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Summary of research on the causes, types and quantities of wear of road construction and rock excavation machine parts

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ABSTRACT: The article provides a brief overview of the research conducted on the causes, types and quantities of wear of road construction and rock excavation machine parts. It mainly shows the material of excavator bucket teeth, the causes of wear and composite materials used to increase durability.

KEY WORDS: friction, abrasive wear, excavator teeth, 110G13L steel.

I. INTRODUCTION

Road-construction and rock excavation machines during operation are exposed to the environment, stones and soil, etc., as a result of which the physicomechanical properties and technical characteristics of the machine change. These changes reduce the efficiency of the machine. For example, the teeth of buckets of excavators with one bucket become unusable for 40-260 hours, depending on the conditions of the rocky soil. At the same time, 35-60% of the teeth fail. As a result of the impermeability of the teeth of the excavator buckets from erosion, energy consumption increases by 1.5-2 times, more than 30% of the fuel is consumed, productivity decreases by 40%, the quality of work deteriorates, and the efficiency of the machine decreases sharply [1].

One of the main reasons for reducing the technical characteristics of machines is the erosion of their working bodies. 80% of machine component failures are due to erosion [1,2].

The working bodies of road construction machines and rock excavators are out of order as a result of abrasive erosion. The rate of abrasive wear depends on the physical and mechanical properties of the part and abrasive materials, the level of loading of the contact surface, the degree of deformation of the surface layer, the temperature and the degree of aggressiveness of the environment. Abrasive particles that cause abrasion may consist of minerals (granite, sand, gravel) or the material of the connecting parts, the product of erosion of parts, sediment.

In abrasive wear, abrasive particles repeatedly deform the friction surfaces of the parts, causing microcracks. The degree of development of these processes depends on the hardness of the detail material and the abrasive particles [2]. The hardness of abrasive particles is higher than the hardness of most structural materials Therefore, such structural materials are rapidly corroded under the influence of abrasive particles. The literature illustrates the following about the relationship between the hardness of an abrasive particle and the hardness of the material of parts to which it is subjected to friction.

II. LITERATURE SURVEY

When studying specific aspects and the mechanism of abrasive wear, scientists were faced with the phenomenon of a sharp increase in the relative abrasion resistance of materials when their hardness approaches the hardness of abrasive particles. This phenomenon is widely covered in the works of M.M.Tenenbaum, V.N.Tkachev,

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R.Kiffer, D.Benezovsky, M.M.Khrushchev, M.A.Babichev, U.Ikromov, A.S.Pronikov, D.N.Garkunov and others [3,4,5,6,7,8,9,10,11,12,13].

III.THE RESULTS OF THE ANALYSIS

Abrasive wear can also occur as a result of friction of machine parts on the material of the processed environment. Examples are erosion during friction of the working bodies of excavators, mining, metallurgical, chemical, as well as road, agricultural and construction machines with soil, stone, gravel, sand and their mixtures.

The abrasion intensity depends significantly on the difference between the hardness of the material of the part H_m and the hardness of the abrasive particle H_a.

In the study of V.N.Tkachev [11] to determine the wear resistance of an alloy operating in an abrasive medium, the following expression is given:

$$\varepsilon = b \cdot H_{\kappa}^{n}, \qquad (1)$$

Where, ε is the relative wear resistance of the alloy; b – coefficient depending on the wear rate; H_{κ} - macro hardness of the alloy; n – a degree indicator that depends on the ratio of abrasive particle and alloy hardness.

At the same time, VN Tkachev said that it is necessary to introduce a dynamic coefficient that takes into account the fracture of the alloy.

M.M.Khrushchev and M.A.Babichev experimentally determined that the linear form of wear resistance is distorted by a certain hardness ratio (Figure 1).

