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SUMMARY and KEYWORDS

POWER AND CHEMICAL ENGINEERING

V. I. Karagusov
Study of carbon-free radiation life support system in spring and autumn periods

Solar energy refers to renewable carbon-free energy. Experimental studies conducted in the springautumn periods of 2018–2021. In the conditions of the sharply continental climate of Western Siberia allowed us to draw a number of conclusions about the applicability of the radiation life support system for cottages, rural houses and other detached buildings. During the research, a large number of experimental temperature measurements are carried out with their recording in the memory of the logger 88598. The temperatures are recorded on the measuring cell of the experimental stand. The obtained experimental data are processed. In spring and autumn, it is more rational to replace radiation conditioning with ventilation, since at night the temperature difference between the radiation panel and the surrounding air is small.

Keywords: life support system, radiation collector, solar radiation, heat flux, carbon-free energy, renewable energy sources, insolation.

V. A. Pronin, A. V. Kovanov, E. A. Kalashnikova, V. A. Tsvetkov
The prospect of using ozone-safe refrigerants with low global warming potential in scroll compressors. Research and practice of using R744 and R290. Part 2

Scroll compressors currently operate successfully on various natural refrigerants, among which the most popular are propane R290 and carbon dioxide R744. This is due to the performance characteristics of the refrigerants studied in the previous article. However, the key to improving scroll technology further adapting or creating new models of compressors is a detailed study of the thermophysical and thermodynamic properties of propane and CO2. The article analyzes the possible areas of application of R290 and R744 from the point of view of the influence of their properties on work processes and the question of the need for structural changes to the compressor. The question of the relationship between the properties of hydrofluorocarbons and natural refrigerants is considered, as well as the possibility of using the theory of thermodynamic similarity to solve it. Data on commercially available scroll compressors operating on natural refrigerants have been taken into account in terms of their advantages and disadvantages. Thus, conclusions are drawn about the prospects for the use of R290, R744 and current research directions for expanding the scope of scroll compressors from the point of view of the general problem of using ozone-friendly refrigerants with a low global warming potential.

Keywords: scroll compressor, propane R290, carbon dioxide R744, hydrofluorocarbons, energy efficiency, properties of real gas, thermodynamic similarity

V. V. Shalay, M. O. Myznikov, M. I. Gildebrandt, E. V. Khodoreva
About the need to replace pumping equipment or impellers of main pumps when pumping capacity of oil and petroleum products changes

The article presents the results of a study related to determining the need to replace pumping equipment or impellers of main pumps to increase efficiency while reducing pumping volumes. Calculations are carried out on the example of a technological section of a specific oil pipeline. The paper demonstrates an approach to assessing the economic feasibility of replacing pumping equipment or upgrading it in conditions of changing transportation volumes. The calculation method can be applied to any oil pipelines and product pipelines.

Keywords: oil pumping, energy efficiency, main pump, efficiency, technological mode, efficiency indicators, regulation, replaceable impeller.

V. V. Shalay, M. O. Myznikov, M. I. Gildebrandt, V. A. Grinevich
Selection of modes and pressure regulation when pumping oil and oil products to save energy

The article presents the results of a study related to the choice of modes and pressure regulation to save electricity. Calculations are carried out on the example of a technological section of a specific oil pipeline. The paper demonstrates an approach to assessing the economic efficiency of each of the flow control options to obtain the required performance. The above arguments and methods of selecting modes can be applied to any oil pipelines and product pipelines.

Keywords: oil pumping, pipeline transport, transportation of petroleum products, energy efficiency, main pump, efficiency,
technological mode, efficiency indicators, regulation, mode selection.

