AJEMA GLOBAL RESEARCH NETWORK

AMERICAN Journal of Engineering, Mechanics and Architecture
Volume 01, Issue 07, 2023 ISSN (E): 2993-2637

Study of the Propagation of the Shock-Air Wave Front in the Axial Air Cavity of a Downhole Charge of Explosives

Sh. A. Ochilov
Associate Professor, Department of Mining, PhD, Assoc., Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

D. R. Makhmudov
Associate Professor, Department of Geotechnology of Coal and Seam Deposits, PhD, Assoc., Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

A. N. Karamanov
Doctoral student of the department "Mining", Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Cm. Raimkulova
Doctoral student of the Mining Department, Tashkent State Technical University named after Islam Karimov, Tashkent, Uzbekistan

Abstract: In order to increase the efficiency of the explosive impact on the rock and reduce the output of oversize in open pits, it is recommended to increase the pressure and time of the explosion impact on the massif by using an axial air cavity. This paper presents the results of studies of the propagation of the shock-air wave front in the axial air cavity of a borehole explosive charge depending on the detonation velocity, the mass of the explosive charge and the cross-sectional area of the axial cavity. The study of the propagation of the shock-air wave front in the axial air cavity of the borehole explosive charge makes it possible to develop the design of a borehole explosive charge with an axial air cavity, which improves the efficiency of blasting by increasing the duration of the blast wave pulse and reducing the specific consumption of explosives.

Keywords: shock-air wave, borehole charge, explosive, overpressure, air cavity, specific consumption of explosives.

Introduction

It is known that the quality of the explosive preparation of the rock mass depends on the productivity and efficiency of all subsequent technological processes for the extraction and processing of minerals in a single system "quarry - processing industry". In this regard, one of the most important characteristics of the blasting technology is the specific energy consumption of explosives, characterized both by energy indicators and types of explosives used, and by the parameters of the location of borehole charges in the destructible ledge. All this necessitates the optimization of parameters and the intensification of the explosive method of crushing as the cheapest and most technologically advanced and, as a result, an increase in the efficiency of the functioning of production processes of technological flows.

The traditional technology of drilling and blasting operations (BVR) at deep levels of quarries has exhausted its capabilities, therefore, it is necessary to introduce more advanced methods that provide for the fully specified quality of rock mass crushing.

The deposits of the Republic of Uzbekistan are characterized by a complex structure of ore bodies, high variability of the contents of useful components, steep dip angles, and unsustainable thickness of ore bodies. Such variability significantly affects the efficiency of mining , significantly complicating the choice of technological parameters of drilling and blasting. At the same time, with an increase in the depth of development to the maximum economically feasible value, water cut and fracture of rocks increase, the influence of the open pit depth on the resistance of ores to explosive destruction increases, and the requirements for the safety of the sides increase. In this regard, scientific research, development and implementation of methods for intensifying the processes of drilling and blasting, increasing the efficiency of using explosive technologies to ensure the required quality of the blasted rock mass, is an urgent task of science and practice of mining, the solution of which helps to increase the economic efficiency of enterprises.

Materials and methods

When conducting research, complex methods were used, including theoretical generalizations and experimental studies in laboratory, field and industrial conditions, mathematical programming methods using modern computer technology in order to develop programs for calculating the effective parameters of drilling and blasting in the Borland language Delphi 7.0, as well as methods of mathematical statistics and correlation analysis of research results.

Analysis of completed studies

the theory of destruction and deformation of rocks by explosion was made by scientists V.E. Aleksandrov , E.G. Baranov , I.P. Bibik , V.A. Borovikov , K.E. Vinitsky , O.E. A. Vovk , G. P. Demidyuk , M. F. Drukovannyy , E. I. Efremov , N. F. Kusov , B. N. Kutuzov Kushnarev , L.N. Marchenko , N.V. Melnikov , E.O. Mindeli , P.S. Mironov , U.F. _ _ , V.N. Rodionov , V.K. Rubtsov , A.F. Sukhanov , V.N. Sytenkov , V.P. Tarasenko , N.U. _ .I. Shemyakin and others. In the works of these scientists, the physics of the destruction process was studied and the main patterns of rock destruction were established, as well as the influence of mining and technological characteristics on the efficiency of blasting.

