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Basic Tribotechnical Properties of Modified Composite Polymer Materials

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ABSTRACT:In the given workresults of experimental researches tribotechnical properties of the composite polymeric materials processed by ultrasound are resulted.

KEYWORDS: ultratuk, obrabotka, polimer, kompozit, napolnitel, tajriba, svoikstvo, tribotexnika, bezashivanie, koeffitsient trenie.

I.INTRODUCTION

At present, composites based on polymers, due to their high strength, hardness and a number of other properties, have found wide application in various branches of the national economy, including in machine building. In the field of creation and research of composite polymer materials and coatings based on them, a large number of scientific and research works were carried out for machine building (V.A.Belyi, N.K.Myshkin, Al.Al.Berlin, S.Sh.Rashidova ,SSNegmatov, etc.) and developed a number of composite polymer materials, which are recommended for use in the working bodies of machines and mechanisms. However, to date, have not found wide application because of their low durability and wear resistance.

The task of modern materials science is to create polymer composites with high physical-mechanical and tribotechnical properties. As is known [1-3], to improve the physicomechanical and other properties of polymer composites, various methods of physical processing, in particular ultrasound, are used. The effectiveness of ultrasonic treatment of polymer compositions increases, if it is carried out at a relatively high frequency and power.

Consequently, the mechanical and chemical action of ultrasound manifests itself especially at high frequencies of oscillation and power, which contributes to dispersing and moving disperse systems, degassing liquids and melts, intensifying the polymerization process and other technological processes [2].

In connection with this study of the physico-mechanical and tribotechnical properties of composite polymer materials processed by ultrasound and improving their performance, meeting modern requirements of machines and mechanisms, is an urgent task.

II.GOAL AND TASKS

The purpose of this work is to investigate and analyze the tribological properties of composite polymeric materials processed by ultrasound.

To achieve this goal, it was necessary to solve the following tasks:

- Investigate the influence of the type and content of filler on the coefficient of friction and wear rate of composite epoxy polymeric materials under various friction conditions;
- to investigate the effect of ultrasonic treatment regimes on tribotechnical properties (wear rate and coefficient of friction) of composite polymer materials.

As an object of study, epoxy composites and the following fillers were selected, providing simultaneously high antifriction and physico-mechanical properties of PKM-graphite, kaolin, talc, phosphogypsum, and also meeting the requirements of high wear resistance and hardness of coatings-iron powder, copper powder and fibreglass.

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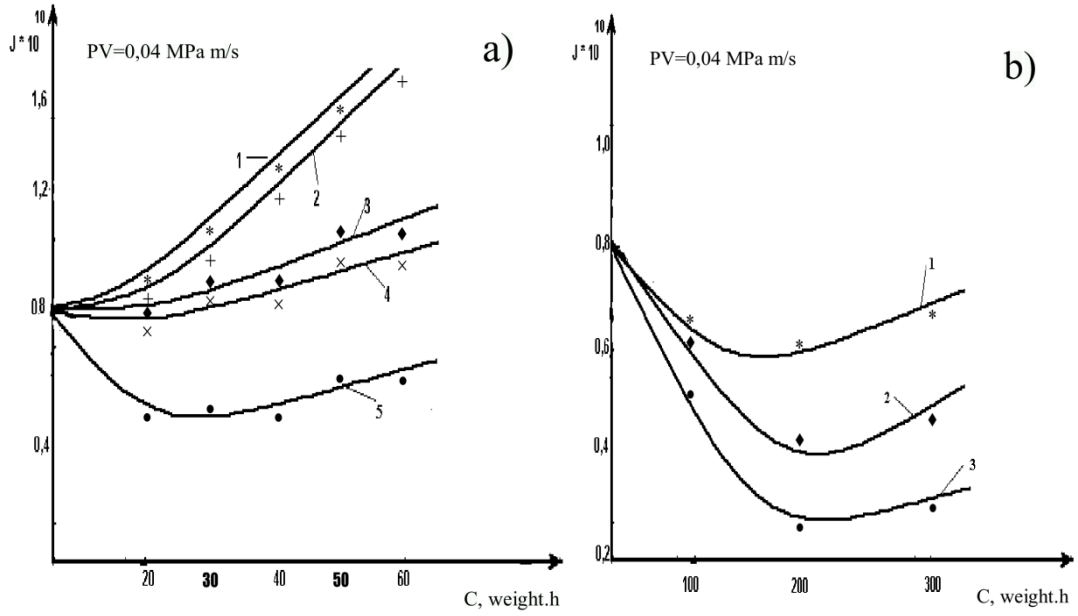
Tribotechnical properties of polymer coatings were determined in accordance with GOST 23.223-85 on an improved tribometer (patent RU No. 1989) [4]. To process the polymer composition, an ultrasonic unit with a frequency of 1000 kHz is selected, which allows processing of polymer compositions, varying the power of ultrasonic vibrations from 80 W to 250 W [5].

