INVESTIGATION OF WEAR OF STEEL SURFACES DURING CONTACT INTERACTION WITH ABRASIVE-FILLED POLYMER COATINGS

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ИССЛЕДОВАНИЕ ИЗНОСА СТАЛЬНЫХ ПОВЕРХНОСТЕЙ ПРИ КОНТАКТНОМ ВЗАИМОДЕЙСТВИИ С ПОЛИМЕРНЫМИ ПОКРЫТИЯМИ, НАПОЛНЕННЫМИ АБРАЗИВОМ

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ABSTRACT

The paper presents the results of studies of the effect of abrasive-filled polycaproamide coatings during the interaction of the roughness of a steel roller on the wear intensity. It is established that under certain conditions, abrasive action can be used as a finishing method of processing the part.

АННОТАЦИЯ

В работе представлены результаты исследований влияния абразивно-наполненных поликапроамидных покрытий при взаимодействии шероховатости стального ролика на интенсивность изнашивания. Установлено, что при определенных условиях абразивное воздействие может применяться как финишный метод обработки детали.

Keywords: wear intensity, abrasive fillers, roughness, wear of steel surfaces, antifriction materials, metal polymer system, polymer coatings.

Ключевые слова: интенсивность изнашивания, абразивные наполнители, шероховатость, износ стальных поверхностей, антифрикционные материалы, металлополимерная система, полимерные покрытия.

Introduction. In recent years, research has been widely carried out on the development of composite metal-polymer antifriction–wear-resistant coating materials [1-5] and the development of metalworking materials and cutting tools based on them [6-10]. In this regard, special attention is paid to the development of antifriction-wear-resistant composite materials, both thermoplastic and thermosetting filled with organomineral ingredients, polymer materials for the purpose of manufacturing composite metalworking materials and cutting tools of metal structures, in particular in the crankshaft system of the internal combustion engine of vehicles and improving the technology of their production.

The authors [14,15] believe that the nature of the interaction of the abrasive particle with the friction surface depends on the degree of its fixation.

I.V. Kragelsky [8] believes that under mechanical action, depending on the shape of the abrasive and the acting loads, the following types of friction bond violations, elastic or plastic displacement of the material and a cut of the embedded material (in this case, an abrasive particle) may occur. Repeated elastic or plastic displacement leads to fatigue destruction of the surface layers of the metal. With an increase in the depth of penetration, elastic displacement turns into plastic deformation of the surface layers. A further increase in the depth of implementation contributes to the formation of the micro-cutting process. Consequently, there can be several types of destruction-wear on the friction surface at the same time.

In works [8-16], the essence and mechanism of abrasive wear are highlighted. It is noted that the nature of the destruction depends on the physical and

mechanical properties of the worn material and the abrasive, the shape in the degree of fixation of abrasive particles, as well as their pressure on the material. It is shown that, depending on these factors, the destruction process can occur in the form of micro-cutting (brittle and viscous destruction) or fatigue (in the elastic region) in poly-deformed (in the plastic region) destruction.

Numerous studies [1-15] show that the structure and properties of the surface layers of various materials have a significant impact on their performance and durability, working under conditions of friction and wear. In this regard, it is of interest from a unified scientific point of view to identify common patterns of the friction and wear process and to develop metal-polymer antifriction-wear-resistant abrasive-filled coating materials on their basis and to create metalworking materials and cutting tools used for finishing metal and other machine parts.

In this work plan, this article is a study of the dependence of the intensity of wear and the roughness of the surface of the steel substrate-great when treated with abrasive-filled polycaproamide polymer coatings.

The object and methodology of the study. The objects of research are powdered thermoplastic polymers (polycapromide, pentaplast, polyethylene) with a dispersion of up to 250 microns. 45 steel was used as a substrate. Various organic and inorganic fillers, as well as dispersed abrasive materials (diamonds, white electrocorundum, silicon carbides, etc.) with particle sizes from 15 to 40 microns were used as fillers. Neazon D was used as a polycaproamide heat stabilizer . The introduction of fillers and other dispersed modifiers was carried out by their mechanical mixing.

Research methods. The strength of the adhesive joint of the coating with metals was evaluated by the methods of normal separation (ZD – 4 machine, at a constant loading speed) and peeling at an angle of 1800 (ZD – 40 machine). In this work, the upgraded MI-1 and SMC-2 machines, the ZD-4 bursting machine, the PMT-3 microhardometer devices, the upgraded PR-05 machine, the horizontal microscope NLI-2 were used for a comprehensive study of the physical and mechanical properties of metalworking materials and coatings to study friction and wear. To study oxidative processes, structural components, as well as other physicochemical changes in the polymer and metal of the adhesive compound, the MIM-8 microscope, the OD-102 derivatograph, the URS-50 IM diffractometer, and chemical analysis methods were used.