On the basis of theoretical and experimental studies of N.Vanderberg , A.I.Golbinder , L.V.Dubnov , N.A.Deremin , V.P.Martynenko , V.F.Tyshevich , L.D.Khotin , A.R. Chernenko and other scientists studied the regime of detonation waves in blasthole and borehole explosive charges with an axial air cavity. Under the influence of the initial pulse, an elongated explosive charge with an axial air cavity is detonated , forming detonation waves. As a result of the action of the products of the detonation wave, a kind of gas piston is formed in the gap between the charge and the axial air cavity, which, according to the laws of gas dynamics, is a pressure jump propagating at supersonic speed.

As a result of the analysis of works [1-12], it was found that during the explosion of an explosive charge in air, a rapid local increase in temperature and pressure of the gaseous products of the explosion occurs, which compress the air adjacent to the charge with a sharp blow. As a result, a shock-air wave arises in the air, which is a pressure jump propagating at supersonic speed. Behind the front, an air flow moves at a lower speed, the pressure in which drops to atmospheric pressure as it moves away from the front, and even goes into a rarefaction phase.

To calculate the maximum value of overpressure in an infinite air medium during the explosion of spherical charges, the formula of M.A. Sadovsky , refined by G.I. Pokrovsky [6,7], is used.

$$\Delta P = 0{,}84\frac{\sqrt[3]{G}}{R} + 2{,}7\frac{\sqrt[3]{G^2}}{R^2} + 7\frac{\sqrt[3]{G^3}}{R^3}, кгс/см^2. \quad (1)$$

where G is the mass of the explosive charge, kg; R is the distance to the place of explosion, m.

The process of formation of the front of the shock-air wave during the explosion of an explosive charge in the axial cavity occurs differently. A shock-air wave with a curvilinear front interacts with the walls of the axial cavity. Regular reflection occurs and a system of incident and reflected waves is formed with common points on the reflection planes. Further, the reflected wave overtakes the incident one and an irregular reflection occurs, resulting in the appearance of sections of a flat front.

For practical calculations of excess pressure at the front of a shock-air wave when it moves along a straight working, the authors of works [6,10] recommend the following dependencies:

$$\Delta P = \left[44\frac{G}{S \cdot R} + 9{,}2\left(\frac{G}{S \cdot R}\right)^{2/3} + 1{,}46\left(\frac{G}{S \cdot R}\right)^{1/3} \right] \cdot 10^5, Па, \qquad (2)$$

where S is the cross-sectional area of the axial air cavity, m ^{2};

for overpressure time

$$\tau = 0{,}92\frac{R}{c}\sqrt[6]{\frac{G}{S \cdot R}} \cdot 10^3, мс \qquad (3)$$

where c is the speed of sound, m/s.

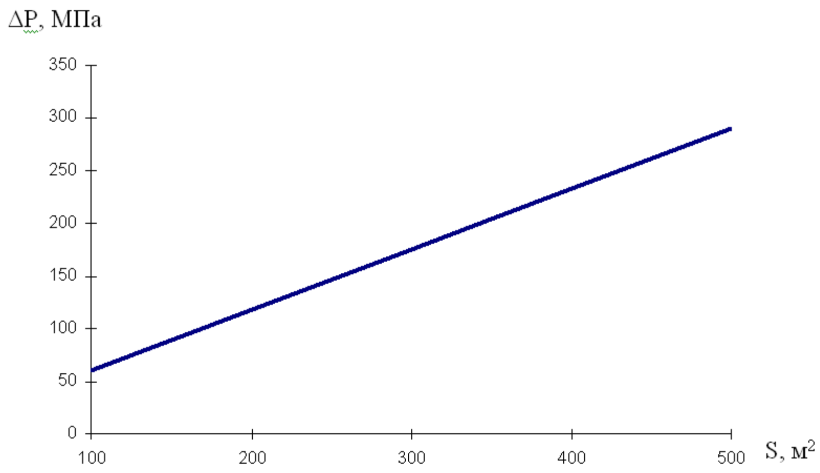
Results and discussion

As a result of the theoretical studies carried out, the dependences of the propagation of the shock-air wave front in the axial air cavity of the borehole charge were established depending on the detonation velocity and explosive density. In table. 1 shows the main characteristics of explosives, determined by the authors of [13].

