EXPERIMENTAL AND TEST STUDY OF THE EFFECTIVENESS OF THE IMPROVED DESIGN OF THE EXCAVATOR BUCKET JAW PLATE

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ABSTRACT

Analysis of the performance of hydraulic quarry excavators shows that many hydraulic excavators used in mining operations operate at a lower capacity than specified in the technical description. This can be caused by unexpected work stoppages, rapid failure of parts and unreliable operation of the excavator operator.

This paper discusses the development of an excavator bucket jaw plate that has a long service life and is technically cost-effective for improving the efficiency of quarry excavators. In addition, the results of experimental tests of the proposed improved bucket jaw plate and their analysis are presented.

Keywords: quarry excavator, collapse size, bucket, jaw, plate, durable, experimental, operational indicators.

INTRODUCTION

To date, the practice of using hydraulic mining excavators shows that the mechanical system of the existing excavator working bodies has a number of significant drawbacks due to the nature of design. As a result of rapid change of physical and mechanical properties of mined rocks and increase of load on working bodies their working life is reduced, that leads to intensive abrasive wear of parts of excavator bucket elements. The important task is to increase the efficiency of
hydraulic open-pit excavators on the basis of increase of excavator shovel bodies productivity as a result of implementation of new high-performance technical and technological decisions.

There are achieved a number of scientific and practical results on acceleration of mining operations, research of economical methods of using the open-pit excavators, use of working bodies of open-pit excavators for resource-saving technologies.

The analysis of productivity of hydraulic excavators, operated at mineral deposits has shown, that increase of efficiency of work of quarry hydraulic excavators is possible on the basis of improvement of a design of their working bodies [1].

Currently, manufacturers of excavator buckets produce a wide range of products, differing by the structural structure of the bucket itself and its individual elements. Manufacturers offer several types of bucket protection elements depending on the application, conditions, type and size. But the main factors are simplicity, reliability, durability and relative cheapness of its design, which is characterized by competitiveness.

The main cause of failure of mining excavators in use today in the global mining industry is failure of these mechanical parts. In earthmoving and excavation operations, the main cause of stoppages due to failure of mechanical parts are the bucket parts that are in direct contact with the rock.

Defects of cutting elements of hydraulic mining excavators depend on a number of factors, mainly on skills of an excavator operator at operation, non-observance of operating rules, unfavourable climatic conditions, changeability of properties of rocks, well blasted large rocks and many other technical factors.

In this regard, there is a need to study the working process of cutting and protecting elements of quarry excavators important for mining industry, to improve reliability and efficiency of operation process and further research in this field is required.

**MATERIALS AND METHODS**

When dealing with quarry excavators during excavation and loading operations it is important to consider the design of these bucket components, one part of which generates high loads of rock with different physical and mechanical properties. This leads to the occurrence and development of the following types of defects [2]:

- Deformation of the walls inside and outside;
- Deformation of connecting parts and technological holes (critical deformation);
- Changes in the factory-designed geometry, i.e. shifting forward or backward in relation to the central axis.

![Figure 1. Types of excavator bucket defects:](image)

1 - Deformation of the wall inside and outside; 2 - Deformation of the connecting parts and technological holes (critical change); 3 - Change of factory-designed geometry, i.e. shifting forward or backward relative to the central axis

The jaw is used as one of the main components of a straight face mining excavator, which is the moving element of the bucket. When the back wall of the bucket is in good condition and for additional cost savings, only the bucket jaw can be replaced separately. For increased structural strength and abrasion resistance the jaw is made from additional internal and external castings of high strength steel, with a Brinell hardness of 500-600NV. Equipped with teeth, adapters, replaceable heavy-duty side cutters, protection between the teeth with welded-on elements, welded-on elements to protect the bottom corners [3].

Hydraulic open pit excavators lead to longer repair times and higher costs due to the rapid wear of the bucket's jaw faces.

Protection of properly scooped buckets depending on the place of use should increase the life time by reducing and eliminating wear and damage of parts of buckets. However, the factors influencing the amount of wear of protective elements
of the jaw part of quarry hydraulic excavators, operated at JSC "NGMK" quarries, and the malfunctions, which occur in this case, have been defined as follows [4]

Thinning of the jaw plate due to the failure of the jaw guard elements, which leads to a decrease in the reliability of the working connection, as well as the breakage of the plate part from the jaw and a picture of this breakage is shown in Fig. 2

![Picture 2](image)

**Picture 2.** Defect resulting from plate separation from the jaw part of the bucket

Hydraulic open-pit excavators have seen the formation of grooves in the jaw area as a result of abrasion on the surface of the jaw section of the bucket.

As a result of abrasion, the cutting edge between the teeth of the jaw has difficulty sinking into the rock, negatively affecting other components of the excavator.

Protective elements of the jaw part of the bucket the cutting edge of the jaw part is lost as a result of erosion and as a result there are cases of fracture of the jaw part of the bucket in the process of operation.

The analysis of results of above-stated researches shows that the majority of mine hydraulic excavators used at open-cast mining have insufficient protection of elements of jaw section, low durability and resistance to erosion, i.e. they lose their properties quickly when exposed to different types of mined rock the jaw part breaks quickly, which results in failure of other parts of excavator and reduction of its operational characteristics.

In connection with the above mention development of technical solutions to improve durability, service life and efficiency of elements of the bucket part of
hydraulic open-pit excavators seems topical.

