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INCREASING DURABILITY OF TEETH OF BUCKLE EXCAVATORS

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ABSTRACT

This article discusses the increase in durability of the teeth of excavator buckets at the Muruntau open-cast mine, which produces one of the best gold in quality. The article reveals in detail the problems of wear of the excavator bucket tooth and ways to solve them to increase their service life.

KEYWORDS: Excavator, Bucket, Bucket Tooth, Abrasivity, Wear, Hardness, Reliability, Rock, Quarry.

INTRODUCTION

Improving the durability and efficiency of the operation of the buckets of single-bucket excavators, is an important task operated in the career "Muruntau." Excavators with a bucket capacity of 8-10 m3 carry out the loading of the blasted rock mass into vehicles for delivery and further processing. The design of the working body of the excavators under study provides for five cast teeth to be installed. They are made of high-manganese casting steel 110G13L. The average life of the teeth, depending on the strength of the rock faces, ranges from 80-200 hours. After wear of the cutting part (limit wear is set within 170-180 mm), the teeth are removed from the bucket and sent for restoration. The reason for the final rejection of the teeth is a breakdown or significant wear of their tail parts.[1]

MATERIALS AND METHODS

Wear of the side surfaces to a noticeable extent occurs only in the cutting part of the tooth. A slightly different nature of wear is observed at the teeth, periodically reinstalled during operation. When reinstalling, the teeth are rotated by 1800 relative to their longitudinal axis, due to which both working surfaces of the tooth wear out uniformly. As a result of repeated rearrangement, worn teeth acquire a streamlined shape with a weakly pronounced wear area. The life of the teeth working in this mode 1.10 - 1.20 times increases, but the need for additional labor costs makes this way ineffective. For the purpose of a more in-depth study of the nature of wear of the teeth of buckets in the laboratory, the following were investigated:

Chemical composition of the sample material, its microstructure, hardness of the tooth on the surface of the wear area and the presence of hardening on it.

Chemical analysis of a fragment of metal samples showed the following element content: carbon — 1.04%; manganese - 16.7%; chromium - 0.7%; silicon - 0.42%; phosphorus - 0,022%; sulfur - 0,018%; Nickel - 0.46%; molybdenum - 0.05%. The chemical composition of the studied metal corresponds to steel 110G13L GOST 2176-77.

Micro-, macro- and metallographic studies of excavator bucket teeth showed that in the process of their abrasive wear, the main changes that occur with the material from which they are made are reduced to surface deformation, due to wear in the form of scratches and tearing out and to the formation of surface and deep inclination.

It should be noted that the work hardening on the surface and in the depths of the working bodies is unevenly distributed and increases where the wear area of the working bodies reaches a maximum value, i.e. the degree of work hardening is directly related to unit loads, which determine the rate of abrasive wear.[1]

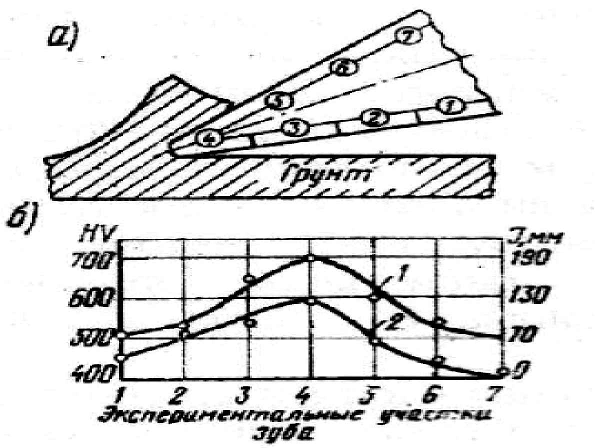

Fig. 1: The distribution of work hardening on the surface of the tooth buckets career excavators (V = 8 ÷ 10 v3) 1 - wear; 2 - hardness.

To establish the presence of work earthling milling, a sample was cut from a fragment of the tooth with a portion of the wear area. Measurements showed that in the surface layer 0.45 mm thick, micro-hardness is HB = 65 MPa, and in the core HB = 42 MPa, which indicates the existence of work hardening on the worn surface (Fig. 1).

The constant angular position of the wear area does not depend on the properties of the material of the teeth and the wear environment, but is determined by the kinematic features of the working equipment of mining excavators.

