Tribological studies of materials for sliding bearings when lubricated with hydraulic fluid

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Abstract. Tribological research of materials BrOPh6.5-0.15, PH4M paired with 40X steel and lubricated with hydraulic fluid AMh-10 showed good antifriction properties. The results of the research on the influence of load, speed and temperature on the coefficient of friction of materials: BrOPh6.5-0.15 and PH4M when lubricated with AMh-10 hydraulic fluid. At a load of 0.5447 MPa, the coefficient of friction of BrOPh6.5-0.15 material at a temperature of 90°C is 1.58 times higher, and at a load of 2.003 MPa, the coefficient of friction of BrOPh6.5-0.15 material is 2.85 times higher than the coefficient of friction of BrOPh6.5-0.15 material at a temperature of 20°C. Materials BrOPh6.5-0.15 and PH4M are promising for application in plain bearings of pumps pumping hydraulic fluid AMh-10.

1 Introduction

Low viscosity fluids are used in most hydraulic systems. The bearing units of transfer pumps must be sealed against the ingress of low-viscosity pumped liquids. Bearing units have their own lubrication system to ensure reliable pump performance. The use of working hydraulic fluids for lubrication of the pump plain bearings simplifies the friction units structurally. For reliable operation of the pump slide bearing when lubricated with low-viscosity hydraulic fluids, new design solutions and the use of antifriction materials providing a low coefficient of friction and low scoring resistance are required. Pumped liquids have low viscosity and in some cases are not suitable for lubrication of pump slide bearings. However, low-viscosity hydraulic fluids, like water, are also used as plain bearing lubricants. An important parameter for lubricity is viscosity. The viscosity of the lubricant is one of the key parameters in the research of hydrostatic bearings. To determine the load carrying capacity of hydrostatic bearing in heavy equipment, the lubricating film viscosity-temperature equation is established [1, 2]. The effect of viscosity-pressure dependence was able to increase the viscosity, friction coefficient and maximum pressure of the film, and reduce the stress parameter of the couple, especially when the skew angle is large [3]. Water is used to lubricate the plain bearings of pumps. Bearing materials in this case should have good antifriction properties [4, 5]. Sliding bearings with the use of rubber at lubrication by water can work for a long time. In work [6] questions are considered and

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results on increase of working capacity of slide bearings at lubrication by low-viscosity liquids are presented. The lubricating film at use of low-viscosity liquids decreases and will not always be able to separate rubbing surfaces that leads to contact of rubbing surfaces. Therefore, the roughness of the bearing friction surfaces is important in the formation of hydrodynamic fluid film between shaft-hub parts [7,8]. To create better conditions for the formation of the lubricating film, constructive solutions for profiling of bearing friction surfaces are used. Grooves on the working surface of the bearing contribute to the increase of pressure in the lubricating film, which leads to an increase in its thickness [9]. The increase of pressure in the lubricating layer increases the load carrying capacity of the plain bearing. Geometric profiling of bearing surface relief is different for lubrication conditions, viscosity, load carrying capacity and characteristics of plain bearing [10, 11]. At designing and creation of plain bearings for work in conditions of lubrication by low-viscosity liquids special attention is paid to materials of friction pairs and their compatibility in work. In friction pairs are used: rubbers, polytetrafluoroethylene (PTFE) and materials on its basis, antifriction alloys on the basis of copper. For instance, fillers in the structure of PTFE improve its tribological properties. The introduction of combined fillers can effectively improve the mechanical and tribological properties of PTFE [12,13]. The tribological characteristics of radiation-modified PTFE were investigated in [14]. It is shown that the surface wear rate of modified PTFE is two orders of magnitude less than that of conventional PTFE. In [15], the results of mechanical properties of radiation-hardened PTFE are summarized. In [16] the applicability of bronze bearings as an alternative to non-metallic bearings is considered. Observance of certain conditions at creation of a friction pair (hardened surface of a journal), the greater bearing capacity and durability is provided. When creating sliding bearings lubricated by low-viscosity fluids, great importance is attached to environmental issues. Research shows that quantifying the environmental impact can help determine when lubrication loss is more important than material selection or vice versa [17].