III.RESULTS

The following results were obtained on the basis of the experimental studies. The degree of ultrasound impact on the tribotechnical properties of polymer composites depends on the type and content of the filler. The optimum value of the duration of ultrasonic treatment of epoxy composites filled with phosphogypsum is 30-35 minutes, with graphite it is equal to 20-25 minutes. The coefficient of friction of epoxy composites filled with phosphogypsum decreases from 0.27 to 0.22, and from 0.27 to 0.21 with graphite. Further increase in the duration of ultrasound treatment leads to an increase in the wear rate and friction coefficient of epoxy coatings filled with various fillers. In epoxy composites filled with graphite, kaolin and phosphogypsum, with increasing filler content, the friction coefficient varies extremely with a minimum (at a content of 30-50 parts by weight).A similar change in the tribotechnical properties of epoxy composites is observed when metal fillers and their oxides are introduced, but at higher filler values (up to 150-200 wt. h.)

The results of the influence of the type of filler and the ultrasound regime on the tribotechnical properties of epoxy composites are shown in Figures 1 and 2.

In the work it is shown experimentally (Fig. 1) that with increasing quantitative content of most fillers, the wear rate of epoxy composite coatings first decreases, then, after passing through a minimum, increases. And the position of the minimum and its value depends on the type of filler. The introduction of graphite, kaolin and phosphogypsum in the composition causes a decrease in the wear of the coatings, glass fibers reduce the wear rate of epoxy coatings by one order. The wear resistance of composite epoxy coatings decreases with an increase in the content of all fillers above 40 parts by weight. (except for phosphogypsum and fiberglass), while for coatings filled with graphite it is larger than for coatings without fillers (Fig. 1a).



1-graphite; 2-soot; 3-talc; 4-kaolin; 5-fiberglass.

1-copper oxide; 2-copper powder; 3-iron powder.

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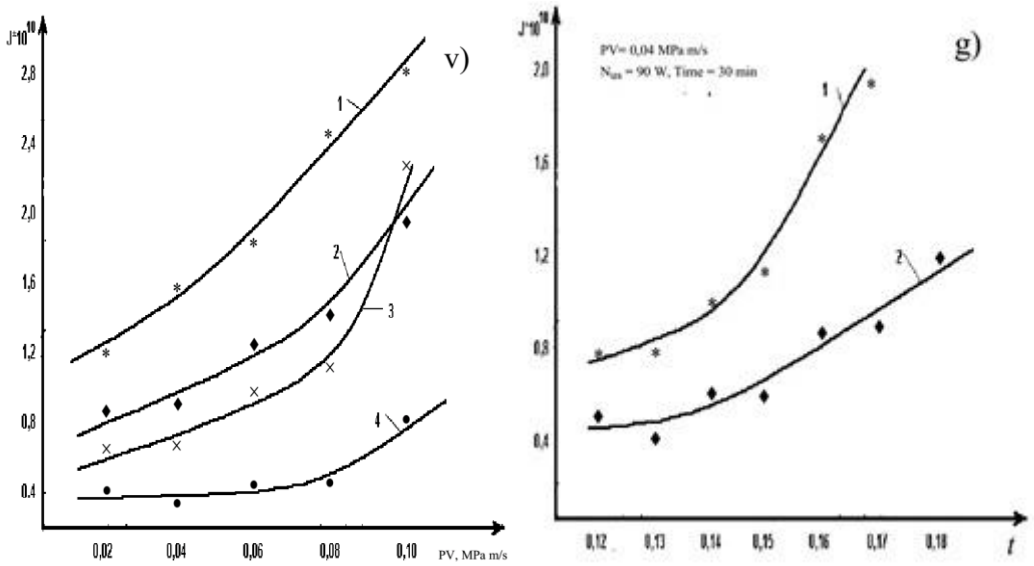

1-graphite; 2-kaolin;
3-phosphogypsum; 4-fiberglass.

1-phosphogypsum; 2-iron powder.

Modes of ultrasonic processing: power - 90 W, duration - 25-35 min.
Figure 1. Intensity of wear of epoxy composite coatings treated with ultrasound

With an increase in the content of metallic fillers, the wear rate of composite epoxy coatings varies extremely. For example, the minimum wear intensity is observed for oxides at 100-150 wt. h, for copper and iron powders - 200-300 wt. h. With an increase in their concentration, the wear rate and the friction coefficient increase (Fig. 1b).

The wear rate of polymer coatings increases with the growth of the PV factor, and with different intensities, depending on the type of material. Intensity of wear in all coatings has a relatively identical tendency to the value PV = 0.04 MPa m/s (Fig. 1bv), and with an increase in PV to 0.08 MPa m/s and more, the rate of deterioration sharply increases. High wear resistance is possessed by pores, filled with glass fibers and phosphogypsum. The optimal value of the factor PV is 0.04-0.05 MPa m/s.

