of its turn and up to heights of 20 km, the liquid under the influence of overloads is distributed in the form of a film in the area of the bottom and side surface with a coverage area of up to 35 %. At the height of the maximum value of the axial overload, liquid fuel residues in the form of a film move to the area of the bottom and the adjacent side surface of the fuel tank. The total coverage area is about 22 %. The introduction of a hot coolant into the fuel tanks to vaporize the liquid remnants of rocket fuel radically changes the picture of the behavior of the liquid. Due to the high speed of the coolant in the tank, axial overload has little effect on the distribution of fuel residues in the rocket tank.

Keywords: fuel tanks, modeling, two-phase flow, rocket fuel, ballistic trajectory.

V. I. Kuznetsov, V. V. Makarov, A. Yu. Shander
Similarities and differences between working processes of Ranque effect and Hartmann–Sprenger tube

The physical and mathematical models of the processes occurring in the vortex tubes (Ranque effect) and Hartmann–Sprenger tube. The physical models most closely corresponding to the physical processes in these devices have been identified. The similarities and differences between the effects arising during the operation of vortex tubes and the Hartmann–Sprenger tube are found. The proof of the influence of viscosity on the Ranque effect and the interaction of gases in the Hartmann–Sprenger tube is given. Regularities of changes in total pressure and total temperature in a vortex tube and a Hartmann–Sprenger tube are given. The factors influencing the energy exchange in the vortex tube and the Hartmann–Sprenger tube are determined. The influence of the exchange of work and heat on the Ranque effect and the Hartmann–Sprenger tube is revealed. The mechanism of energy transfer between gas layers in a vortex tube and in a dead-end Hartmann– Sprenger cavity is found.

Keywords: Ranque effect, vortex tube, Hartmann–Sprenger tube, energy exchange, viscosity, angular velocity gradient, linear velocity gradient.

E. V. Leun, A. A. Poliakov, S. A. Zashchirinsky, V. K. Sysoev, K. M. Pichkhadze, V. V. Shalay
Some features of impact penetration of penetrators into ground of celestial bodies

The article discusses the features of the inertial explosion of metal products and the prevention of its occurrence during its impact introduction of a metal penetrator into the ground of celestial bodies. The possibility of an inertial explosion in metal penetrators is determined when calculating the critical overload of the Gcr that exceeds a certain threshold value for each metal. These values are determined for a number of alloys and high-purity metals widely used in rocket and space technology for Earth and space temperatures. The features of reducing the critical overload threshold of the Gcr for space conditions at cryogenic temperatures and ways to prevent an inertial explosion are discussed.

Keywords: space research, celestial body, penetrator, impact penetration, high-speed impact, overload, critical velocity, subsurface ground, inertial explosion.

G. S. Russkikh, S. V. Shalygin
The algorithm for generating internal structure of product considering stress-strain on example three-point bending

An algorithm is proposed for optimizing the internal structure of a sample obtained by 3D printing, while maintaining the mechanical strength and rigidity. The basis is the pre-calculated stress-strain state of the sample in an elastic isotropic setting. Numerical simulation results are obtained showing the performance of the optimized design using the example of the three-point bending problem. Comparison of the results of numerical modeling, optimized and monolithic samples, in elastic isotropic formulation is presented.

Keywords: additive technologies, internal structure optimization, stress-strain state, 3D printing, mechanical properties, weight reduction.

A. V. Kupryashov
Study of dynamics and rigidity of multifunctional coating of protective element of aircraft

In this work using a finite element study the author has numerically solved the problem of the dynamic behavior of a multifunctional coating of an aircraft protective element. The researcher conducted the simulation using the Femap with NX Nastran software package, The result of the modal analysis is the values and patterns of natural and secondary vibration modes of the multifunctional coating of the protective element of the aircraft using a special module the author has determined the distribution of effective modal masses in tabular form, Also, as a result of calculations, the author of the article obtained the value of the structural rigidity of the protective coating, The results presented in this work allow us to analyze the behavior of protective systems and structural elements of an aircraft with a multifunctional coating applied to the outer surface in real operating conditions, The design team can use the research results of this article in order to increase the efficiency of the development of a new structures and structures of a composite coating for multifunctional purposes, protective elements and materials for space technology.

Keywords: finite element method, stiffness, numerical simulation, vibration frequency, modal analysis, protective coating.

D. A. Savchin, V. P. Nazarov

Development and analysis of simulation of liquid-propellant rocket engine pump head curve obtaining process

The paper describes the model of the centrifugal pump head curve obtaining process which helps in consideration of the implementation of automated systems in liquid-propellant rocket engine manufacturing. The work contains the simulation of automated and non-automated head curve obtaining. The developed model shows that the automated process exceeds the non-automated analog in terms of error values and labor intensity.

Keywords: automatization, hydraulic test, head curve, piezo-resistive pressure sensor, mathematical model, centrifugal pump.