The aim of the work is to study tribological parameters of plain bearing materials when lubricated with hydraulic fluid.

2 Materials and Methods

The research of tribological parameters was carried out on samples of tin bronze BrOPh6.5-0.15 and radiation-hardened fluoroplastic 4 (PH4M) paired with 40X steel. The tested samples are shown in Figure 1. The tests were carried out in a plane-ring pattern, simulating a pump thrust bearing. The chosen test pattern makes it possible to adapt the test results to other test patterns.

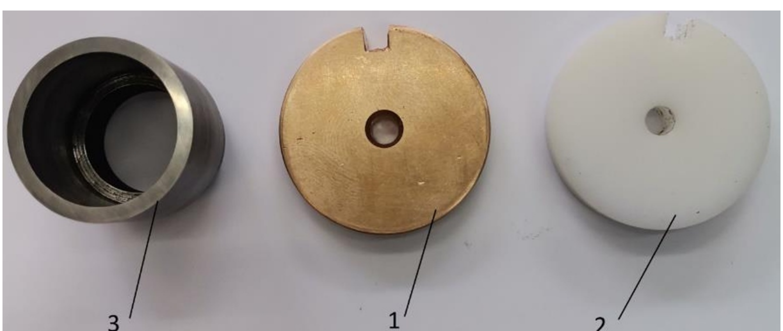

Fig. 1. Test samples: 1-BrOPh6.5-0.15, 2- PH4M; 3 – 40X steel

BrOPh6.5-0.15 samples had a roughness of 0.1-0.2 µm. The surface hardness was 70 Mpa. The roughness of PH4M samples was 0.167 – 1.0 µm, and the HV microhardness at 20g load was 48 Mpa. A sample of hardened 40X steel with a hardness of HRC52-54 was used as the reciprocal pair in the tests. The samples made of BrOPh6.5-0.15 and PH4M acted as thrust bearing thrust bearing of the pump, fully immersed in a beaker with hydraulic fluid Amh-10 (working fluid of the hydraulic system pumped by the pump). Tribological tests of samples were carried out under conditions of rotational motion. Linear velocity was 1.0 – 2.5 m/s, axial load: 0.5447 – 2.0032 Mpa, temperature - +20…+90 °C. The contact area was 1.758 cm2, the average diameter of the ring sample was 28 mm. Research of tribological parameters of friction pairs BrOPh6.5-0.15 – steel 40X and PH4M – steel 40X was carried out on the friction machine MAST-1, which was modernized, including a permanent drive, a system of regulation and control of shaft speed and friction torque measurement with subsequent online processing on the computer. The tests were conducted in accordance with the methodology [18].

3 Results and Discussion

During the tests, the load and speed of the upper sample made of 40X steel were set stepwise. Figure 2 shows the variation of friction coefficient of BrOPh6.5-0.15 material from load, speed at temperature +20 ° C, and lubricant AMh-10. The test results showed that with increasing speed the friction coefficient for all load variants decreases.

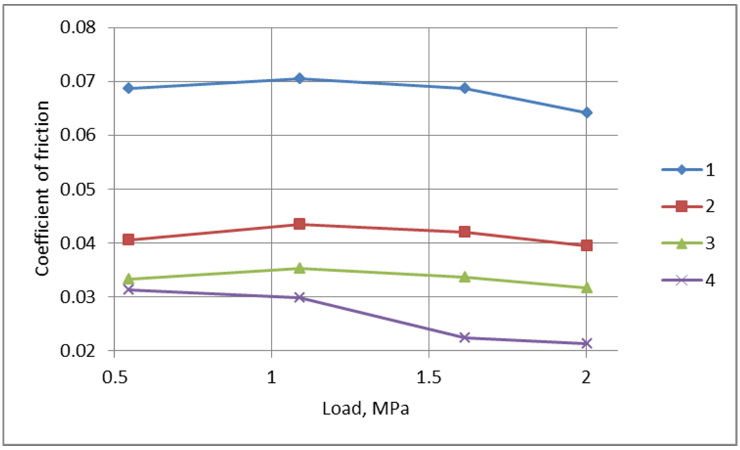

Fig. 2. Variation of friction coefficient from the load of BrOPh6.5-0.15 material at AMh-10 lubricant, temperature +20°C and speed, m/s: 1-1; 2-1.5; 3-2; 4-2.5

