WAYS TO INCREASE THE WEAR RESISTANCE OF THE CUTTING BODIES OF DIGGING MACHINES

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Abstract: *at present, the solution to the problem of increasing the wear resistance and efficiency of functioning in the operating conditions of the cutting bodies of earth-moving machines is an urgent problem.*
The article presents the results of a study of the process of intensity of abrasive wear by the energy approach, working bodies of earth-moving machines. Influence on the service life of working bodies to the limiting state of internal energy, hardening (work hardening) of steel 110G13L, the effect of plastic deformation and the rate of wear.
Keywords: *abrasive wear, chemical composition, bucket teeth material, microhardness, cutting bodies of earth-moving machines, boron-containing materials.*

ПУТИ ПОВЫШЕНИЯ ИЗНОСОСТОЙКОСТИ РЕЖУЩИХ ОРГАНОВ ЗЕМЛЕРОЙНЫХ МАШИН

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Аннотация: *в настоящее время решение проблемы по повышению износостойкости и эффективности функционирования в условиях эксплуатации режущих органов землеройных машин, является актуальной проблемой.*
В статье приведены результаты исследования процесса интенсивности абразивного износа энергетическим подходом рабочих органов землеройных машин. Влияние на срок службы рабочих органов до предельного состояние внутренней энергии, упрочнение (наклеп) стали 110Г13Л, эффекта пластической деформации и темпа изнашивания.
Ключевые слова: *абразивное изнашивание, химический состав, материал зубьев ковша, микротвердость, режущие органы землеройных машин, борсодержащие материалы.*

The solution to the problem of increasing the wear resistance and efficiency of functioning in the operating conditions of the cutting bodies of earth-moving machines is an urgent problem.

As we know, technological methods are divided into methods of volumetric and surface hardening. The methods of volumetric hardening of parts involve carrying out any technological operations, as a result of which the material acquires increased antiwear properties in all working sections.

It is known that austenite has a pronounced ability to harden (work harden) during cold deformation. In this case, the hardness of the hardened steel 110G13L increases to HB 550 ... 800, and its wear resistance under conditions of abrasive wear with significant shock loads becomes 8-10 times greater than that of 35L steel [1]. Therefore, volumetric hardening is an effective method for increasing the durability of cutting bodies made of 110G13L steel. Also promising is the direction of developing a technology that provides for the production of a formed composite alloy of cutting bodies by electroslag surfacing.

According to the given data, the coefficient of increasing the wear resistance of the blast-hardened bucket teeth is 1,37. The most widespread method is surface hardening by surfacing. Using this method, a layer of wear-resistant metal of a greater thickness can be obtained relatively quickly, this is especially important when restoring worn-out cutting elements of buckets.

The relationship between the structure of materials and their wear resistance is one of the most important, but at the same time, the most controversial problem [2].

When the working bodies of earth-moving machines are worn out, irreversible changes occur in the surface layers of the material. Their character and rate of flow are determined by the magnitude of external influences and, at first glance, do not affect the state of the deep layers. However, numerous studies have shown that almost any effect of the external environment on the free surface of a solid is transmitted to the inner regions of the material. Therefore, the state of the surface layers, in most cases, determines the behavior and properties of the entire volume of the material, its performance characteristics. Metallographic studies have shown that with an increase in boron content, the microstructure of the deposited metal changes from to eutectic (with zero boron content), to eutectic (with boron content 1,5% and higher). In this case, the microhardness of the eutectic increases from H_{50} 6800 to H_{50} 10200, the strengthening phase to H_{50} 19500 MPa and the microhardness to HRC 64. At these values of hardness, the surface fracture process acquires a polydeformational (fatigue) character with a lower wear rate.

So, in the process of wear of the working bodies of earth-moving machines, the separation of wear particles in the surface layers can be accompanied by deformations and local release of a large amount of heat. Local heating in the fracture zone causes structural transformations, similar to transformations during steel tempering, which lead to a change in the initial properties. Therefore, the value of the hardness of the material serves as an estimate of the resistance of the metal to plastic deformation, but not destruction [3].

According to the energy theory, the destruction of the surface layers, i.e. their wear and tear and the destruction of the entire solid are subject to the same laws. The main difference between the processes lies in the mechanism of their course. If the destruction of a solid occurs simultaneously throughout its entire volume, then surface wear is a process of gradual separation of wear particles from the surface volumes of the material that have accumulated a critical supply of internal potential energy. The source of the accumulation of internal energy is the work force of friction, most of which is dissipated in the form of heat, and its smaller share, estimated in the work at 9-16%, is accumulated in the material.

The change in the internal energy of the wear material is equal to the energy of the new surfaces formed during destruction and the energy accumulated in the metal during the interaction of the friction surfaces "working body - soil" in the form of latent deformation energy. Plastic deformation more quickly saturates the metal with energy than elastic deformations, and the volume of the deformed material depends on the load and on the energy saturation of the material.

Boron-containing alloy turned out to be the most wear-resistant among the tested ones. In this regard, the effect of boron on the structure, phase composition and physical and mechanical properties of wear-resistant metal with a basic content of carbon 3, chromium 25 and boron up to 3,6% was studied.

By means of optical and electron microscopy, it was found that with an increase in the boron content, the microstructure of the deposited metal changes from to eutectic (without boron) to after eutectic (1,5% and higher). Using the method of X-ray structural analysis, it was determined that boron, alloying chromium carbides with Cr_7C3, promotes the formation of carboborides Cr_2BC, CrBC M23 (BC) 6. In this case, the microhardness of the eutectic increases from H_{50} 6800 to H_{50} 10200, and of the hardening phase - up to H_{50} 19500 MPa. The high values of the microhardness of the structural components led to an increase in the average microhardness to H_{50} 11000 MPa and aggregate hardness to HRC64. This led to an increase in the relative hardness of the metal and abrasive, estimated by the coefficient K_T. At $K_T < 0,6 ... 0,7$ there are prerequisites for direct destruction of the surface layer by shearing or tearing off.

With the above values of the hardness of boron-containing surfacing, the value of $K_T > 0,6 ... 0,7$ and, therefore, the process of surface destruction acquires a polydeformational (fatigue) character with a lower wear rate.

Based on the research, it has been established that the maximum wear resistance of the deposited metal is achieved with a boron content of 2,0 ... 2,2%.

Its further increase (up to 3,6%) leads to a decrease in the chromium content in the eutectic, the hardening phase and the fusion zone.

This, in turn, promotes the acceleration of the decomposition of austenite and the formation of a martensitic structure in the fusion zone. The latter causes an increase in internal stresses and causes brittle spalling of the deposited layer when the boron content exceeds 3%. Modern concepts of abrasive wear indicate a significant dependence of the wear resistance of materials on their physical and mechanical properties. For the established wear of alloys due to plastic deformation, the relationship between wear resistance and shear resistance seems most likely.

Thus, as a result of tests of deposited teeth of various shapes when cutting model and natural soils, it was found that the most wear resistance is boron-containing surfacing of the E-300X25G2R2ST type, which exceeds the wear resistance of T-590 electrode surfacing by 1,5 ... 2,5 times.

In addition, the strength of high carbon boron materials has been established. Moreover, the optimal boron content in the deposited layer should be 2,0 ... 2,2%.

With the specified boron content, the microhardness of the base increases to 10200 MPa, the hardening phase to 19500 MPa, and the aggregate hardness of the wear-resistant layer, with its sufficient viscosity, increases to HRC 60 ... 64.

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