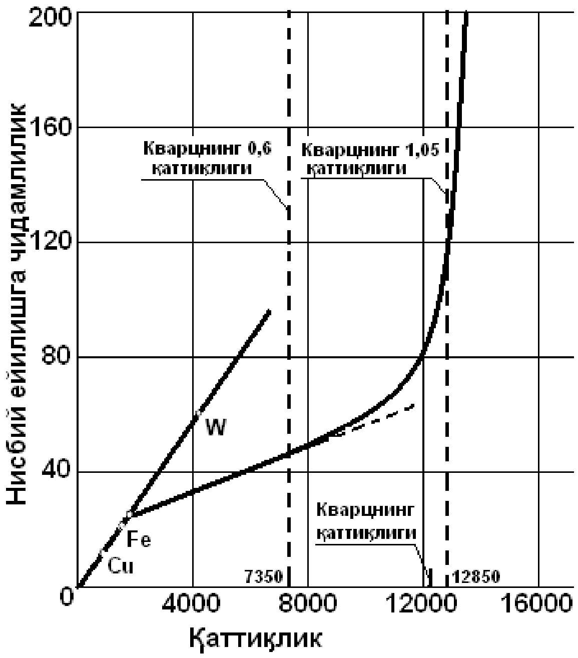

Figure 1. Wear resistance depending on the hardness of the materials [13]

As can be seen from the figure, a straight line connection breaks when the ratio of materials and abrasive hardness is 0.6, and the wear resistance of the material begins to increase sharply.

They showed three specific relationships that determine the conditions of wear when studying the effect of the hardness ratio of abrasive particles on the wear of the material of the working fluid.

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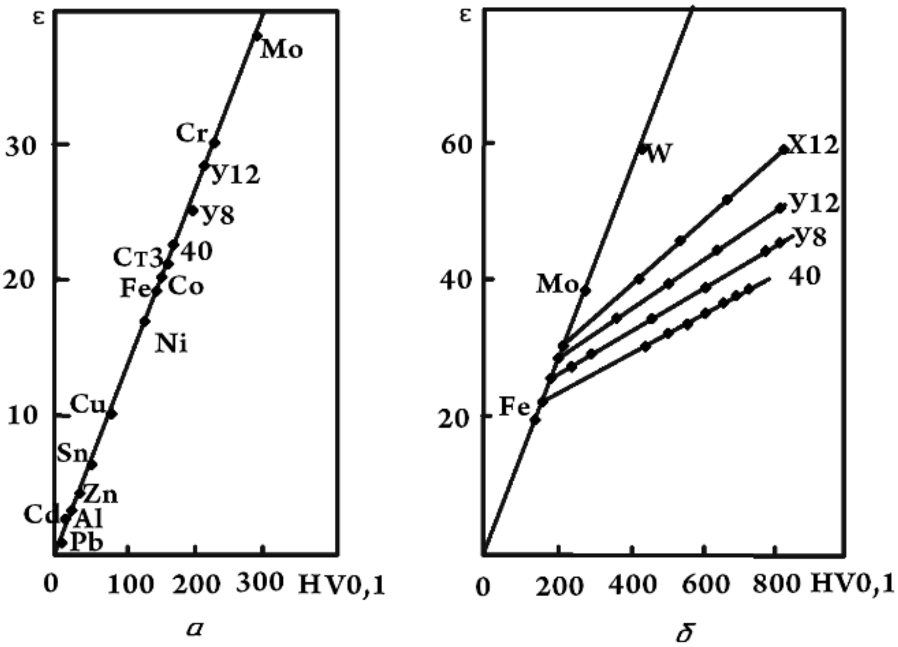
When the ratio of the hardness of the material (H_M) and abrasive (H_a) is $H_M/H_a \leq 0,6$, the wear resistance increases linearly. When the ratio is in the range of $0,6 \leq H_M/H_a \leq 1,4$, the wear resistance will have an increasing parabolic bond. With a ratio of $1,4 \leq H_M/H_a$, a hyperbolic sharp increase in wear resistance is observed. Or wear resistance increases by tens or even hundreds of times.

The literature, edited by B.N.Arzamasov [12], provides data on the wear resistance of pure metals and steels depending on their hardness. (Figure 2).



a-discharged pure metals and steels;
b-thermally treated pure metals and steels

Figure 2. The ratio between the relative wear and hardness of pure metals and steels during abrasive wear [12]

In this literature, the following is given as a commentary on the picture. Abrasive wear causes the most damage to machines that come in contact with soil. Wear under the influence of natural abrasive particles cannot be eliminated, it can only be protected with sealants and a material with high hardness (preferably higher than abrasive hardness) for friction compounds, which are much more effective. Typically, such materials are brittle and therefore they are unsuitable for dynamically loaded machine parts. To get rid of this problem, it is necessary to cover the work surface of the part with wear-resistant material. High-alloy steels (hard alloys), hard alloys, ceramic materials are used as coating materials [12].