A. A. Kapelyukhovskaya, G. I. Chernov, A. Yu. Gromov, A. M. Kalashnikov, V. I. Karagusov, A. M. Paramonov
Theoretical analysis of expansion process of wet water vapor in working chamber of piston long-stroke linear drive of compressor unit

In this paper, the process of expansion of wet water vapor in a piston long-stroke low-speed drive of a low-flow compressor unit is considered. The study is carried out on the basis of the developed mathematical model, which includes both the basic thermodynamic equations and the equations describing the process of heat exchange of the working substance with the walls of the working chamber during the expansion process. The results of the calculations carried out reflect the dependences of pressure, temperature and degree of dryness on changes in the volume of the working cavity at various values of the initial degree of dryness in the process of expansion and the duration of the process. An analysis of the results obtained shows that an increase in the cycle time and a decrease in the initial degree of dryness lead to an intensification of the process of condensation of wet steam in the process of expansion and the possibility of obtaining complete condensation of the working fluid.

Keywords: expansion process, condensation, piston unit, wet steam.

D. Kh. Sadvakasov, G. I. Chernov, V. L. Yusha
The analysis of influence of uncertainty factors on mathematical modeling of process of reverse expansion of ammonia in low-speed reciprocating compressor stage. Part 1

The paper presents an analysis of the influence on the mathematical modeling of the process of reverse expansion of ammonia in the area of wet steam, implemented in the working chamber of the reciprocating compressor stage, of such uncertainty factors as the method for calculating the heat transfer coefficient, the surface temperature of the wall of the working chamber and the degree of dryness at the beginning of the process of reverse expansion. The mathematical model is based on the equations of the first law of thermodynamics for a body of variable mass, the equation of state of a real gas, the Clausius– Clausius and Newton–Richmann equations. The results of the calculation showed that the instantaneous values of the pressure and temperature of ammonia, as well as its degree of dryness during reverse expansion in the wet steam region, significantly depend on the chosen method for calculating the heat transfer coefficient. The process under consideration is also significantly influenced by the temperature of the walls of the compressor working chamber, in which the compression process is implemented, and the degree of dryness of ammonia at the beginning of the expansion process.

Keywords: ammonia, wet steam, superheated steam, reverse expansion process, mathematical model, heat transfer coefficient, nucleate boiling.

A. A. Sekacheva, L. G. Pastukhova, A. S. Noskov
Numerical study of pipeline wall thickness influence on natural dynamic parameters of hydromechanical system

This article is devoted to solving the problem of noise and vibration in complex pipelines of hydromechanical systems. In the study, the first ten frequencies of natural oscillations are calculated for

sections of the pipeline system filled with water with outer diameters of 60, 70, 102 mm and various thicknesses of the pipeline wall. It is determined that for all the investigated diameters, a decrease in the natural vibration frequencies for all modes of natural vibrations with an increase in the thickness of the pipeline wall is characteristic. Thus, the assumption is confirmed that an increase in the rigidity of the pipeline reduces the likelihood of oscillations in the pipeline. It is concluded that in straight sections the pipeline system with diameters up to 102 mm behaves only as a mechanical system.

Keywords: pipelines, hydromechanical systems, natural oscillation frequencies, vibration, noise, dynamic characteristics of pipelines, pressure fluctuations of the working medium.

E. R. Butakova, A. A. Sekacheva, A. S. Noskov
Study of operation of spool hydraulic control unit that transmits reduced pressure signal to control hydraulic distributors, control cylinders, parameters of axial piston pumps and hydraulic motors

The article discusses the test results of three modernized hydraulic control units. In the course of the experiments, the nodes are refined with subsequent refinement tests. As a result, of the research, the following results are obtained a characteristic of the dependence of the differential pressure on the flow rate, a dependence of the reduction pressure on the angle of the handle, pressure drops in the working bends of the control unit, etc. The analysis of the results and comparison with theoretical calculation shows that there are three main types of adjustment characteristics: parallel theoretical —with laminar flow, three — zone and quadratic — with turbulent mode.

Keywords: hydraulic control unit, spool valves, pressure reduction, flow-rate characteristics.

