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The Influence of Mono-and Polyreinforcement on the Tribological Properties of Polymer Composites based on Organic Silicon Binder

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Abstract
The article examines the effect of discrete basalt fiber and hybrid mixture on the tribotechnical properties of the organosilicon binder. It was established that basalt plastic with a fiber content of 40-50 mass.

Index terms— basalt fiber, graphite, coefficient of friction, intensity of linear wear, antifriction aggregate, rolling bearing.

1 I. Introduction

he reliability and durability of metallurgical, food, and textile equipment directly depends on the trouble-free and efficient operation of sliding bearings [1]. The metal base of the bearing ensures its rigidity and strength, and anti-friction filler (AFF) ensures its resistance to wear and corrosion, stability of properties during operation. The choice of AFF depends on the operating conditions of tribological units equipped with rolling bearings. One of the technological methods of increasing the wear resistance of bearings is the use of polymer composite materials (PCMs) as AFF. Rolling bearings modified by AFF are characterized by stable operation under the influence of high temperatures, moisture, abrasive dust, acids and alkalis, resistance to shock loads. Another important advantage of using AFFs made of PCMs is the stability of operation in conditions without additional lubrication. Today, hybrid (polyreinforced) PCMs, containing a mixture of fibrous and powder fillers as a filler, are being actively used. It is known from literary sources [2] that the use of fibrous fillers provides strength and resistance to PCMs loads, and powder fillers are able to provide the effect of "self-lubrication" [3,4]. Thus, the use of rolling bearings containing hybrid PCMs as an AFF made it possible to 5 times, compared to open and sealed rolling bearings which are lubricated by plate lubricators.

Taking into account the above, the development of a new wear-resistant AFF is an urgent task of modern materials science.

2 II. Research Objects and Methods

Organosilicon rubber (OR) was chosen as a polymer matrix for the creation of AFF.

We used the followings to create basalt plastics (BP) and hybrid PCMs based on organosilicon polymer:

discrete basalt fiber (BF) with an elementary fiber diameter of 13 ?m (JSC "NDI SV", Ukraine); -hidden crystalline graphite which is characterized by an unfinished texture, often contains an admixture of finely dispersed carbonaceous matter in its composition [5,6]; Preparation of composites based on organosilicon polymer containing mixtures was carried out in a horizontal mixer followed by thermoreactive crosslinking of the polymer matrix at a temperature of 393 K for 30 minutes. The tribotechnical properties of the composites according to the "disk-pad" scheme were studied on the SMC-2 friction machine, under conditions of friction without lubrication, at a load of 1,0 MPa, and a sliding speed of 1,0 m/s. The counterbody is steel 45 (45-48 HRC, R ? =0,32 ?m) [7]. The temperature in the contact zone was determined using a thermocouple at a distance of 3 mm from the friction surface.

3 III. Research Results

It can be seen from table 1 There is a sharp drop in wear resistance With a further increase in the BF content in the composite up to 70 mass.%. This can be explained by the fact that the degree of uniformity of polymer distribution on the surface of the fiber has significantly decreased, as a result, the structure of the composite contains a significant number of pores and voids. This conclusion is confirmed by the study of the friction surface of BP samples after the tests. Comparing the friction surfaces of BP (see Fig. 1), it can be seen that the composite containing 70 (b) mass.% of BF undergoes significant morphological changes compared to the content of 50 mass.%: you can observe zones of BF precipitation (circled) due to insufficient adhesion between BF and the organosilicon matrix on the friction surface of basalt plastic. It is interesting to note that the coefficient of friction of the developed BPs reaches about 0,9. It can be explained by the fact that BPs belong to frictional fillers, as a result, they increase the friction forces in the contact zone between the steel counterbody and the test sample. This conclusion is confirmed by measuring the temperature in the contact zone between the BP and the steel counterbody. In the course of the experiment, it was found that its value varies between 443-485 K (friction path is 1000 m). This can be explained by the fact that BF is characterized by a low thermal conductivity (0,064-0,096 W/m?K), as a result of which the removal of temperature from the contact zone is insufficient [7].

Hidden crystal graphite was added to the BP to reduce the coefficient of friction and temperature in the contact zone,. It was established that hybrid PCMs are superior to basalt plastics 72-168 times in terms of the intensity of linear wear (see Table **??**). This is due to the fact that the hidden crystalline graphite performs the function of a solid lubricating material, and in the process of friction, its finely dispersed wear products are transferred to the surface of the steel counterbody and form a protective (anti-friction) layer on it (see Fig. 2). The latter is characterized by high adhesion to the metal counterbody and low resistance to shear, as a result of which there is a decrease in frictional forces between the sample and the counterbody. Thus, the coefficient of friction of hybrid PCMs friction is 0,3-0,5, which is 1,8-3 times less compared to BP. The confirmation of what has been said is a decrease in temperature in the contact zone between the sample and the counterbody by 100 degrees. In addition, other possible factors that affect the improvement of the tribological properties of PCMs are the thermal properties of the filler. It is known from literary sources [8] that graphite is characterized by a high (from 278.4 to 2435 W/(m?K)) coefficient of thermal conductivity, close to a copper one. According to the theory [9], high indicators of thermal conductivity contribute to the removal of heat from the friction zone and, as a result, the localization of high temperature in the contact zone of tribological pairs disappears, accordingly, the probability of the development of processes of thermomechanical destruction in the volume of the part, which leads to its catastrophic wear, decreases, as a result, reducing the reliability and stability of work [10]. The obtained results of laboratory studies allowed to proceed to production tests. Food industry equipment includes a significant number of heat treatment and baking processes, which in turn requires constant lubrication of rolling bearings. The hybrid PCM ? 4 was used in the modification of rolling bearings (? 62306, Fig. 3) of AFF, which are used for the tunnel oven for baking confectionery products and equipment for roasting peanuts. The operating temperature reaches 473-523 K. The results of production tests confirmed the feasibility of using the developed PCM as an AFF.

