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Influence Of Operating Modes Of The Vacuum Pump Of Lamellar Type On Change Of An End Backlash.

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ABSTRACT

Vacuum pumps of lamellar type (VPLT) have been widely used in various fields of industry and agriculture due to the simplicity of design, uniformity of supply, availability of maintenance and other advantages. However, they have a number of drawbacks, such as: a low overhaul life and a decrease in productivity with long cycles of continuous operation. This is due to the increase in the end clearance due to the heating of the pump parts, which occurs when contacting the working surfaces of the blades, side covers and housing. To increase the overhaul life and increase the duration of continuous operation of the pump, the modernization of the VPLT series is proposed. The deviation of the temperature of the housing and the side covers of the pump, during the research, was minimal and did not exceed ± 0.2 °C. Analysis of the obtained data showed that the heating of the serial VPLT is stabilized at a temperature of about 80 ° C, and the upgraded VPLT at 65 ° C. The increase of the total end clearance in the series pump due to its heating is equivalent to the wear value in this coupling, corresponding to an operating time of 200-250 hours. The total clearance in the upgraded VPLT also increased with a long cycle of continuous operation, but due to design features, it practically has no effect on its performance.

Keywords: rotary type machines, temperature, end gap, wear.

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INTRODUCTION

Vacuum pumps of lamellar type have been widely used in various fields of industry and agriculture. They are distinguished by the simplicity of design, uniformity of supply, availability of maintenance and low cost in comparison with other similar devices. At the same time, pumps of this design have a number of drawbacks, such as: low overhaul life and reduced productivity as a result of continuous long-term operation [1]. This is due to the increase in the end clearance due to the heating of the pump parts, which occurs when contacting the working surfaces of the blades, side covers and housing [2, 3]. This is a consequence of the use of materials in the manufacture of VPLT parts with different coefficients of thermal expansion (textolite, cast iron, steel, etc.).

To increase the overhaul life and increase the supply stability during long cycles of continuous operation of VPLT, constructive solutions protected by patents for the utility model and invention were proposed [4, 5, 6]. But to confirm the efficiency of modernization, it is necessary to carry out a number of studies, including the dependence of the clearance size on the temperature of the pump heating during long cycles of continuous operation.

The aim of these studies is to determine the influence of the heating temperature of the housing and side covers, depending on the duration of the pump operation, on the increase in the end clearance, both in the serial VPLT and in the modernized one.

MATERIAL AND METHODS

To fulfill this goal, an experiment was planned, during which the working temperature of the VPLT and the size of the end gaps between the side covers and the rotor were monitored for continuous operation for 6 hours. In the experiment, a pump was used from the vacuum unit UVU60 / 45B-0.75.

The temperature of the pump casing and side covers was measured using thermoelectric converters, which are chrome-copel thermocouples (XK (L)). The point of connection of the thermocouple was installed in the drilled blind holes in the housing and in the covers of the vacuum pump. The thermocouples were connected directly to the ADC, which registered the potential difference as a function of temperature. To calibrate the thermocouples they were lowered into a container with water, which was heated from 20 to 100 ° C, and every 20 ° C the difference in their potentials was measured. The water temperature was controlled by a standard mercury thermometer GOST 8.317-78. Measurements of the hull temperature were carried out 1 hour after the pump was warmed up.

For the operational measurement of the end clearance, holes were drilled in the lower part of the side covers, which were silenced with bolts for the duration of operation. The lower part of the side covers, for monitoring the end clearance, was chosen in connection with the fact that according to Mzhelsky M.I. in this region the largest share of end-to-end flows is observed [7]. Measurement of the size of the end clearance was carried out using a micrometric depth gauge of GM-25 0.01 GOST 7470-92, with a reading accuracy of 0.01 mm and a margin error of ± 5 µm. The value of the total end clearance as a result of heating of the VPLT parts was calculated by the formula:

$$T_S = (T_p + T_z) - (T_p^N + T_z^N)$$

where: - end clearance between the rotor and the side covers of the front and rear, respectively, mm;

- nominal face gaps between the rotor and side covers of the front and rear (at t = 22 ° C), respectively, mm.

The total end clearance was determined in order to avoid influence on it, longitudinal displacement of the rotor in the bearing units.

To investigate the effect of operating modes of the proposed VPLT on the change in the size of the end clearance, the serial vacuum pump from the vacuum unit UVU60 / 45B-0.75 (Fig. 1) was modernized according to the proposed design solutions. Measurements of temperature and end clearance were carried