The optimum content of fillers, at which the friction coefficient of epoxy compositions decreases, is 35-45 wt.h. graphite and phosphogypsum, 150-250 wt.h. of copper and iron powder (Fig. 1g). Minimal wear of epoxy compositions, is 35-45 wt.h. fiberglass and phosphogypsum, 200-250 wt.h. iron and copper powder. Processing by ultrasound makes it possible to obtain highly filled composite materials that have a sufficiently high complex of physico-mechanical properties. Modified by ultrasound composite materials and coatings of them have a sufficiently high strength at filling 30-50 wt.h. while unmodified at 20-30 wt.h.

On the basis of the conducted researches it is established that with an increase in the duration of the ultrasonic influence, the wear rate and coefficient of friction of the coatings decrease. The best results for epoxy coatings are achieved with a duration of (τ_{time}) of 25-35 minutes. Comparative analysis of full-epoxy compositions, processed and untreated ultrasound, showed that the intensity of wear of coatings treated with ultrasound is reduced to 1.5-2 times.

IV. ANALYSIS OF THE RESULTS

On the basis of the analysis of the research results, the correlation dependence of the wear rate and friction coefficient of the filled epoxy coatings on the ultrasonic treatment regimes was obtained (Fig. 2).

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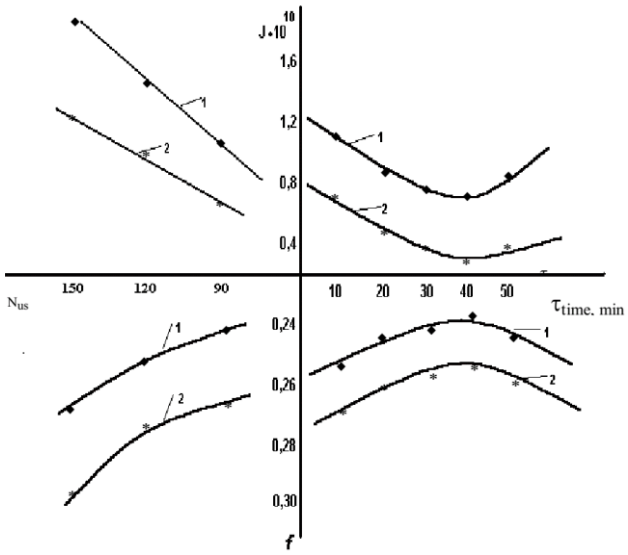

1-graphite; 2-iron powder.

Figure 2. Correlation dependence of the wear rate and friction coefficient of composite epoxy coatings on the modes of ultrasonic treatment.

Dependence of the wear rate and the coefficient of friction on the duration of the ultrasonic field is mainly extreme. The optimal change in these properties is observed with a treatment time of 25-35 minutes. Further increase in the duration of the exposure leads to a deterioration in the properties of the coatings. Increasing the power of ultrasonic treatment leads to a proportional increase in the wear rate of the coatings. The coefficient of friction of composite coatings varies insignificantly up to ultrasonic power equal to 100 W, and its further increase leads to a sharp increase in the coefficient of friction and, thereby, to a decrease in the wear resistance of coatings. Analyzing these data, we can conclude that for all coatings the change in wear rate and friction coefficient correlates with the change in the physicomechanical properties of epoxy composites.

The results of the study showed that the ultrasonic effect leads to a decrease in the wear rate of the coatings. For epoxy composite coatings, the maximum relative reduction in the friction coefficient is Δf_{max} = 15-20% and wear rate ΔJ_{max} = 30-40%. Obviously, such an efficiency of ultrasonic treatment of coatings is explained by an increase in the reactivity of the polymer matrix and fillers in the ultrasonic field. In this case, the change in the power of the ultrasonic field has a similar effect on the coefficient of friction and the intensity of wear.

It has been found that ultrasonic action is more effective if the epoxy composition is filled with iron powder and phosphogypsum. The filling with graphite also gives a positive effect: where Δf_{max} decreases to 15% at ΔJ_{max} = 40%, which is achieved by 30-35 minutes ultrasonic treatment. Ultrasonic treatment of epoxy composites gives good results when filling with iron powder (duration of ultrasound is τ_{time} = 20-25 min), talc (τ_{time} = 25-30 min) and graphite (τ_{time} = 30-35 min). It should be noted that for unfilled epoxy composites ΔJ_{max} = 80%, Δf_{max} = 32% and for filled ΔJ_{max} = 50%, Δf_{max} = 20%. This is due to the fact that the fillers create certain limitations and thereby reduce the effectiveness of ultrasonic treatment at large contents.

V. CONCLUSIONS.

Thus, the paper shows that the tribotechnical properties of polymer coatings largely depend on the mode of ultrasonic treatment. It has been revealed that ultrasonic treatment of composite epoxy films reduces the coefficient of friction by 15-25%, increases wear resistance by 25-30%, i.e. up to 1,5-2,0 times in comparison with untreated coatings and allows to increase the degree of filling of compositions by 30-55%, depending on the type of filler. After ultrasonic

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treatment, composite materials and coatings based on them have higher antifriction-wear properties due to the improvement of their physicomechanical properties.

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