

## ABSTRACT

dissertation for the degree of Doctor of Philosophy (PhD) on

OP 8D07203 – Mining Engineering

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### **Computer-aided design of rational parameters of blasting operations in the course of driving of underground horizontal mining**

#### **The relevance of the topic.**

Until now, at many mining enterprises in the world, the parameters of drilling and blasting operations (BVR) during the penetration of underground mining are taken on the basis of experimental data. They require their experimental confirmation and scientific and technical justification. At the same time, the specific consumption of explosives is taken as the main criterion for choosing the parameters of the BVR, which in principle should take into account various physical and mechanical properties of rocks, chemical and physical properties of the explosives used, spatial placement of charges in the exploding array. However, this condition is the very requirement of its solution.

In addition, the degree of crushing of the rock of the exploded rock mass is considered as an estimated indicator of the result of drilling and blasting operations.

Thus, in the approaches used in practice to determine the parameters of the BVR, the desired indicators are the initial parameters of the explosion, i.e. the specific consumption of explosives, the parameters of the BVR in the exploding layers of the mine. In the well-known works devoted to determining the parameters of the location of charges in the exploding layers of preparatory and cleaning workings, these issues are not deciphered. This brief summary information shows that despite the presence of numerous works, the creation of a scientifically based methodology for determining the parameters of drilling and blasting operations during the penetration of underground mining is an important and urgent task of mining science and production.

Drilling and blasting operations are a complex of important mining and technical measures during the sinking of underground mine workings. Their correct choice determines the technical and economic indicators of all subsequent technological processes. Therefore, the problem of improving BVR technologies when sinking underground horizontal workings is in the focus of attention of specialists dealing with this issue.

**The purpose of the study** is to develop a scientifically based methodology for determining the rational parameters of blasting operations during the penetration of underground horizontal workings using the key results of the explosion of a cylindrical explosive charge in an array of rocks and the creation of their automated design.

**The idea of the work** is to increase the efficiency of drilling and blasting operations based on innovative methods of computer-aided design of rational parameters of the location of charges and the granulometric composition of blasted rocks in the faces of horizontal preparatory and treatment workings.

#### **Research objectives:**

In accordance with the stated goal, the following tasks are formulated in the dissertation:

1. Substantiation of the analytical method for determining the granulometric composition of natural individuals in an array of rocks by the average size of the individual.

2. Development of an analytical method for determining the rational location of explosive charges in the faces of underground horizontal preparatory and treatment workings.

3. Creation of an analytical method for determining the granulometric composition of the exploded rock mass in the faces of preparatory and treatment underground horizontal workings.

4. Testing of the computer-aided design system for the parameters of drilling and blasting operations and the granulometric composition of blasted rocks in the faces of preparatory and treatment workings.

**The main provisions submitted for protection:**

1. The granulometric composition of natural separations in an array of rocks is mathematically expressed by the average size of the individual. The content of natural separateness in the rock mass generally varies exponentially.

2. The parameters of the cylindrical log – the main element of the beaten layer are determined by the size of the zone of fine crushing around the log holes of rocks. Chipping and contouring holes are selected according to the principle of rational placement in the array that successfully connects the physical and technical properties of the exploding rocks, the physical and chemical characteristics of the explosive used and the parameters of the location of charges in the rock array with the final results of the explosion

3. The granulometric composition of the exploded rock mass is predetermined by the joint consideration of the size of the zones of intensive crushing of rocks around the hole charges and the virtual content of natural separations in the rock mass formed due to the collision of rock pieces during movement in the second and third stages of the explosion.

**The main results of the study:**

1. Analytical dependences of natural separations in small-block, medium-block, large-block and very large-block rock massifs for various scales of the size of natural separations are established. Software has been developed for the automated determination of the granulometric composition of natural individuals in an array of rocks by their average size in conditions of underground mining of minerals.

2. On the basis of the regularities of the formation of a fine crushing zone around the cut-in hole charges, a new approach to determining the parameters of a cylindrical cut-in, the main element of the beaten rock layer in horizontal mining, is justified. Using the principle of rational arrangement of charges in the exploding array, analytical dependencies are derived for the placement of chipping and contouring holes in the bottom of the mine. Computer-aided design of rational parameters of blasting operations during the penetration of underground horizontal workings has been created.

3. On the basis of joint consideration of the size of the zones of intensive crushing of rocks around the hole charges and the virtual content of natural separations in the rock mass, formulated as a result of the collision of pieces of rocks during movement in the second and third stages of the explosion, an analytical method for determining the granulometric composition of the exploded rock mass during the hole chipping in underground preparatory and treatment workings has been developed. A computer program for automated determination of the granulation of the exploded rock mass has been created.

4. The system of automated design of parameters of drilling and blasting operations and granulometric composition of blasted rocks in the faces of preparatory and treatment workings has been tested and partially implemented in production at Zhezkazgan mines of Kazakhmys Corporation LLP.