4 IV. Conclusion

As a result of the conducted tribological studies, it was established that polyreinforced PCM, which contains 35 mass.% of BF and 35 mass.% of hidden crystal graphite, is characterized by the best set of tribological properties. The fiber provides the composite with strength and resistance to the influence of loads, and the hidden crystal graphite provides a "selflubricating" effect. The confirmation of the latter is the formation of a transfer layer on the friction surface of the steel counterbody. Based on the obtained results, polyreinforced PCM sample ? 4 is recommended for use as an AFF of rolling bearings of tribological units of equipment of modern technology which work in conditions of friction without lubrication and under the influence of high temperatures (473-523 K) and dust.

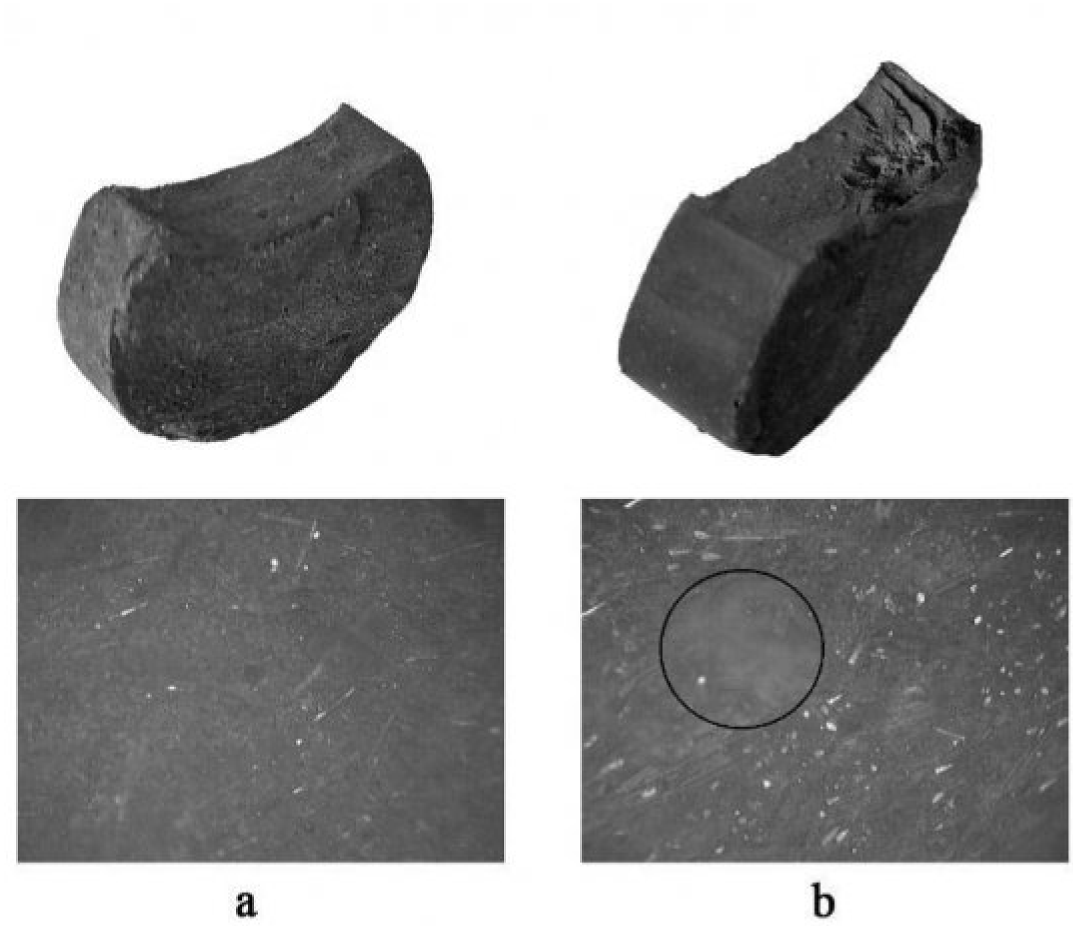

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Figure 1: Figure 1 :

2

Figure 2: Tablde 2 :


2

Figure 3: Figure 2 :

1

Indicator	40*	Fiber content, mass.% 50*	60**	70***
Intensity of linear wear, ? h ?10 -6	3,38	2,16	6,61	7,36
Temperature in the contact zone, K	443	485	386	378

where * -friction path is 1000 m;

-friction path is 480 m;

* -friction path is 370 m.

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Figure 4: Table 1 :

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