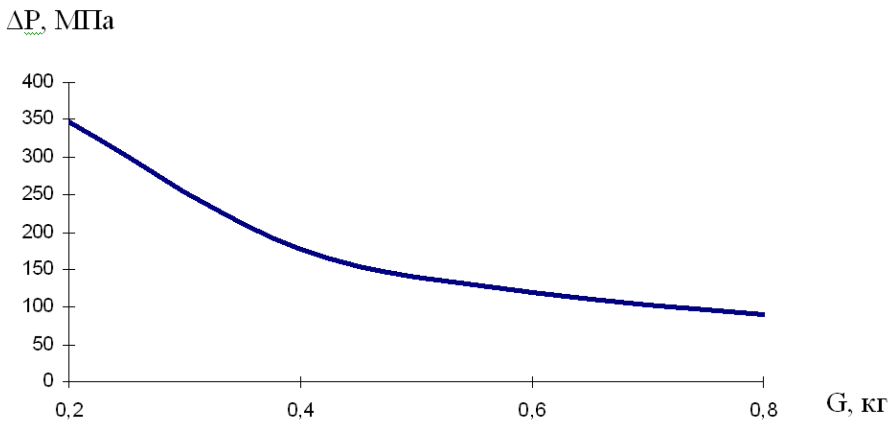
Table 1

BB name	Density of explosives, $\rho_{explosives}$, kg / m ^{3}	Detonation velocity, D, m/s	Heat of explosion Q, kJ/kg	Air shock wave speed ω, m/s	adiabatic exponent,γ
Grammonite 79/21, GOST 21988-76	800-850	3200-4000	4285	4700 - 5000	1.9
Granulite AS-4, GOST 21987-76	850-900	2600-3500	4522	3250 - 4100	1.54
Granulite AS-4V, TU 85-620-82	800-850	3000-3500	4522	3750 - 4700	1.56
Granulite AC-8, GOST 21987-76	870-950	3000-3600	5191	3750 - 4700	1.52
Granulite AS-8V, TU 84-620-82	800-850	3000-3600	5233	3750 - 4700	1.56
Granulite M, GOST 21987-76	780-820	2500-3600	3852	3200 - 2560	1.48
Granulite S-2, GOST 21987-76	800-850	2200-3000	3939	2750 - 3500	-

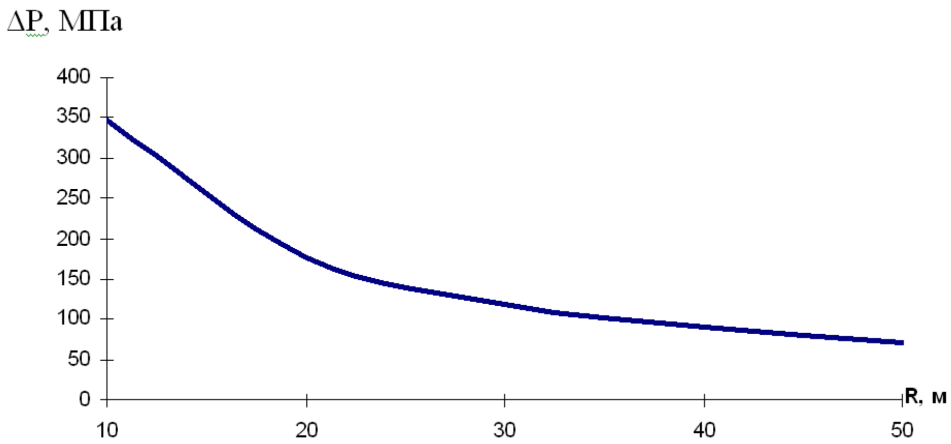
Also, the dependences of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the cross-sectional area of the cavity and the mass of the explosive charge at various distances were established (Fig. 1-3).



Rice. 1. Dependence of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the cross-sectional area of the cavity



Rice. 2. Dependence of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the mass of the explosive charge