At a load of 2.003 MPa and a speed of 1.5 m/s, the friction coefficient of BrOPh6.5-0.15 material is 1.63 times less than at a speed of 1 m/s, and at a speed of 2 m/s the friction coefficient is 2.02 times less, and at a speed of 2.5 m/s it is 3.01 times less, respectively. Figure 3 shows the variation of friction coefficient BrOPh6.5-0.15 from load and speed at temperature +90 °C and lubricant AMh-10.

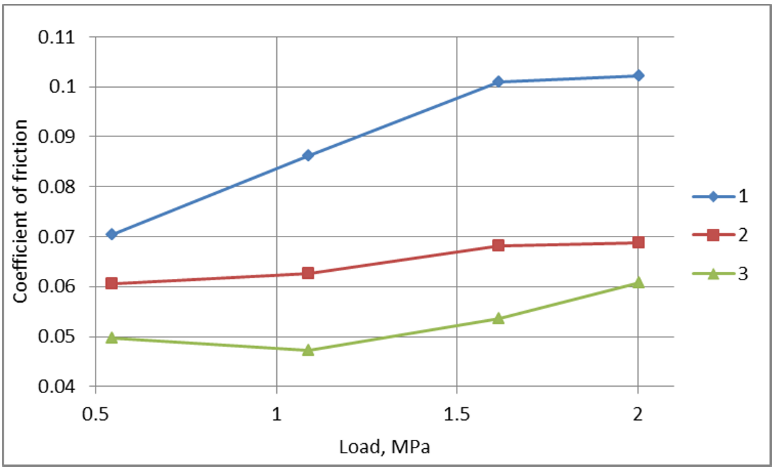

Fig. 3. Variation of friction coefficient from the load of BrOPh6.5-0.15 material at AMh-10 lubricant, temperature +20°C and speed, m/s: 1-1; 2-1.5; 3-2.5

At a load of 1.089 MPa and a speed of 1.5 m/s the friction coefficient of BrOPh6.5-0.15 material is 1.37 times less than at a speed of 1 m/s, and at a speed of 2.5 m/s the friction coefficient is 1.82 times less than at 1 m/s. Figure 4 shows the variation of friction coefficient BrOPh6.5-0.15 from speed and load at temperature +20 °C and lubricant AMh-10.

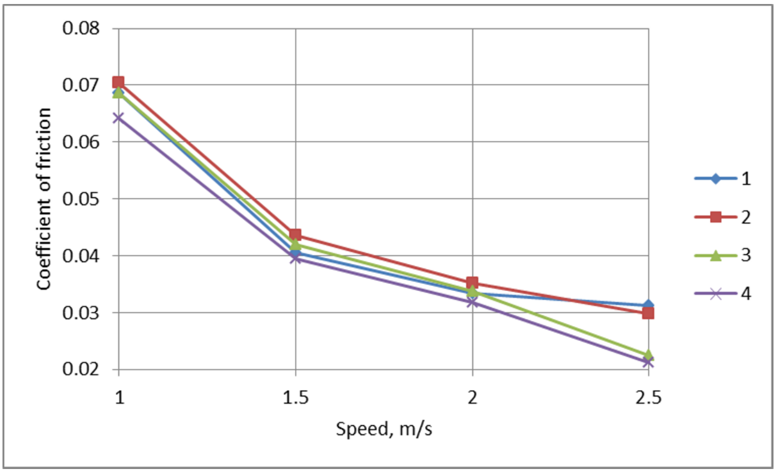

Fig. 4. Variation of friction coefficient from speed of material BrOPh6.5-0.15 at lubricant AMh-10, temperature +20°C and load, MP: 1-0.5447; 2-1.0893; 3-1.6157; 4-2.003

With increasing speed, the coefficient decreases throughout the load range considered. At a speed of 2.0m/s the variation of the coefficient of friction is in the range of 0.032-0.035. Figure 5. shows the dependence of the coefficient of friction on the load at a speed of 2.5 m/s, lubricant AMh-10, temperature +20 °C of materials: BrOPh6.5-0.15 and PH4M. At a load of 2.003 MPa the friction coefficient of PH4M material is 1.8 times higher than the friction coefficient of BrOPh6.5-0.15 material.

