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Research paper

Portable complex for controlled explosive reactive drilling of rocks

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Abstract

The developed portable explosive-reactive complex for drilling-and-blasting operations in complex mining-geological conditions is considered. The basic design features of the complex are given. The main principles of ensuring the effectiveness of explosive-reactive drilling are formulated. The conditions for the appearance of the effect of the dynamic pressure on the rock of the complex ensuring its recoiling work are considered in detail.

Keywords: *Adjustable detonation mode; Explosive reactive complex; Explosive drilling; Portable, Rock.*

1. Introduction

The developed portable explosive reactive complexes (ERC) belong to the class of solid-fuel pulsating explosive devices. They designed for explosive drilling of rocks of various strengths in mining and geological conditions difficult for transport and traditional drilling equipment [1-3].
An important task in the design and development of a portable ERC was the reduction of mass-dimensional characteristics of the products while increasing their performance and reliability.
Portable ERC, designed for explosive drilling rocks, have the electric system of initiation, which includes autonomous power supply (APS), remote control (RC), the block electric initiation (BEI) and a set of special electric detonators (SED).

2. The method of operation of explosive reactive complexes

The basis of a universal portable explosive-reactive complex is an explosive-reactive installation consisting of an electric initiation unit and an operating unit. The working body is a set of three modules, each containing seven cassettes with shaped charges and electric detonators of increased safety in each. Destructive cassettes have a distinctive feature - the ring arrangement of bottom-hole and cumulative charge, as well as specially designed electric detonators. Each detonator connected to a power electric initiation, electric wires passing through the housing of the cassette.
Special electric detonators installed in ring and clamping charges, equipped with cumulative ring pits. Each blasting plant can contain from one to three docked working modules (depending on the task solved). The explosive device itself placed in the launch device. Charging of the electric initiation unit carried out from the power source through the main electrical cable.
The detonators are initiated sequentially, starting from the bottom and ending with the upper cassette in a regulated mode with a frequency of up to 1000 Hz. The required frequency of initiation of destructible cassettes is preliminarily set by means of a regulator located on the panel of the remote control.
The main view and elements of the developed portable ERC complex are shown in Fig.1.

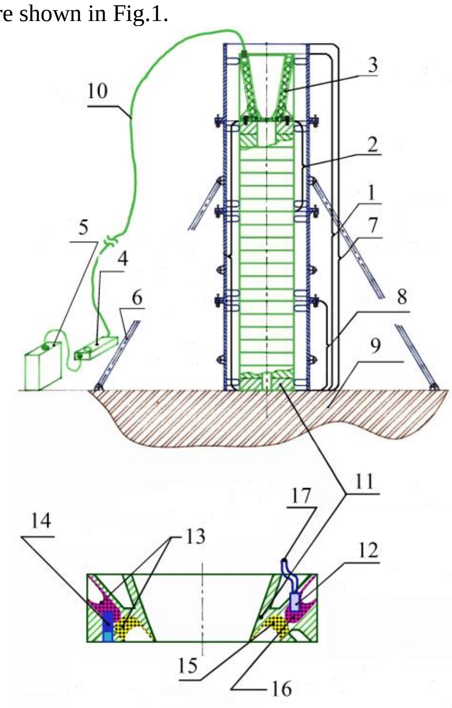

Fig.1: General view and basic elements of the device of the complex.
1- explosive reactive complex, 2- working module (WM), 3 block electrical initiation (BEI), 4- remote control (RC), 5- autonomous power supply (APS), 6- mounting stand, 7- support console, 8- unite supporting the console, 9- breakable rock,10- electric cable, 11 – cassette with charge of explosive, 12- special capsule detonator, 13- cumulative funnels, 14- special electric detonators (SED), 15- ring charge for primary destruction of rock, 16- ring charge for dynamic pressing to the rock and additional destruction, 17 – connecting cable from BEI.

External appearance of the explosive jet block is shown in Fig. 2.

Fig. 2: External appearance of explosive reactive block

3. Features of the developed explosive reactive complex

The principal feature of the ERC complex is the recoilless working explosive-reactive installation, which appearances the effect of dynamic pressure WM to the surface of soil. This is done by advancing a temporary phase detonation reflector of the pressure charge in the external circuit compared to the downhole charge of the inner contour of the reflector cassette.
Features mode of detonation initiation are discussed in the article [4].
The implementation of simultaneous overlap of the charge initiation and detonation pressure is shown in Fig. 3.

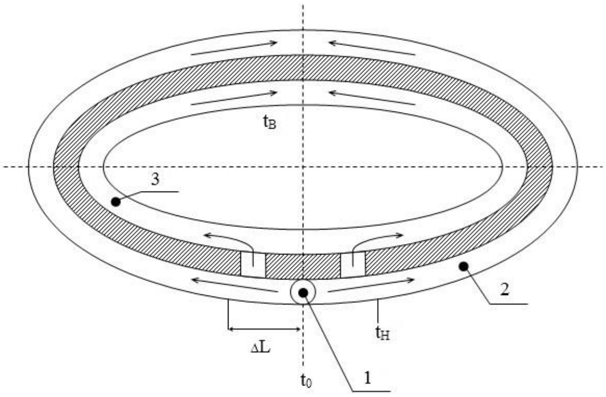

Fig. 3: Schematic view of the simultaneous overlapping initiation and detonation pressure charge.
1- The special electric detonator [5]; 2, 3 - the pressure and downhole explosive charges.