**Objects of research or development** – explosive destruction of rocks at the mines of Kazakhmys Corporation LLP by shpurov charges.

**The subject of the study** is the rational placement of charges in the exploding array to ensure the required quality of the exploded rocks at the mines of Kazakhmys Corporation LLP.

#### **Methodological base of scientific research**

When performing scientific research, complex research methods were used, including analysis and generalization of scientific and technical information, theoretical research, mathematical modeling methods, mathematical statistics methods for processing experimental data and feasibility studies of various technology options, correlation and regression analysis, as well as empirical and object-oriented programming methods for creating software modules.

**The novelty of the topic** lies in the development of an innovative system for automated forecasting of the results of BVR using the established new patterns of crushing rocks by the explosion of a cylindrical explosive charge during the penetration of underground horizontal workings. The fundamental difference between the proposed methods for determining the parameters and results of explosions from the known ones is that in mining science, for the first time, the limiting radius of the explosive cavity formed by the explosion of explosives in the rock has been adopted as the determining indicator of the results of an explosive explosion in a solid medium. It successfully links the final result of the explosion with the physical and mechanical properties of rocks, the physical and chemical characteristics of the explosive used and creates a scientific basis for the development of various software modules for the automated prediction of the results of the BVR during the penetration of underground horizontal workings.

A new structural-hierarchical model of rock massifs has been created. For the first time, the regularities of the formation of the virtual content of various pieces of rocks as a result of their collision in the second and third stages of the explosion were established.

#### **Practical significance of the work**

With the use of the created software modules for automated determination of the parameters of the BVR and prediction of the granulometric composition of the exploded rock mass (CAD BVR), operational passports of the BVR are compiled with a detailed location of charges in the beaten rock layer, with the predicted granulometric composition of the exploded rock mass. With the help of CAD BVR, an unlimited number of BVR calculations can be performed in underground horizontal workings of various shapes and sizes. By competently controlling the blasting process during the penetration of underground horizontal workings, it is possible to achieve the necessary technological parameters of the exploded rock mass in underground mines.

These procedures are based on proven methods for determining the granulometric composition of natural rock mass separations by their average size (blockiness of the rock mass), strength characteristics of rocks under explosive loading conditions, and the relative limiting radius of the explosive cavity

#### **Заклучение**

1. Analytical dependences of natural separations in small-block, medium-block, large-block and very large-block rock massifs have been established. The content of natural separations in the rock mass generally varies exponentially. With the help of the MS Excel 2009 program, a structural-hierarchical model of rock mass fracturing has been created. It allows us to determine the calculated granulometric composition of natural separations in arrays of different block sizes by their average size at different scales of the size of natural separations. A classification of the rock mass by blockiness is proposed, indicating the percentage of natural separations.
2. Software has been created for automated determination of the granulometric composition of natural individuals in an array of rocks by their average size during underground mining of minerals. The results obtained reflect the real state of affairs in practice and confirm the

suitability of the proposed methodology for automated determination of the granulometric composition of natural individuals in the rock mass.

3. An analytical method has been developed for determining the rational location of explosive charges in the faces of horizontal underground preparatory and treatment workings. It includes a new approach to determining the parameters of a cylindrical log cabin-the main element of the beaten rock layer in horizontal mining, based on taking into account the size of fine crushing zones around the log holes. The placement of chipping and contouring holes in the bottom of the mine is subject to the principle of rational arrangement of charges in the exploding array. The consolidated analytical method for determining the rational parameters of the BVR successfully links the physical and technical properties of the exploding rocks, the physical and chemical characteristics of the explosive used and the parameters of the location of charges in the rock mass with the final results of the explosion.
4. A computer program for computer-aided design of rational parameters of blasting operations during the penetration of underground horizontal workings has been created.
5. A computer program has been developed for automated determination of the granulation of the exploded rock mass in underground preparatory and treatment workings.
6. Comparison of theoretical, experimental and production data in the conditions of the mines of Kazakhmys Corporation LLP showed a high degree of their identity. This result created the conditions for the implementation of the developed computer-aided design of the BVR parameters and the determination of the granulometric composition of the blasted rock mass in the faces of preparatory and treatment workings.
7. Comparison of theoretical, experimental and production data in the conditions of the mines of Kazakhmys Corporation LLP showed a high degree of their identity. This result created the conditions for the implementation of the developed computer-aided design of the BVR parameters and the determination of the granulometric composition of the blasted rock mass in the faces of preparatory and treatment workings.
8. The new parameters of the BVR at the underground mines of Kazakhmys Corporation LLP allowed to reduce the specific consumption, increase the yield of rock mass by 5-7%, respectively, with the provision of the required granulometric composition of the exploded rock mass and the movement of the face, which is confirmed by the relevant materials of Kazakhmys Corporation LLP.