M. Fouladivanda, M. A. Heidary
A study into the impact of chloride ions on the make-up hydrogen compressors / trans. from Engl. M. A. Fedorova

The presence of unwanted chemicals in process lines and downstream equipment causes defects and failures, which sometimes have significant impacts on systems and imposes extra costs for the production process. In this study, one pair of four-stage make-up hydrogen compressors is investigated. These reciprocating compressors which serve as a part of the hydrogen treating unit have failed approximately simultaneously. The feed of these compressors is net hydrogen-rich gas. Both dry compressors have shown similar problems in the first and second stages. The simultaneous rise in the cylinder temperature and decrease in the flow has forced shut-down of the compressors for the next actions in the process. Initial inspections have revealed some kind of deposits covered the cylinder and its components. The valves, liquid tested and results have shown significant leakage of all the suction and discharge valves of the cylinders. Moreover, the thickness of all piston rings have decreased up to 50 percent which is more than allowable values. The compositions of deposits, tested by X-ray fluorescence (XRF) and X-ray diffraction (XRD), result from the analysis shown that it contains 35,2 percent (mass fractions) of Chlorine and 27,5 percent of Iron, and noticeable amount of Sulfur or Phosphor. XRD analysis has reported that the Iron Chloride Hydrate is the main part of the fouling sample. In this paper, the impact of the aforementioned chemicals on the compressor components are investigated, and some approaches are proposed to absorb or inhibit these chemicals.

Keywords: hydrogen compressors, cylinders deposits, forced shut-down, X-ray tests, absorption and inhibition.

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I. Ivkovic-Kihic, M. Read, Sh. Rane, A. Kovacevic
«Compressors and their systems». Post conference report / trans. from Engl. M. A. Fedorova

The article presents an overview report of the 12th International Conference on Compressors and their systems which was held in a hybrid format from September 6 to 8, 2022 in the City, University of London, UK. At this prestigious scientific and educational forum, within the framework of the plenary

session, world experts made reports in the field of compressor technology and de-carbonization, as well as presentations at several technical and panel sessions on such topics as screw, scroll, vane and piston compressors; compressor systems and their diagnostic and control systems; turbo-machines; mathematical modeling and optimization of compressors, expanders and their systems. In addition, within the framework of the conference, a traditional short training course and a Forum on CFD (gas dynamic calculations) in rotary positive displacement machines were held. The introductory session was devoted to the basics of CFD implementation using the finite volume method. New studies in the field of CFD in rotary volumetric machines were presented, including those based on such programmes as ANSYS Forte and OpenFOAM. Complex modeling approaches, such as SCORG and GT-Suite, also attracted the attention of participants. Information about the next conference on Compressors and their systems, which will be held in 2023, is presented.

Keywords: compressors and their systems, designs, workflows, diagnostics and control systems, mathematical modeling, CFD, conference.

AVIATION AND ROCKET-SPACE ENGINEERING

V. I. Kuznetsov, V. V. Makarov
Physical and mathematical model of working process of the Hartmann–Sprenger tube

The question of the operation of the Hartmann–Sprenger tube is considered. The influence of the parameters of the incident gas flow on its parameters at the end of the dead-end cavity is investigated. The mechanism of energy transfer from the incoming flow to the flow entering the dead-end cavity has been determined. The proof of the influence of viscosity and shear stresses on the occurrence of transfer of kinetic energy from the incident flow to the flow entering the dead-end cavity is given. The influence of the exchange of work and heat on the mechanism of energy transfer in the dead-end cavity of the Hartmann– Sprenger tube is revealed.

Keywords: Hartmann–Sprenger tube, energy exchange, linear velocity gradient.

V. Yu. Kudentsov, A. V. Kudentsov, N. A. Kuzina, V. I. Bimatov
Thermal loading of spent rocket stage structure during ballistic descent

The results of a numerical calculation of the aerodynamic heating of a spent rocket stage structural elements during its controlled descent along a ballistic trajectory are presented. The influence of the initial trajectory parameters on the specific convective and radiant heat fluxes is determined. To assess the thermal loading of the spent rocket stage structure, the parameter of the total specific energy flux is introduced. It has been established that in the range of initial speeds of the spent rocket stage from 1800 m/s to 2600 m/s, an increase in the initial speed by 200 m/s leads to an increase in the specific convective flow by an average of 11 % for the tail compartment and the fuel tank and by 5 % for the oxidizer tank. The share of the specific radiant energy flux withdrawn from the surface in relation to the specific convective energy flux is from 0,15 to 0,19 for the tail compartment, from 0,12 to 0,15 for the fuel tank and not more than 0,009 for the oxidizer tank. Empirical dependencies are proposed for the preliminary stage of assessing the temperature state of the spent rocket stage structure when moving on a ballistic trajectory. The error of the calculation results according to the proposed dependencies does not exceed 12 %.