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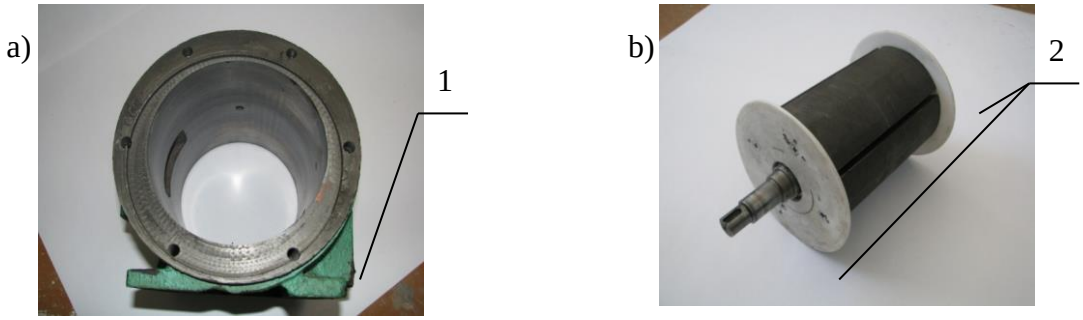
out similarly. In the modernized vacuum pump the end gaps "end plate - side cover" and "end plate - blade" were monitored.



a) - the hull; b) rotor;
1- housing bore; 2 - end plates.

Figure 1: Body and rotor of the modernized VPLT

RESULTS AND DISCUSSION

The deviation of the temperature of the hull and the side covers of the pump, during the research, was minimal and did not exceed ± 0.2 ˚C. This is due to the fact that these parts have a large contact area and, as a result of heat exchange, their temperature is equalized.

Based on the results of the experiment, the dependencies of the pump heating temperature on the time of continuous operation (Fig. 2) and the size of the end clearance on the pump heating temperature were constructed (Fig. 3).

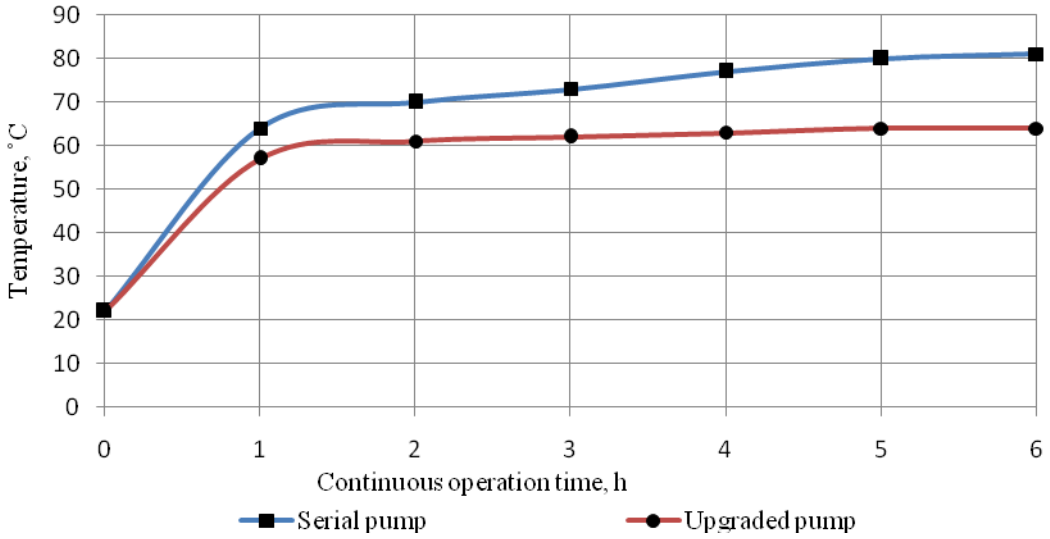


Figure 2: Dependence of the pump heating temperature on the time of continuous operation

Analysis of the data in Figure 2 shows that after heating for an hour, the temperature of the serial pump is 64 ° C and stabilized only after 4.5 hours of operation, about 80 ° C. The temperature of the modernized pump after one hour of operation was 57 ° C and stabilized after 2.5 hours of operation, about 65 ° C. The decrease in the operating temperature of the upgraded VPLT body compared to the production one is explained by the fact that the contact of the end surfaces of the blades with the side covers is completely eliminated, due to the mounting of the end plate, which causes friction and, as a consequence, additional heating.

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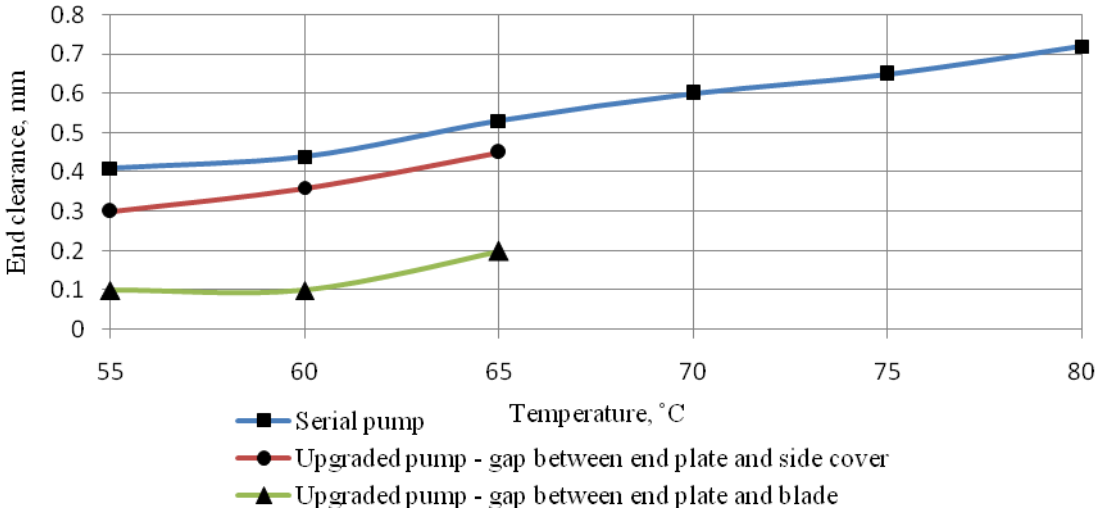

