Determination of the possible causes factors of the functionality impairment of the career excavator

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Abstract. The paper deals with the factors of the possible reasons for the deterioration of the functional characteristics of a career crawler excavator, identifying such factors as “machine - career excavator”, “personnel – excavator drivers”, “materials” and “external environment” as well as secondary causes, main aspects of these factors. The reasons for the failures of the career excavator stick in the conditions of the ore deposits of the Southern Urals are established. It is shown that the greatest number of failures is associated with excavator drivers' low qualifications and insufficient experience.

1. Introduction

The study of the conditions and nature of operation of mining excavators, the analysis of statistical data and scientific and technical literature revealed a number of factors that have a significant impact on the technical condition of excavators.

It should be noted that in the course of long-term computational and experimental studies of mine excavators with “loading shovels”, the authors experimentally and theoretically established the laws governing the formation of loading conditions for working equipment. Four (five) design calculation principles of the working equipment were established as a result of studying and summarizing the conditions for the formation of loading modes [1] and combinations of forces acting on the working body and in all elements of the working equipment were determined.

For a number of years the studies of operating modes and causes of failures in the working equipment of mining excavators have shown that the main causes of failures of the handle of mining excavators with a rack-and-pinion head are: a high level of their dynamic loading exceeding the allowable one; structural form, leading to high stress concentration; consequences of repair effects; relatively low qualification of machinists [2].

2. Methodology

Cause & Effect Diagram (Ishikawa diagram) was used as an approach to allocate causes in a logical sequence when analysing factors affecting the deterioration of the functional characteristics of a crawler mounted mining shovel during its operation.

In the analysis, all factors are identified and recorded, even those that seem insignificant. Identification of the possible causes factors of the functional characteristics deterioration of a crawler mounted mining shovel, such factors as “machine - career excavator”, “personnel - excavator drivers”, “materials” and “external environment” as well as secondary factors that make up these factors. The
reasons may be in the design and characteristics of a career excavator, at its age, its service life, the current technical condition of the excavator, etc. The causes of frequent crashes can be explained by the excavator driver’s actions and qualifications who perform excavation functions for the rock mass, as well as repairmen serving the mining machine. The operation of quarry equipment takes place in different natural and climatic, mining and geological conditions; therefore, the environmental factor is certainly decisive, also it is necessary to consider the organization of mining operations, the quality of preparation of the face and rock mass, etc.

All factors meaning the contribution to the intensification of the resource development by a career excavator and driver’s participation in this process can be divided into three groups:
- with a minimal driver's influence on there source development: the influence of the environment, geological and mining conditions;
- with a noticeable influence of the driver on the resource development: the quality of the face and rock mass preparation, the technical state of the excavator;
- with a decisive influence of the driver on the resource development: excavator driving, which is directly dependent on the driver.

It should be noted that to date, there is no method to extend failure free operating period for an excavator, or to control their durability in the development of blasted rock formations. There are only methods for calculating the static, dynamic and fatigue strength of metal excavators, which are used at the design stage. The basis for these calculations is the characteristic load regulations, significantly different from the actual ones acting on the working equipment.

For soft soils of I-III categories according to the classification of Yu.I. Belyakov, N.G. Dombrovsky, S.A. Pankratova, Yu.I. Belyakova, A.N. Zelenin in their works established the load distribution spectra for different types of excavators. However, the results of these studies cannot be applied to solve the durability problems of bearing steel structures of excavators that are used in the development of blasted rocks.

The performance of excavators is known to depend significantly on the quality of the explosive rocks preparation for excavation, characterized, as a rule, by the average diameter of a piece in the shotpile (N.Ya. Repin, A.V. Biryukov, I.A. Panachev, A.S. Tashkinov, L.I. Andreeva, T.I. Krasnikova).

The change in PSD of excavated rocks, their degree of fragmentation and the quality of face base study, the load in the load-bearing metal structures will change, and in the process of scooping when the bucket encounters a substandard piece, they reach maximum values leading to the formation of various micro- and macrocracks and subsequent destruction of the structure [3].

3. Results
Studies of the failures causes in the career excavators stick under the conditions of MMP PJSC MMK and JSC UMMIW showed that the greatest number of failures is associated with the drivers’ qualification [4-6]. The distribution of excavator drivers at MMP PJSC MMK and JSC UDistribution of excavator machinists.

Uchalinsky GOK for work experience according to the work experience and the failures number of career excavator sticks are shown in Figures 1 - 3.

![Figure 1](image1.png)  ![Figure 2](image2.png)

**Figure 1.** Distribution of excavator drivers at MMP PJSC MMK by work experience.  **Figure 2.** Distribution of excavator drivers at Uchalinsky MMTIW by work experience.
Figure 3. Distribution of excavator stick failures in management by the drivers of the considered work experience.

The data analysis presented in Figure 3 shows that the greatest number of excavator stick failures happen when it is operated by the drivers with work experience of 1-5 years.

The following studies [7-12] found that all drivers with the considered work experience had different values of time between failures of the stick beam, which depend on the change in the basket lifting speed when digging the rock mass (Table).

Table. The results of excavation production observations of mining.

| Drivers’ work experience, years | The average time of digging rock mass, s | Maximum basket lifting speed, m/s | Mean time between failures of a beam stick, thousand m³ |
|---------------------------------|----------------------------------------|---------------------------------|-----------------------------------------------------|
| 1-5                             | 12                                     | 0.87                            | 223                                                 |
| 5-10                            | 13.9                                   | 0.75                            | 762                                                 |
| 10-15                           | 17.5                                   | 0.6                             | 1325                                                |

In most cases, the stick failures manifest themselves as fatigue cracks, which lead to brittle fractures (Figure 4).

Figure 4. The fragile destruction of career excavator stick.

4 Conclusion

Thus, the analysis of scientific publications and field studies of the causes of career excavators stick failure for breakdown patterns show that the main causes of excavator stick failures are drivers’ qualification and the structure shape influence (high stress concentration), which requires additional research.

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