Keywords: heat flows, rocket stage, aerodynamic heating, ballistic trajectory.

I. S. Vavilov, P. S. Yachmenev, V. V. Fedyanin, K. I. Zharikov, P. V. Stepen, A. I. Lukyanchuk, I. A. Kuzmenko
Two-gaps microwave ion engine and its study by aerodynamic method

The article contains the authors' research in the field of jet propulsion systems with low energy consumption of small spacecraft of the class of nanosatellites. The paper presents a microwave ion engine with double acceleration of ionized gas in the gaps formed by the end surfaces of cylindrical resonators. The results of an experimental study of the pressure force of a jet set of ionized gas by the aerodynamic

double angle method are presented. A stand for determining the power parameters of week plasmajet is presented. The design of the prototype is presented. The total energy consumption of the prototype is 5 watts, the accelerated gas flow rate is up to 200 km/s, the jet pressure force on the sensing element of the stand is 0,1 μN. The working body of the prototype is nitrogen at a pressure in a vacuum chamber of 18 Pa.

Keywords: volumetric resonator, microwave, plasma, small spacecraft, nitrogen, thrust, speed.

I. S. Vavilov, K. I. Zharikov, P. S. Yachmenev, V. V. Fedyanin, P. V. Stepen, A. I. Lukyanchuk, I. A. Kuzmenko
Calorimetric studies of microwave ion thruster

The authors continue their work in the field of calorimetric studies of the parameters of an accelerated ionized gas jet of prototypes of microwave ion micro-thrusters with an energy consumption of up to 10 watts. This paper presents an improved calorimetric method. The introduction into the design of a heat receiver in the form of a thin screen makes it possible to allocate the thermal component formed by the passage of an electric current through the plasma in the accelerating gap. Calorimetric studies of the prototype with a two-electrode accelerating system are carried out at the same accelerating voltages and power of the microwave generator and different mass gas flow rates. It is shown that at a nitrogen consumption of 5,668•10–9 kg/s, the velocity of the mixed jet (neutral gas with ionized component) of the gas was 63,75 m/s, the jet thrust is 0,36 μN. With a nitrogen consumption of 1,611•10–8 kg/s, the speed of the mixed gas jet was 47,9 m/s, the jet thrust was 0,77 μN.

Keywords: calorimeter, microwave, plasma, small spacecraft, nitrogen, thrust, speed, thermal imager.

A. V. Pobelyansky, D. K. Dmitriev, A. A. Levikhin
Intensification of convective heat exchange of walls of heat pipe of 3D-printed micro-sized turbojet engine

The article considers the solution of the urgent problem of creating a micro-sized turbojet engine using 3D printing. The article describes one of the ways to cool the walls of the heat pipe of a small combustion chamber made of heat- resistant material 08KhN53BMTYu. One of the acceptable ways to cool the walls of a small-sized chamber heat pipe is convective heat exchange of the outer side of the heat pipe due to intense vortex formation in the boundary layer of the flow. This effect is achieved by the device of projections on the outer wall of the heat pipe.The article highlights the peculiarity of the shape of the protrusions, which must be carried out taking into account the technological limitations of 3D printing. The article presents a description of an experimental stand for the study of the thermal state of the heat pipe of micro turbojet engines, the method of processing experimental data and the results of experiments on the heat transfer of the heat pipe shell with and without them.

Keywords: micro-sized turbojet engine, combustion chamber, heat pipe, complex-integrated design, intensification of convective heat exchange, additive technologies.