UDC 621.891

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Research of the impact of ambient temperature on the wear resistance of metal-polymer composite materials used in aviation plain bearings.

Metal-polymer composite materials were tested at ambient temperatures of 20°C and 60°C. The effect of temperature on the wear resistance of metal-polymer composite materials, which can be used in aviation hinge bearings, was determined. It was determined that the greatest influence on the amount of wear intensity is generated by heat generation, caused both by the friction process and dynamic load, as a result of the reverse movement.

Introduction. Tribological and other properties of polymer composite materials are affected by temperature. This mostly concerns the Young's modulus, which is one of the main important factors of polymer composite materials, as it characterizes their rigidity. Its noticeable decrease under the influence of temperature can have a significant impact on contact and tribotechnical characteristics.

Analyzing the effect of temperature on metal-polymer composite materials, it can be concluded that all materials that include polymer materials have changed the wear result to a greater or lesser extent. This is explained by the fact that any polymer changes its strength characteristics when the temperature rises, and as a result affects the result of friction.

According to the operating conditions of bearings on aircraft, their operating temperature is within -50 to + 50 °C. If we consider the operating conditions of helicopters operating on the African continent, the temperature range is from 0°C to +120 °C.

Therefore, the effect of temperature on the testing of metal-polymer materials is quite an interesting factor that changes the wear resistance of materials.

The purpose of the study: To determine the influence of the temperature of the external environment on the wear resistance of modern metal-polymer composite materials, which are used for the manufacture of aviation hinge bearings.

Test methodology. For the testing of metal-polymer composite materials for aircraft bearings, the installation [1] was chosen, which allows testing in oscillating movements with the influence of temperature on the samples.

The test conditions corresponded to the following parameters:

1. The amplitude of movement is 500 μcm.
2. The frequency of oscillations is 3 Hz.
3. Specific load – 10 MPa.
4. The number of working cycles – 10^5 cycles.

Materials for testing were defined as modern composite metal-polymer materials [2], which are used in engineering by leading companies in the world, mostly: Zedex ZX-324VMT, Iglidur X1, Fluroglide and metal-polymer tape (МПС) Ф-4К15М5.

Effect of temperature on the wear resistance of metal-polymer composite materials. Figure 1 shows the change in wear resistance of composite metal-polymer materials at temperatures of 20 °C and 60 °C.

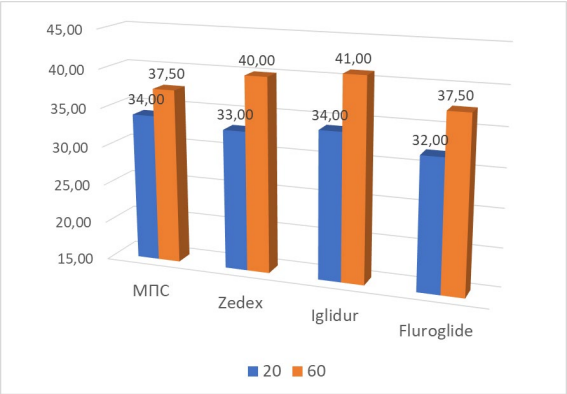

Fig. 1 – Wear resistance of anti-friction metal-polymer composite materials at temperatures of 20 °C and 60 °C.

An increase in temperature from 20 °C to 60 °C does not significantly affect the tested composite materials from 8 to 15%, because the anti-friction metal-polymer composite materials selected for testing are a complex structure of more than five materials with different structures and characteristics.

The operating temperature range of almost all materials ranges from -50 to +120°C. The temperature affects the metal-polymer tape the least - within 8%. A difference in wear of 3.5 microns in testing may even be an error in research. The insignificant effect of temperature on the composite material is explained by the fact that the layer of PTFE+15%C+5%MoS^2 material on the babbitt is located on a metal tape that dissipates and distributes heat. The applied polymer, on which the temperature has the greatest influence, acts as a material for running-in. All other materials that make up this composite material do not change their characteristics (stiffness, Young's modulus, hardness, etc.) as much as the PTFE polymer.

Fluroglide material is affected by temperature to a greater extent than metal-polymer tape and is about 10%. This material is created on the basis of reinforced fabrics with polymer materials, and the temperature effect increases the subsidence of the material under the action of the load. But the framework of the composite material and the fibers that are included in the composition hold the tension and therefore the impact is greater than in the metal-polymer tape and less than in other materials among those that passed the test and that differ in their composition.

Materials ZX-324VMT and Iglidur showed the greatest increase in the temperature wear rate, which is about 15-20%. The material ZX-324VMT is created on the basis of PEEK with the addition of other polymers and fillers. That is, the basis of the design of this material is a polymer reinforced with carbon fibers.

As a result, temperature affects this composite material almost as much as it does polymer materials. The parameters of temperature's impact on the reinforced polymer and the presence of fillers of varying origins show some degree of variation. Almost the same effect occurs on the Iglidur material. The difference in wear rates is explained by different functional fillers present in these materials and different sizes of reinforcing fibers. In terms of structure, these materials are very similar with the difference only in the materials and their quantity.

During the process of friction, the heat generated in the contact zone and it is dissipated into the environment, the temperature of the tribosystem is always in dynamic equilibrium under constant operating modes, and fluctuates from the equilibrium point depending on the operating conditions of the articulated bearings. A feature of metal-polymer composite materials in hinged sliding bearings is a large area of actual contact and low thermal conductivity, which is much lower than in metal-metal contact. As a result, the formation of a greater intensity of heat generation, which occurs under the action of high loads (static, dynamic) operation of the bearings, as a result of less heat removal from the contact zone.

For hinged sliding bearings with metal-polymer composite materials, one of the most important criteria for determining the limits of application of materials is the amount of stress that destroys the metal-polymer material. According to works [3, 4], it is related to temperature with a linear law. In addition, the authors of the works determined that with an increase in temperature, compressive compressive stresses decrease and their magnitude depends on temperature more intensively than the deformation of the metal-polymer material.

In metal-polymer hinged bearings, this is explained by the complex design of composite materials (PTFE and carbon reinforced fibers with the addition of solid lubricants in a matrix of another polymer or babbitt). When loaded under normal temperature conditions, the coating deforms like a viscoelastic material, since the stiffness of the polymer matrix and carbon fibers in the transverse direction is approximately the same. In this case, the strength of the coating is relatively high. As the temperature increases, the stiffness and strength parameters of the polymer amorphous matrix decrease quite sharply (its softening occurs), while oriented and much more thermally resistant carbon fibers practically do not change their properties. At the same time, PTFE with functional additives is squeezed between the fibers, and the deformation of the metal-polymer material is determined mainly by the stiffness of its reinforcing frame, rather than the matrix. The same picture occurs when working with a metal-polymer tape, but the reinforcing fibers in this case are babbitt material.

Thus, increasing the test temperature from 20 to 60°C affects polymer composite materials to a greater extent than metal-polymer tape. At this stage, a significant role in wear resistance is played by the material's ability to dissipate heat, which occurs in the contact zone from reversible sliding. It has also been established that the carbon fabric of the Fluroglide material can withstand a higher temperature than the babbit of the metal-polymer tape. The key role in the durability of articulated bearings that work in non-standard temperatures will be played by the selection of the design of composite materials and the polymer materials themselves for specific working conditions.

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