Therefore, the wear resistance in abrasive wear of surfaces is used in heavy-duty parts such as carbide alloys, castings and welding materials, which have a structure consisting of a solid carbide phase and a matrix that holds them firmly. Hundreds of types of casting and welding materials are used in industry. They contain up to 4% carbon and carbide-forming elements (Cr, W, Ti). An increase in the carbide structure of the material (up to 50%) leads to an increase in wear resistance.

The structure of such materials consists of special carbides (WC, TiC, TaC) associated with the use of cobalt, as well as high-carbon alloyed (structure: perlite + carbide) steels, such as X12, X12M, R18, R6M5.

From the above it is seen that *in a certain ratio of the hardness of the material of the part and the abrasive particles, abrasive wear does not continue in its usual form, the mechanism of the wear process changes radically, and accordingly, the intensity of abrasive wear decreases sharply*. Of course, the mechanism of the abrasive wear process is indescribably complex. It is also affected by stresses accumulated as a result of the action of abrasive particles on the

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surface layer, metal displacement, and structural changes. However, there is evidence to confirm that the links described above are generally correct.

Coating the surfaces of the working bodies of road-construction machines and rock excavators with carbide composite materials increases their wear resistance, reduces the consumption of spare parts and materials, reduces the cost of operation and maintenance of excavators, increases the efficiency of the machines.

In the sandy-stony soils of Central Asia, rapid erosion of the teeth of the excavator is observed. For example, the excavator EO-3221, after digging 6,000 cubic meters of sand and stone, the tooth length wears out up to 20 mm and becomes unusable, and after 13-15 shifts the teeth is changed. According to the standards, EO-3322 excavator teeth can be replaced 2.2 times a year. However, in practice, these teeth are replaced up to 18 times in our Republic. In this case, a maximum of 20% of the metal of the working body wears out. Over 80% of the remaining high-quality metal becomes invalid. Therefore, one of the ways to reduce the consumption of such metals and materials and increase the efficiency of the machine is to reuse them by welding wear-resistant material on the working surfaces of worn working bodies.

Typically, teeth made of 110G13L steel are restored by welding with coated electrodes.

The study and analysis of the working process of road-construction machines showed that welding of working surfaces from 110G13L and 35GL steels with carbide composite materials containing tungsten carbide to increase the wear resistance of working bodies gives the greatest efficiency.

In addition, welding of chromium-boride carbide materials X-5, KVX-45, HR-19 excavator teeth made of structural steels gave good results in Uzbekistan.. At the same time, the service life of the teeth of the excavator increased by 2.5–3 times.

Today, in the world, the volume of production of a number of new types of hard alloy welding electrodes and advanced powder composite materials is growing.

However, in Uzbekistan there are no planned scientific studies on their application to increase the wear resistance of the working bodies of road-construction machines and rock excavators and justify their parameters. Therefore, the authors set out to conduct research on this issue.

V. CONCLUSIONS

1. Nowadays, the teeth of single-bucket excavator buckets become unusable for 40 to 260 hours depending on the rock-soil conditions. In this case, 35-60% of the teeth fail. It was determined that, as a result of the impermeability of the teeth of the excavator buckets from erosion, energy consumption increases by 1.5-2 times, more than 30% of the fuel is consumed, productivity decreases by 40%, the quality of work deteriorates, and the efficiency of the machine decreases sharply.

2. It has been found that 80% of machine downtime is caused by various types of wear.

3. Hundreds of types of casting and welding materials are used in the industry. They contain up to 4% carbon and carbide-forming elements (Cr, W, Ti). It was found that an increase in the carbide structure in the material (up to 50%) leads to an increase in wear resistance.

4. The study and analysis of the working process of road-construction machines showed that welding of working surfaces from 110G13L and 35GL steels with carbide composite materials containing tungsten carbide to increase the wear resistance of working bodies gives the greatest efficiency.

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