Figure 3: Dependence of size of an end backlash on temperature of the case of the pump

Experimental studies have shown that thermal expansion of the end gap as a result of continuous, long-term operation of the series pump is almost linear in the range from 60 to 80 ° C. On average, with an increase in the temperature of the pump casing, by 10 ° C, the end clearance increases by 0.1 mm. A change in temperature from 60 to 80 ° C, with continuous operation, increases the end clearance by 0.28 mm. Such an increase in the total end clearance in the series pump due to its heating is equivalent to the wear value in this coupling, corresponding to an operating time of 200-250 hours. This is especially critical for pumps with more than 75% of the life-time resource (600 hours or more).

The clearance between the end plate and the blade, as a result of the heating of the modernized pump, increased by 0.2 mm. This is due to the difference in the temperature coefficients of the linear expansion of the materials from which the blades (textolite) and the rotor (cast iron) are made.

Increasing the temperature of the body of the upgraded pump to 65 ° C also leads to an increase in the gap between the side cover and the end plate by 0.15 mm. At the same time, as shown earlier studies [8], this gap has practically no effect on the volume flow and the ultimate vacuum, due to design features. Consequently, the heating of the upgraded VPLT as a result of prolonged, continuous operation will not significantly affect its performance.

CONCLUSION

The conducted researches showed that the increase in the end clearance as a result of continuous, continuous operation of the serial VPLT is 0.28 mm, in the temperature range from 60 to 80 ° C. This leads to a reduced supply and ultimate vacuum, with continuous operation for more than 2 hours. Therefore, to eliminate the negative factors caused by the increase in the temperature of the housing and the side covers of the serial pump, it is necessary to take breaks every two hours, or to provide for its additional cooling. The heating of the housing of the modernized vacuum pump is less intensive and is 65 ° C. Due to design features, such heating of the modernized VPLT does not have a significant effect on its supply and ultimate vacuum. This indicates the effectiveness of the proposed design solutions for the modernization of VPLT.

REFERENCES

[1] Zakharin, A.V. Practical recommendations for increasing the efficiency of rotary-type machines / A.V. Zakharin, P.A. Lebedev, R.A. Magomedov, R.V. Pavlyuk, N.A. Maryin, E.A. Ivakhno // In the collection: Problems of economy and operation of automotive engineering. Materials of the International Scientific and Technical Seminar named after V.V. Mikhailova. 2014. P. 63-65.

[2] Relative wearing resistance of vapor friction rotation vacuum pumps / A. Zakharin. A. Lebedev, R. Pavlyuk, P. Lebedev // Engineering for Rural Development. 2018. Vol. 17. P. 97–101.

[3] Zakharin A.V. Analysis of wear of parts of a modernized vacuum pump of plate type // Vestnik APK

Stavropol'ya. 2012. № 2 (6). P. 40-41.

[4] Pat. 2333392 Russian Federation, F04C18 / 344 (2006.01). Rotary plate compressor / A.T. Lebedev, A.V. Zakharin, A.S. Slyusarev [and others]. - No. 2007108890/06; claimed. 09.03.2007; publ. 10.09.2008. Bul. № 25. - 5 p.

[5] Pat. 43043 Russian Federation, F04C18 / 344. Rotary plate compressor / A.T. Lebedev, M.A. Krasnikov, P.A. Lebedev [and others]. - No. 2004125976/22; claimed. 30.08.2004; publ. 27.12.2004. Bul. №36. - 4 p.

[6] Pat. 54107 Russian Federation, F04C18 / 344 (2006.01). Rotary plate compressor / A.T. Lebedev, A.V. Zakharin, [and others]. - No. 2005122266/22; claimed. 13.07.2005; publ. 10.06.2006. Bul. №16. - 4 p.

[7] Mzhelsky M.I. Leakage of air inside the vacuum pump of the milking plant // Mekhanizatsiya i elektrifikatsiya s.kh. - 1970. - No. 10. P. 45 - 46.

[8] Lebedev, A.T. The duration of continuous operation of a vacuum pump of plate type and its productivity / A.T. Lebedev, A.V. Zakharin // Traktory i sel'khozmashiny. 2011. № 10. P. 36-38.