Algorithm of probabilistic assessment of fully-mechanized longwall downtime

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Abstract. The problem of increasing the load on a long fully-mechanized longwall has several aspects, one of which is the improvement of efficiency in using available stoping equipment due to the increase in coefficient of the machine operating time of a shearer and other mining machines that form an integral part of the longwall set of equipment. The task of predicting the reliability indicators of stoping equipment is solved by the statistical evaluation of parameters of downtime exponential distribution and failure recovery. It is more difficult to solve the problems of downtime accounting in case of accidents in the face workings and, despite the statistical data on accidents in mine workings, no solution has been found to date. The authors have proposed a variant of probability assessment of workings caving using Poisson distribution and the duration of their restoration using normal distribution. The above results confirm the possibility of implementing the approach proposed by the authors.

1. Introduction
At present, most of the mines in Russia carry out the mining of coal seams according to the “mine-longwall” scheme, when all coal mining is concentrated in one high productive longwall. At the existing concentration of mining operations, any longwall stops due to failures in one of the face technological element lead to significant financial losses. In Kuzbass, the highest indices of load on a fully-mechanized longwall were achieved by mining the medium thickness and thick seams developed by parallel workings leaving protective pillars between them. With an increase in the depth of mining operations at the mines the problems associated with the negative effect of rock pressure on the state of workings, the mining and geological conditions of which are characterized as complex, is becoming more urgent.

The attempts made to group the deposits (and their sites) in terms of complexity of mining and geological conditions for the implementation of efficient technologies for carrying out, walling and protecting the development workings do not completely exclude emergency situations. [1, 2]. Considering the fact that objective geological information on the coal seam and host rocks characteristics is formed on the basis of a limited database of exploratory wells and operational exploration in the process of mining, there is a difficulty in making reliable technological decisions about accident-free maintenance of workings due to the variability of geological conditions [3, 4].

To ensure the control over the state of these excavations at the mines of OJSC SUEK Kuzbass, the technological service of workings walling is functioning, with the help of which in-situ studies are conducted and recommendations are being developed to improve the quality of the construction of the anchor support with increasing working depth [5], however, the decisions often fall behind the change
in mining and geological conditions. In connection with that, the task of simulating the load on the face as a random variable that depends on these complicating factors, including those related to the change in the state of workings [6-8], is very relevant.

2. Methods of research

For the solution of the set problem it is proposed to use the methods of probability theory to estimate the number of roof cavings in the working, the main principles of which are discussed in [7-9]. The roof caving is seen as a rare random event that obeys Poisson distribution, which is modeled using a random number generator based on the inverse function method [10]. The use of the analytical dependences given in [7-9] allows the probability of roof caving in the development workings to be determined and the parameter λ of Poisson distribution to be estimated for further use in determining the number of emergency situations during the simulation period. Such an estimate is made by means of analytical or numerical solution of the equation, which is obtained by substituting the value of caving probability in the dependence describing Poisson law.

The task of downtime estimation (restoration of the working) is solved using a random number generator with a normal distribution [10], the parameters of which are determined on the basis of statistical data on the mines of the south of Kuzbass.

3. Results and discussion

As a result of the performed studies the integrated structural scheme of the estimation algorithm of downtime due to roof cavings in the model of technological scheme of a fully-mechanized longwall was developed. It is given figure 1.

![Diagram](image)

**Figure 1.** Enlarged structural scheme of estimation of downtimes caused by roof cavings in the workings.

On the basis of the proposed algorithm, an additional module was implemented to the model of a fully-mechanized longwall [11, 12] and the assessment of the state of mine workings was made with a calculated probability of roof caving p = 0.04. The duration of observation period was 7 months, the
results of modeling the actual frequency of working caving are given in table 1. The average frequency of roof caving in the workings for all simulation periods was 0.0398, which is close to the declared probability of $p = 0.04$.

| Observation period, months | Frequency of roof cavings in the workings |
|---------------------------|-------------------------------------------|
| 1                         | 0.0356                                    |
| 2                         | 0.0356                                    |
| 3                         | 0.0356                                    |
| 4                         | 0.0600                                    |
| 5                         | 0.0438                                    |
| 6                         | 0.0300                                    |
| 7                         | 0.0384                                    |

### 4. Conclusions

1. In connection with the increase in the concentration of mining operations and the complication in the mining, geological and technological conditions of the work in the faces, the problem of modeling the load on the face as a random variable that depends on the random complicating factors associated with the change in the state of workings is very relevant.

2. Using the probabilistic estimate of the number of working cavings and the duration of their restoration, it is possible to realize the imitation model of the face operation, taking into account the influence of the state of working site on the coefficient of machine time of a shearer.

3. The obtained results confirm the possibility of using the approach proposed by the authors for estimating the actual operational time of a working site.

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