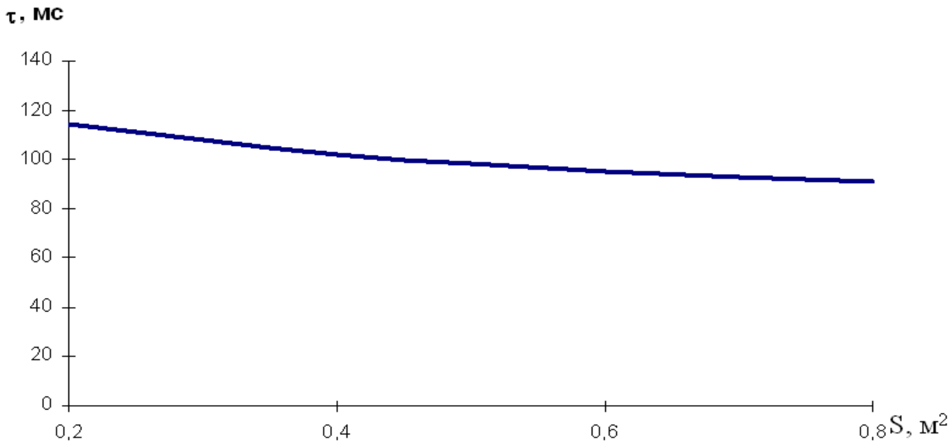
Rice. 3. Dependence of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the distance

The resulting dependence in Fig. 1 shows that with an increase in the cavity cross-sectional area from 0.2 to 0.8 m ^{2}, the excess pressure at the front of the shock-air wave in the axial air cavity of the borehole explosive charge decreases from 350 to 70 MPa.

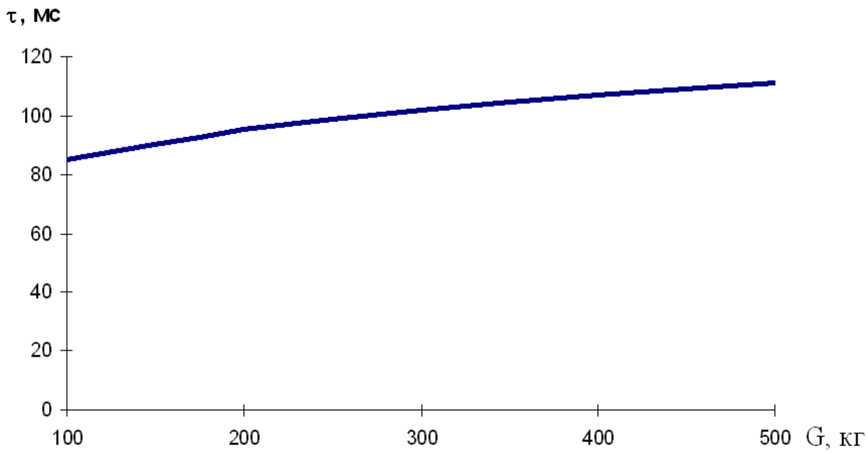
On fig. Figure 2 shows the dependence of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the mass of the explosive charge. The obtained dependence shows that with an increase in the mass of the charge from 100 to 500 kg, the excess pressure at the front of the shock-air wave in the axial air cavity of the downhole charge increases from 60 to 300 MPa. The resulting regularity is characterized by a dependence of a linear type.

As a result of the research, the dependence of the propagation of the shock-air wave front in the axial air cavity of the borehole explosive charge on distances was established (Fig. 3). The obtained dependence shows that with an increase in the distance from 10 to 50 m, the excess pressure at the front of the shock-air wave in the axial air cavity of the borehole charge decreases from 350 to 60 MPa.

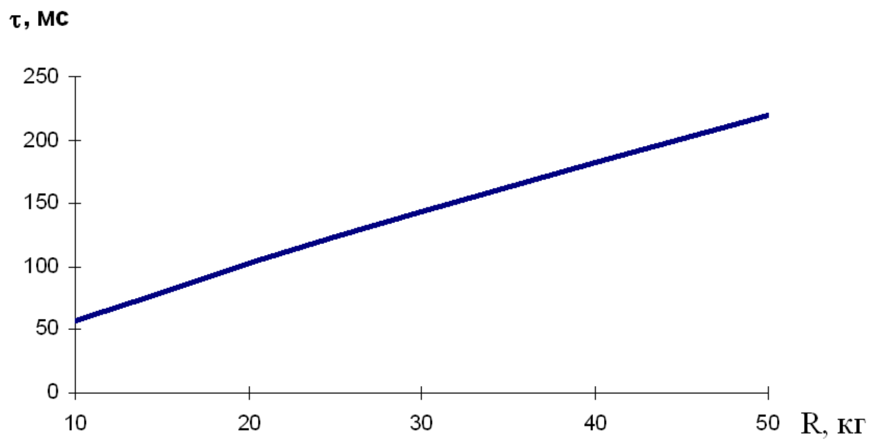
Theoretical studies have established the dependences of the action time of the front of the shock-air wave in the axial air cavity of the borehole charge on the cross-sectional area of the cavity, the mass of the explosive charge at various distances, the results of which are shown in Fig. 4-6.