**THE MAIN PART**

One of the main elements of the bucket jaw of the straight shovel hydraulic mining excavator is the plate section. The plate section of the jaw of the EKS-1200 hydraulic quarry excavator currently in operation at NGMK JSC serves to fit between the teeth of the bucket cutting elements, the tooth fixing adapter and the plate protection (crawler) elements, as shown in Figure 3.

![Figure 3 General view of the jaw section of a hydraulic mining excavator](image)

The jaw plate of the hydraulic mining excavator is 2180 mm for the rear part welded to the jaw plate and 420 mm for the welded side wall parts with the following characteristics. The total width of the jaw plate is 635 mm. There are 4 adapters on the plate and there is room for 2 more adapters on the side walls of the bucket. The distance between the adapters is the same 294 mm. The width of each of the adapters is 190 mm. The installation and dimensions of the teeth on the plate are shown in figure 4.
Figure 4: Installing and sizing the adapters on the backhoe bucket support

Abrasive abrasion of the plate of the jaw part of the bucket, shown in Fig. 4, leads to erosion due to impacts, while due to the weight of the plate part, a high load is formed, and the plate part breaks away from the bucket jaw. As a result of these negative consequences, the duration of work on repairing the excavator bucket, operating costs and load capacity will increase.

An improved design of the slab section has been developed, which allows to reduce and eliminate malfunctions associated with the separation of the slab section from the jaw of the excavator bucket.
Figure 5 General view, cutouts and their dimensions of the improved bucket jaw plate

As a result of theoretical studies and observations of the operation of submersible elements in production, the number of adapters and teeth installed on the bucket plate section of the RH-40 quarry hydraulic excavator, equal to the bucket size of the EX-1200 quarry hydraulic excavator, is five.

A new plate design has been developed to reduce the time and materials (gas, electrode) required to install adapters on the jaw plate (Fig. 5).

The general appearance of the improved bucket jaw plate is of the same importance as many standard sizes of the jaw plate. The difference between the
improved design of the cheek plate and the standard design of the cheek plate depends on the number of adapters installed on it, the distance between the adapters and the installation of protective devices between the adapters.

The space for the adapter and the plate protection elements between the adapters installed on the front side of the improved bucket jaw plate section is reduced by one compared to the standard jaw plate section.

The dimensions of the two sides of the plate on which the protective elements are installed are 315 mm, and the distances for installing the protective elements closer to the center are 349 mm. There are three spaces for installing adapters on the proposed plate, with a distance of 308 mm for the adapter located in the center and 236 mm for installing side adapters. According to the figure, the pitch of the adapters installed on the plate part of the bucket is set to 420 mm.

![Figure 6. Installation of adapters on the proposed bucket jaw plate:](image)

**Figure 6. Installation of adapters on the proposed bucket jaw plate:**

1 - plate; 2 - adapter; 3 - side walls of the bucket.

**EXPERIMENTAL RESULTS**

To increase the productivity of the excavator bucket used in quarries, the shape of its jaw plate was changed and new improved designs of jaw protection elements were developed.

In order to determine the effectiveness of the above developments, i.e. the impact on the performance of the excavator bucket, their tests were carried out.

In the experimental work, the support plates of the excavator bucket and their
performance on improved plates were studied. During the experiments, changes in the service life of the plate of the simple and improved jaw part of the bucket, their mass, and the number of adapters in the plate part were taken into account.

The weight of the main structural plate part of the excavator bucket jaw was 647 kg, 4 adapters mounted on it - 300 kg, 4 teeth - 104 kg and 4 plate protective elements between the teeth - 392 kg, thus, the total weight of the excavator bucket jaw was 154 kg. The total operating time is on average 3000-3100 hours.

The weight of the improved plate part of the HITACHI EX-1200 excavator was 587 kg, 3 adapters 225 kg installed on it, 3 teeth 78 kg and 3 plate protective elements between the teeth 448 kg, thus, the total weight of the improved excavator bucket jaw part 1354 kg, and the total operating time is on average 3000-3100 engine hours.

In addition, experiments have shown that in both cases, the service life of adapters installed on the jawbone plate averages 1000-1050 hours. To install 1 adapter on the plate, it takes 1 shift (12 hours) of time and welding products per worker per duration. This means that during the entire operation of the plate, the adapters need to be welded to it 2.5 - 3 times.

The improved bucket jaw plate provides 1 adapter and 1 tooth retainer every 2 months (1000-1050 hours) compared to the basic version. On the other hand, savings on adapters and teeth automatically reduce maintenance and operation costs.

**CONCLUSION**

Experimental - test results During the analysis of workability of excavator shovel plate parts, when looking at crowns and teeth installed on 1 excavator shovel jaw for 1 year, the crowns are 6 less than the base, i.e. 20% less, and the number of teeth is 24 less, i.e. 20% less.

Based on the above results, the time and labour required to weld the crowns to the plate and to replace the bucket teeth can also be reduced by 64 hours, i.e. by 15-17%.

In addition, the improved bucket jaw has simplified the bucket design by reducing the total working weight of the plate section to 187 kg. It goes without saying that the weight of the working excavator is directly proportional to its fuel consumption. Hence, by simplifying the design of the excavator's working body, this resulted in a relative reduction of fuel consumption by its internal combustion engine.
REFERENCES