The wear area is a convex surface and the tangent to it, apparently, coincides with the tangent to the trajectory of the tooth, i.e. the longitudinal axis of the tooth and the tangent to the wear area form the actual cutting angle. It is not possible to change the angular position of the wear area and, therefore, durability increase should include strengthening not only the front and rear surface of the tooth, but also the entire material of the cutting part.

During the development of the rock in the Muruntau open-cast mine, it has been established that the wear is faster than the forming work hardening rate, and this is confirmed by the change in the hardness of worn surfaces, which are 16-30% lower than the initial ones. Operational tests of the weld teeth were carried out by comparing the length of the teeth of excavator buckets. To do this, in addition to the two buried teeth, three non-hardened teeth were mounted on the excavator bucket. The operating time of the tested teeth of excavator buckets was 200-240 mash / h. Depending on the background operation.

After reaching the value of linear wear of the cutting part of the reference (not strengthened) cutting parts of the teeth - 170 mm, the tests were terminated. The corresponding measurements of worn teeth showed the following results (Table 1).

Table 1: Results of measurements of worn teeth of career buckets excavators (V = 8 ÷ 10 m3).

Linear wear	Reference teeth	Experienced teeth (weld) T-590
Cutting part of teeth, mm	170-180	140-150

RESULTS AND DISCUSSION

The resulting reduction in wear of the cutting part of the experienced teeth as compared to the reference ones shows that the use of wear-resistant surfacing for large teeth of buckets with a capacity of more than 2.5 m3, as a method of surface hardening of teeth of career excavator buckets, proved to be effective due to the specific operating conditions.

Among the large number of different methods used to restore and harden the working bodies of excavator buckets, electro-slag surfacing (ESC) occupies a prominent place. This is explained by a number of features of the ESN, namely: the high performance and quality of the weld metal, the possibility of surfacing in a single pass of a layer of almost any thickness, the relative simplicity of obtaining a bimetallic layer or a layer of varying chemical composition. These advantages of ESN over other methods, which appear when surfacing large teeth of excavators, are especially noticeable. Due to the effectiveness of using the methods of electro slag surfacing of volumetric hardening of teeth, an experienced surfacing of worn teeth was performed. Surfacing of the teeth is made on the installation of ES in WRME in NMMC. At the first stage, 110G13L steel was selected for the consumable electrode. At the second stage - steel 50 hg. The surfacing modes remained the same as in the case of surfacing with 110G13L steel, is shown in fig. 2.

Fig. 2: General view of the teeth of steel welds 50HG.

Volumetric hardening of the weld cutting parts was performed using heat treatment. The test teeth were subjected to volumetric hardening with heating to a temperature of to = 840 – 860o C, a holding time in the furnace for 3 hours and cooling in oil. Then the set of teeth got a high tempering at a temperature of to = 420 – 4700 C, aging in the furnace for 3 hours, followed by cooling in air. The second set of teeth went through low tempering at a temperature of to = 200 – 2400 C, exposure to the furnace for 3 hours and cooling in air. After heat treatment, the hardness of the metal of the deposited cutting part of the tooth, which passed the low tempering HB = 460.

The operational tests of the experienced teeth were also carried out by the method of comparison when they were jointly mounted on one bucket with the reference teeth, which were used to use three standard new teeth and two teeth that were restored on the ESC installation using the recommended technology.

The study of changes in the configuration and size of the teeth of the buckets was carried out by measuring them using a special template. The contours of the teeth of the buckets were circled on the tablet and measured after every 12 hours of operation of the machine in the face.

In the process of work, the length of the cutting part of the teeth after loading 17-24 thousand tons of rock is reduced by 160-200 mm, which is 40-50% of the original length of the cutting part of the teeth.

With the advent of wear areas with a negative rear angle, the sharpening angle increases from 30 to 54 ° C. This, in turn, leads to an increase in drag resistance to soil excavation.
The front face wears out less intensely, since the friction force that occurs when rock is moved along the front face of a tooth is much less than the friction force that occurs when rock is moved on the rear face. The change in the profile of the front face occurs in the direction of increasing the angle of tapering.[3]

The rear cutting angle has a great influence on the wear rate of the teeth. With an increase in the back angle, the contact surface of the cutting part of the bucket tooth with the rock mass decreases, and linear wear along the back face of the tooth decreases accordingly. However, it should be borne in mind that an excessive increase in the rear angle leads to an increase in the cutting angle, as a result of which the drag increases significantly. Increasing is the cutting angle from 40 to 60 ° C leads to a doubling of the drag of the tooth.