Rice. Fig. 4. Change in the action time of the excess pressure of the front of the shock-air wave in the axial air cavity of the borehole charge, depending on the cross-sectional area of the cavity



Rice. Fig. 5. Change in the action time of the overpressure of the front of the shock-air wave in the axial air cavity of the borehole charge depending on the mass of the explosive charge



Rice. Fig. 6. Change in the time of action of the overpressure of the front of the shock-air wave in the axial air cavity of the borehole charge depending on the distance

The resulting dependence, shown in Fig. 4 shows that with an increase in the cross-sectional area of the cavity from 0.2 to 0.8 m ^{2} , the time of action of excess pressure at the front of the shock-air wave in the axial air cavity of the downhole explosive charge decreases from 115 to 90 ms .

Dependence in fig. 5 shows that with an increase in the mass of the explosive charge from 100 to 500 kg, the time of action of excess pressure at the front of the shock-air wave in the axial air cavity of the borehole explosive charge increases from 85 to 115 ms .

The resulting dependence, shown in Fig. 6 shows that with an increase in the distance from the center of the explosion from 10 to 50 m, the time of action of excess pressure at the front of the shock-air wave in the axial air cavity of the borehole explosive charge increases from 60 to 225 ms .

Conclusions

The regime of detonation waves in elongated explosive charges with an axial air cavity has been studied. The speed of propagation of the front of the shock-air wave in the axial air cavity is established depending on the detonation speed of industrial explosives and the dependence of the propagation of the front of the shock-air wave in the axial air cavity of the borehole charge on the sectional area of the cavity at various distances and the mass of the explosive charge. The time of action of the front of the shock-air wave in the axial air cavity of the borehole charge is determined depending on the cross-sectional area of the cavity and the mass of the explosive charge at various distances.

Bibliography

1. Directory. Open pit mining / K.N. Trubetskoy , M.G. Potapov , K.E. Vinitsky , N.N. Melnikov and others - Moscow: Mining Bureau, 1994. – 590 p.
2. Drukovany M.F., Kukib B.N., Kuts V.S. Drilling and blasting in quarries. – M.: Nedra, 1990. – 367 p.
3. Kutuzov B.N., Skorobogatov V.M., Erofeev I.E. etc. Handbook of explosives. – M.: Nedra, 1988. – 511 p.
4. Khuzhakulov A.M., Karimov E.L., Latipov Z.E., Nomdorov R.U., Khakkulov S. Study of the mode of detonation waves in borehole charges with an axial air cavity // Socio-economic and environmental problems of the mining industry. , Construction and Energy: Proceedings of the 15th International Conference on Mining, Construction and Energy. - Minsk: BNTU, 2019. - T. 1. - S. 255-263.
5. Shvedov K.K. On the reasons for the scatter of experimental data on pressure and the polytropic index of detonation products of condensed explosives and the possibility of their

accurate determination. – Chernogolovka, Institute of Chemical Physics of the Academy of Sciences of the USSR, 1985.

6. Pokrovsky G.I. Explosion. - M., 1973. - 182 p.
7. Khanukaev A.N. Physical processes during rock breaking by explosion. – M.: Nedra, 1974. – 224 p.
8. Adushkin V.V. Influence of density and humidity of sandy soil on the dimensions of the boiler cavity during a camouflage explosion // FGV, 1979. – No. 3. – S. 107-116.
9. Lyakhov G.M. Fundamentals of explosive wave dynamics in soils and rocks. – M.: Nedra, 1974. – 192 p.
10. Dubnov L.V., Bakharevich N.S., Romanov A.I. Industrial explosives. - M.: Nedra, 1988. - 358 p.
11. Babayans G.M., Martynenko V.P., Chernenko A.R. Borehole breaking of ore using charges with an axial air cavity // Review. Inform . – M.: Chermetinformatsia , 1984. – 22 p.
12. Kutuzov B.N., Komashchenko V.I., Noskov V.F. and others. Laboratory and practical work on the destruction of rocks by explosion. - M.: Nedra, 1981. - 255 p.
13. Kutuzov B.N., Skorobogatov V.M., Erofeev I.E. etc. Handbook of explosives. – M.: Nedra, 1988. – 511 p.