The times of detonation are determined from the relationship

$$\begin{cases} t_н = \dfrac{L_н}{2D_н} \\ t_н = \dfrac{\Delta L_н}{2D_н} + \dfrac{L_b}{2D_b} \end{cases} \quad (1)$$

Where $t_н$ and t_b– the time of detonation on the outer and inner contours of the reflector, in seconds (s);
$L_н$, L_b - is the length of the outer and inner contour of the cassette, m;
$D_н$ and D_b – speed of detonation of explosives on the inner and outer contours of the cassette, m/s;
ΔL- is the linear delay of the process of detonation in an internal circuit of the cassette from the outer, m.
The second condition is the dependence of the length of jet pressure and bottom-hole charges from the difference of the radius of the borehole and the cassette

$$R_c - R > \frac{V_{ex} \cdot \sin\beta}{S}\left[\frac{(k-1)\cdot E \cdot \rho}{\sigma}\right]^{1/k} \quad (2)$$

R_c - radius of the formed borehole, m; R – radius of the cassette, m;
V_{ex} – the volume of the explosive charge, m^3;
S - is average cross – section of the explosion products from the reflectors, m^2;
σ – tensile strength of rocks in triaxle compression, Pa;
E - calorific characteristics of the used explosive J/kg;
k –coefficient of polytope and adiabatic;
ρ– charge density, kg/m^3.

The scheme of one cartridge work showed on the Fig. 4.

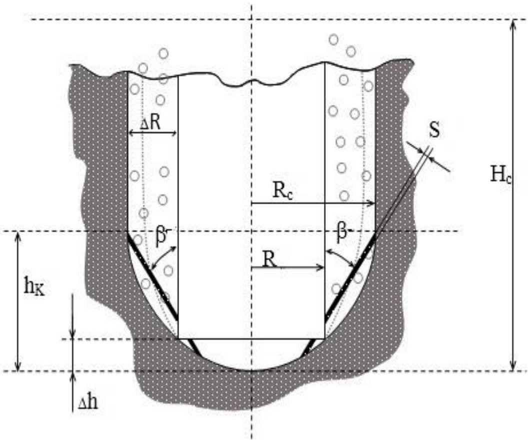

Fig. 4: The scheme of one cartridge work.
β -the optimal angles of release of the blasting on the rock [6];
H_c - the depth of the formed well, m.
ΔR - the clearance between the block and cartridge bore.
$h_к$ - the depth of penetration of wells one cassette, m;
Δh – the gap between the lower point of the well and magazine, m.

The effectiveness of the ERC is a regulated mode of initiation by a specially designed electric detonators instant action (SED) that allows one to control the frequency (ν) of successive explosions in a time range not exceeding time of the destruction of the tapes

$$\frac{3\upsilon \cdot H_c}{d}\left(\frac{\sigma}{E\cdot\rho}\right)^{k-1/k} \le \nu \le 1000, \quad (3)$$

where υ – the speed of well bore sinking, m/s;
H_c – depth of a borehole, m;
d – the borehole diameter, m.

4. Results

It is found that the frequency mode of initiating cassettes equipped with explosives affects:
- the efficiency of rock destruction (the optimum range is from 100 to 500 Hz);
- the height of the sludge discharge from the face to the day surface. When the rocks destroyed in optimal mode, in the frequency range from 100 to 500 Hz, the height of the sludge release rises from 6 to 30 m, at a frequency of 1000 Hz, the ejection height reaches 60 m.

The efficiency of the ERC achieved through the implementation of the following conditions:
- the use of BEI, which in the process of operation do not depend on external power supplies and provide a controlled mode of initiating the SED with a frequency of up to 1000 Hz;
- the use of SED of instantaneous action, possessing high safety during their operation and initiation from BEI;
- the use of disposable cassettes equipped with destructible reflectors, which ensure highly efficient accumulation of energy of explosion products on the rock to be destroyed
- reactive recoilless operation of cassette tapes operating as a bottomhole charge, which ensures sufficient retention time of the explosion products acting on the rock to be destroyed, and minimizes the time interval for feeding the next cassette to the bottomhole;
- high-speed destruction of rocks of various fortresses in the form of a well, which significantly reduces the time and financial costs of their development.

In the future, it is possible to use a radio-controlled ERC with several degrees of protection.

This method of drilling is recommended for mining, engineering and construction works in difficult mining, geological and climatic conditions [7-10]. Comparative analysis of mechanical and gas-dynamic means of rock destruction shows that ERC- does not have equivalent analogues of the same purpose, including for use in special mining operations, as well as in methods of space protection of the Earth from collision with asteroids [11-12].

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