The correct choice of the value of the rear cutting angle of teeth is an important condition for increasing the durability of the cutting element of the working body of career excavators. Usually the rear angle is taken within 5-12°.[2]

When examining the experimental teeth of excavator buckets after 50 mph-hour. the work was established: there were traces of large metal spalls on the cutting parts that were deposited with steel 50HG, and on the tooth that had undergone low tempering, a tip of up to 100 mm was chipped. The total testing of the experienced teeth was 150 mas-hour. After dismantling the worn teeth from the bucket, they were visually inspected and linear wear measurements of their cutting parts were made. The results of the tests are summarized in table 2.

Table 2: The results of operational tests of the teeth of the buckets 50HG steel-built excavators at Muruntau quarry.

№	Mark of deposited material	Characteristic Hardening	Tooth shortening, mm
1	Steel 50hg	Bulk hardening at t3 = 840 - 860C High vacation when t0 = 420 - 470C	160
2	Steel 50 hg	Bulk hardening at t3 = 840 - 860C Low leave with t0 = 200 - 240C	180
3	Steel 110g 13l	——	180
4	No surfacing (new)	——	170

The data in Table 2 shows that, despite the defects in the deposition and metal spalling in the cutting part, the wear resistance of the teeth deposited by 50HG steel turned out to be comparable to the wear resistance of not only the teeth restored by the existing technology, but also new teeth. A very important conclusion follows from this: the existing ESR technology can be effectively upgraded by replacing the expensive high-manganese steel 110G13L with a cheaper counterpart, which at least leads to a sharp reduction in the cost of restoring the teeth while maintaining their durability at the achieved level. However, for the conducted research, the technological compatibility of the austenitic structure of steel 110G13L and, for example, sorbitol of tempering of heat-treated steel 50HG, established during these experiments is of more importance. It must be assumed that in the fusion zone of the above steels, a transition structure arises with a complex structure, having signs of both austenite and sorbitol. Therefore, it is necessary to include in the technological process during the manufacture of teeth double annealing from a temperature of 800–830 ° C with slow cooling at a speed of no more than 25 degrees / hour and subsequent quenching at a temperature of 1050–11000 ° C, which contributes to increasing the durability of the teeth of the buckets by 20–25% replacing steel 110G13L with cheaper steel grades of type 50HG.

One of the ways to increase durability, we consider the constructional method, it is to change the shape of a tooth to the place of a standard wedge-shaped tooth, we propose a three-sided molded tooth. With operational tests in the Karakutan quarry, the triangular tooth had a resource compared to a standard tooth 15 to 23% more. Figure 3 shows a general view of the front wall of the bucket with the experienced teeth mounted on it.

Fig. 3: General view of the front wall of the bucket with established teeth on it.

CONCLUSIONS

By studying the patterns of movement of rocks (abrasive particles), you can choose the size, shape and geometric parameters of the teeth of excavators in these conditions of operation with the greatest durability.

Rocks (abrasive particles) being in contact, make a mixed movement, consisting of sliding, rolling and rotation. Such a character of movement depends on continuously changing forces, both in magnitude and in direction, the physical and mechanical properties of the abrasive, the cleanliness of the surface of the wear part and a number of other factors. On the working bodies of excavators, it is not always possible to study the complex influence of the listed factors on the speed and nature of the relative movement of abrasive particles in the core.

Triangular wedge teeth actively penetrate into the rock, as if joining into it with a high specific pressure, therefore, with the least resistance and as they move further, they destroy the rock by continuous puncturing of the cutting edge. The front three facets, the back and side faces, displace the rock particles above and below the tooth, or force them out of the area where the teeth act, or press them into the less dense layers of the rock being developed. Vertically located third gran in the process of rock destruction plays the role of a rock splitter, as well as changes in the trajectory of abrasive rocks and contributes to the stability of the tooth with the bucket.

During the study has been achieved following results:

1. Increases wear resistance and performance of excavator bucket teeth.
2. Increases its durability and service life of the excavator bucket teeth.
3. Provides the least resistance to tooth incision into the rock.
4. The teeth of the form triangular wedge is actively being introduced into the breed.
5. Reduces the complexity of staff.
6. Reduces the energy intensity of the process.
7. Increases development productivity.

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