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В докладах представлены результаты теоретических и экспериментальных исследований, проведенных в Казахстане, Германии, России, Японии и Украине по следующим направлениям: холодильная техника и компрессоростроение, теплохладоснабжение, системы кондиционирования воздуха и жизнеобеспечения, экология в холодильной промышленности, холодильная и пищевая технология. Сборник рассчитан на специалистов и ученых, работающих в областях холодильной, пищевой, химической, нефтеперерабатывающей промышленностей, а также на специалистов по системам кондиционирования воздуха и жизнеобеспечения жилых, коммерческих зданий и спортивных комплексов.

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EFFECTS OF WORKING FLUID PARAMETERS ON EXPANSION PROCESS OF A ROTARY VANE REFRIGERATION MACHINE

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All over the world in the area of energy saving and problem solving aimed at reducing anthropogenic effects on the environment, refrigeration machines that are used natural working medium as refrigerants become increasingly important [1]. For this reason actual is the development of a new refrigeration technology based on high-efficiency thermodynamic cycles. In this regard Stirling refrigerating machine get topical priority.

Working fluids of Stirling refrigeration machine are eco-friendly substances (helium, argon, nitrogen, air) [2]. Helium and nitrogen are of concern with regard to their thermodynamic properties, namely those which allow to have high coefficients of heat transfer and to provide a gas flow with relatively low pressure drop.

To improve the design of the piston Stirling refrigeration machine structural optimization rotary vane gas refrigeration machine (RVGRM) is carried out.

Objects and methods of research. To study effect of changes working fluid operating parameters in process of expansion the mathematical modeling cycle RVGRM is carried out.

Results and discussion. In this paper we propose a mathematical model for calculating the basic parameters RVGRM cycle affecting the operation cycle, the machine control and operating processes occurring in it for the given criteria.

The main parameters to be examined are the temperature and pressure in the machine during the expansion process.

The temperature during expansion changes under the law:

$$T_{exp}(\alpha) = T_3 \left(\frac{V_3}{V(\alpha)}\right)^k \quad (1)$$

The pressure change during expansion can be described as:

$$p_{exp}(\alpha) = p_3 \left(\frac{V_3}{V(\alpha)}\right)^{n_2} \quad (2)$$

Functions of distributions of temperature and pressure of the working fluid, depending on the angle of rotation of the shaft of the machine and based on mathematical modeling cycle. Graphs of functions are shown in Figure 1 and 2, respectively. The pressure at the beginning of the expansion process is taken equal $p_3 = 10, bar$ and temperature $T_3 = 303K$.

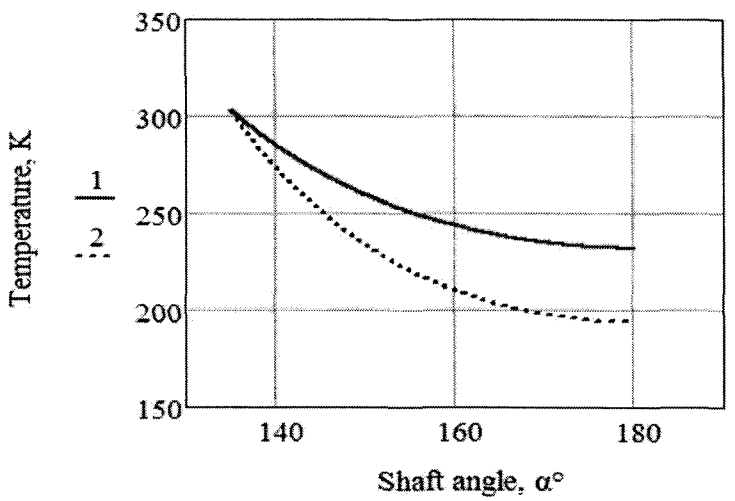

Figure 1 – The temperature changes of the working fluid in the expansion process. 1 – Nitrogen; 2 – Helium.

Fig. 1 show that the minimum temperature of the working fluid in process of expansion in the machine is achieved by using nitrogen $T_{min}^{N} = 232K$, and using a helium temperature $T_{min}^{He} = 195K$. This temperature difference is explained by the properties of the working fluid in a particular angle of inclination of the adiabatic.

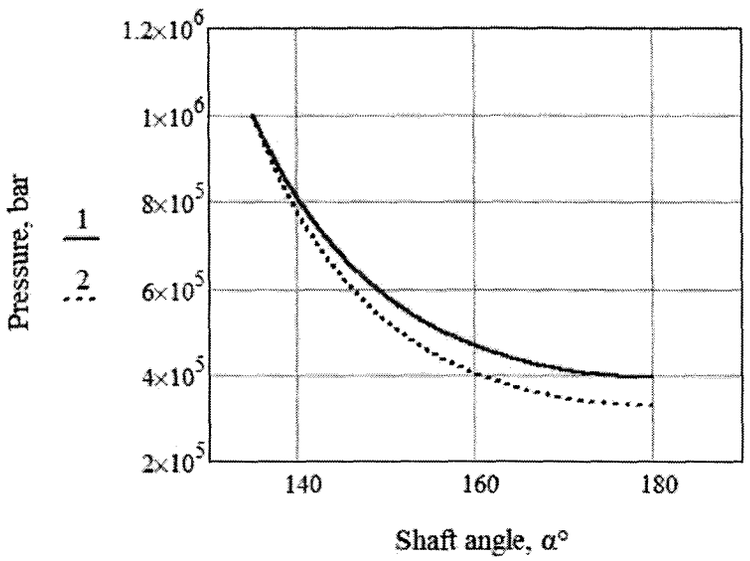

Figure 2 – The pressure changes of the working fluid in the expansion process. 1 - Nitrogen; 2 - Helium.

From Fig. 2 it is seen that the minimum pressure in the chamber reaches in process of expansion using nitrogen $p_{min}^{N} = 4bar$ and using helium $p_{min}^{He} = 3.4bar$.

The main advantages of RVGRM are as follows:

1. energy efficiency (increased up to 30% in comparison with the piston machine);
2. compactness (decreased up to 60 % the weight and volume);
3. minimum frictional losses in the rotary guide;
4. reduced (or absent) wear of the pistons and cylinder
(housing) surfaces;
5. possibilities to simplify sealing and lubrication;
6. full-balanced mechanical system without vibration of the frame;
7. optimal motion conversion mechanism and transmission law of the oscillating rotary vane machine;
8. possibility to control the rotary vane machine via the conversion mechanism.

Note that the in temperatures below $T_{min} < -30$ °C efficiency of RVGRM are considerably higher than the vapor-compression systems. This complication is associated with the need to move to a two-stage compression in the vapor-compressor plants.

Thus, the use of RVGRM different working fluids allows us to operate in a wider range of cooling temperatures (0 to -80 °C) in one machine and obtain high energy efficiency.

The research results show that the proposed model can be used for the design and optimization of rotor-vane gas refrigeration machine.

The proposed rotary-vane gas refrigerating machine is advantaged to compare with known analogous piston devices.

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