Research results and their analysis. We have found that when moving a polymer coating filled with abrasive particles over the surface of the parts, even with a slight contact pressure, their relatively intensive wear occurs. As noted above, under certain conditions, the wear intensity is high and the abrasive effect can be used as a finishing method for processing machine parts.

The study of the physical laws of the metal removal process in this processing method allowed us to establish that when an abrasive fixed with a polymer binder interacts with the surface of the part, a kind of abrasive wear of the latter occurs.

Figure 1 shows that at the initial moment of contact interaction of the abrasive-filled coating, the value of the surface roughness parameter Ra will decrease intensively, and the removal of metal from the steel surface will increase almost proportionally. After a certain time has elapsed, the metal is removed and the surface roughness is stabilized.

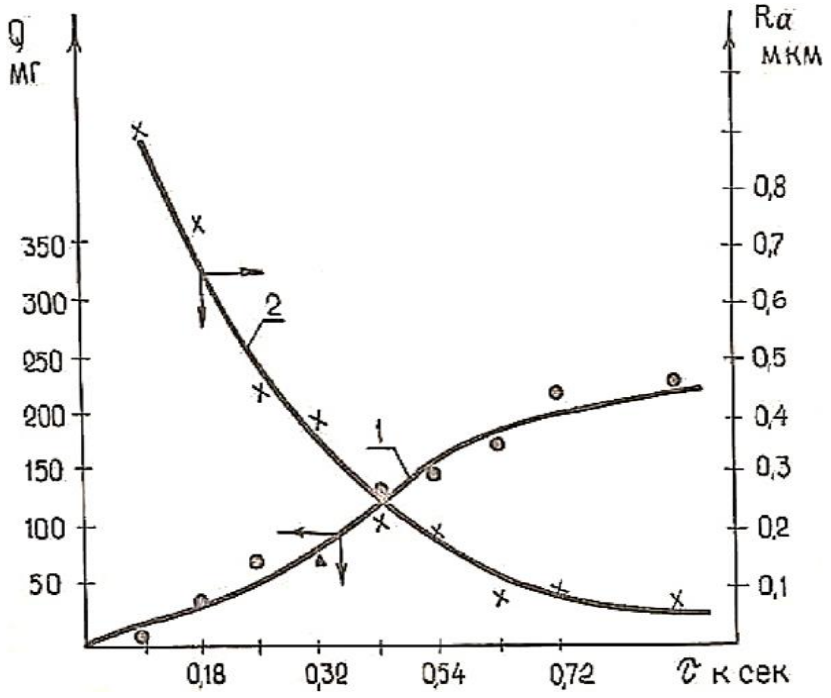

Figure 1. Dependence of the wear intensity (curve 1) and the surface roughness of the steel roller (curve 2) when treated with an abrasive-filled polycaproamide coating (adhesive – silicon carbide green; counterbody – steel 45; P= 10 mn/m^2; h= 0.75 m/sec)

Let's consider the role of sludge forming agents in the finishing of steel parts. Of interest are the studies performed on the sludge resulting from the wear of the surface. Sludge analysis is most important for determining the degree of metal dispersion and the nature of the formation of wear particles.

Figure 2 shows an abrasive-filled coating that worked with a steel shaft for 0.72 K sec. Even with the naked eye, you can see the products of wear (sludge) resulting from the wear of the surface. The difficulty of analyzing the sludge was due to the varying degree of dispersion of metal particles.

Figure 2. Photo of sludge particles

A photograph of sludge particles (Fig.2), which is a product of wear, showed that along with large particles, fine particles smaller than 1 micron are predominant. The shape and size of the sludge particles suggest that under these conditions of finishing, direct destruction of the metal in the form of micro-cutting may take place. However, it is not excluded in the course of the process called micro- and submicroscription [10].

When studying the nature of wear during abrasive action on the surface of machine parts, it was shown [14,17-20] that at low normal pressures, when the resulting stress on the contact pads is less than the yield strength, the destruction of metal from micro- and submicroscription dominates. The intensity of this type of destruction is quite high and ensures the removal of surface layers of metal under abrasive action before its fatigue destruction from cyclic reshaping.

Conclusion. It is established that when an abrasive-filled polymer coating interacts with the surfaces of machine parts, even with a slight compact pressure, relatively high intensive wear occurs. In this regard, this process can be used as a finishing method for processing machine parts.

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