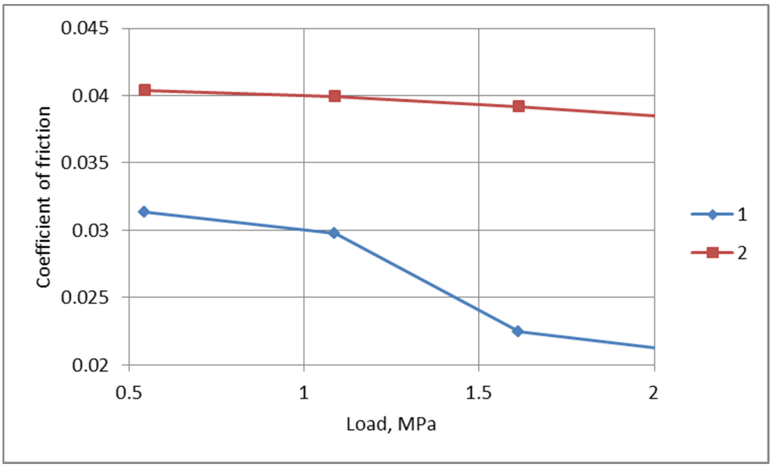

Fig. 5. Variation of friction coefficient from load at speed 2.5 m/s, lubricant AMh-10, temperature +20 °C materials: 1-BrOPh6.5-0.15; 2-PH4M

Figure 6 shows the dependence of the coefficient of friction at a speed of 2.5m/s, lubricant AMh-10, temperature 20 and 90 °C of BrOPh6.5-0.15 material on steel 40X.

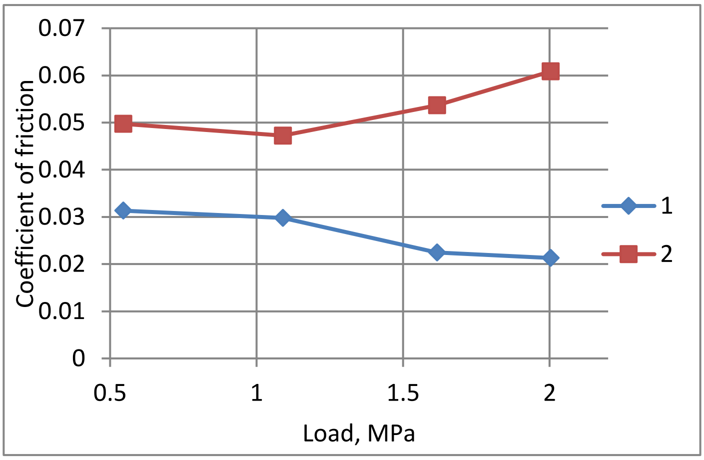

Fig. 6. Variation of friction coefficient from load at speed 2.5m/s, lubricant AMh-10 BrOPh6.5-0.15 material at temperature, °C: 1-20, 2-90.

At a load of 0.5447 MPa, the coefficient of friction of BrOPh6.5-0.15 material at 90°C is 1.58 times higher, and at a load of 2.003 MPa, the coefficient of friction of BrOPh6.5-0.15 material is 2.85 times higher than the coefficient of friction of BrOPh6.5-0.15 material at 20°C, respectively.

4 Conclusions

Tribological research of materials BrOPh6.5-0.15, PH4M in pair with steel 40X and lubricant AMh-10 hydraulic fluid showed good antifriction properties. At a load of 0.5447 MPa the friction coefficient of BrOPh6.5-0.15 material at 90°C is 1.58 times greater, and at a load of 2.003 MPa the friction coefficient of BrOPh6.5-0.15 material is 2.85 times greater than the friction coefficient of BrOPh6.5-0.15 material at 20°C, respectively. Materials

BrOPh6.5-0.15 and PH4M are promising for application in sliding bearings of pumps pumping hydraulic fluid AMh-10.

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