ABOUT ASYMMETRY OF A HYPERSOUND SHOCK WAVE

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Abstract

The analysis of basic approaches on improving of rock blasting is made. The components of an explosive impulse are described. The result is that the technique of laboratory researches of the blast-hole refractor effects on the radial impulse of explosion. The estimation of experiments' results is done. The results of industrial applications on Ukrainian mines are given. The future directions are planed.

Abstrakt

Je provedena analýza základních přístupů ke zlepšení rozpojování hornin. Jsou popsány složky rázu exploze. Výsledkem je, že metoda laboratorních výzkumů refraktoru pro vývrt pro nálož má vliv na radiální ráz. Je proveden odhad výsledků experimentu. Jsou uvedeny výsledky průmyslové aplikace na dolech na Ukrajině. Jsou navrženy budoucí směry.

Key words: explosive impulse, blast-hole charge, refractor, redistribution, industrial application.

1 INTRODUCTION

The theoretical background of the explosive impulse calculation is done in [1]. One of perspective approaches to the directed destruction of rock blasting is an application of a design of a charge with an air clearance in the ground part of a blast-hole [2]. It promotes a significant decrease in the initial peak pressure and an increase in duration of action of products of a detonation (PD) on walls of a charge chamber. The method of the specific consumption of the explosion decrease offered in [2] provides the use of a water shirt along the length of a charge that promotes an increase of the blast-hole charge activity factor and a decrease of the dust content. The work [3] is devoted to a research of influence of explosive loadings on samples of various geometry because of an extension of an explosion impulse in time. The theoretical calculations of impulses of explosion in the presence of a barrier of a different form, results of laboratory researches are given here.

2 COMPONENTS OF AN IMPULSE OF EXPLOSIVE

According to [1] the value of the impulse, which is active on a lateral surface of a charge at the direct initiation is defined from the expression (1).

$$I = \frac{i_0}{16} \cdot \left[\frac{16 + 23 \cdot \alpha + 8 \cdot \alpha^2 - 15 \cdot \alpha^3}{(1+\alpha)^2} + 3 \cdot (1-\alpha) \cdot \ln \frac{1+\alpha}{1-\alpha} + 3 \cdot \alpha \cdot \ln r \right], \quad (1)$$

$$\alpha = \frac{x}{l}, \quad (2)$$

where r – charge radius, mm; l - charge length, mm; x – intermediate position ranged from 0 up to l.

This expression defines for various values the value of the impulse I: for $\alpha = 0 \quad I = i_0$; for $\alpha = \frac{1}{4} \quad I = 0{,}94 \cdot i_0$; for $\alpha = \frac{1}{2} \quad I = 0{,}8 \cdot i_0$; for $\alpha = \frac{3}{4} \quad I = 0{,}64 \cdot i_0$; for $\alpha = 1 \quad I = 0{,}25 \cdot i_0$.

The value i_0 representing a specific impulse on a face surface of a charge is defined as

$$i_0 = \frac{32}{27} \cdot p_f \cdot \frac{l}{D}, \tag{3}$$

where p_f - pressure at the front of detonation wave, MPa; l - charge length, mm; D – speed of a detonation of explosive, m/s.

The expressions show that any change of an impulse on length of a charge has no linear dependence. The calculations have shown that the ratio of the value of the radial impulse of explosion I_r to the value of the axial one I_a is equal 0,925.

If there is an air clearance in the ground part of a charge , the ratio I_r / I_a decreases and becomes essentially equal 0,34. The application of a refractor in the ground part of charge increases I_r / I_a up to the value 1,12 [4]. In comparison with the previous results the axial impulse decreases 2,37 times, and the value of the radial one - increases 1,39 times.

3 THE LABORATORY EXPERIMENTS WITH A REFRACTOR FOR BLAST-HOLES SETTING DOWN ON A CONTOUR

A construction of a refractor for blast-holes setting down on a contour (CR) is shown on Fig.1. It is intended for preservation of rocks located outside the contour. It is executed in the form of the spatial construction formed by crossing of a lateral surface of the basic cylinder to other (secants). One end turned to the bottom of the blast-hole is flat. The other end turned to the mouth has the form of a segment. The axis of the secant cylinder is perpendicular to the axis of the base cylinder. Tests of the CR are made on a ballistic pendulum (Fig.2).

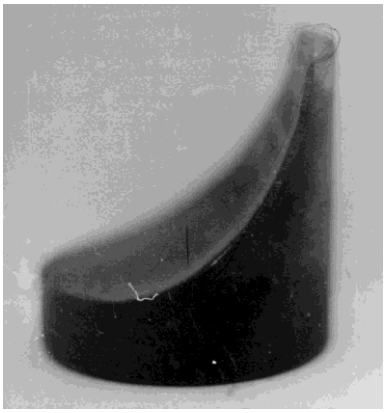

Fig.1 Construction of a refractor for blast-holes setting down on a contour

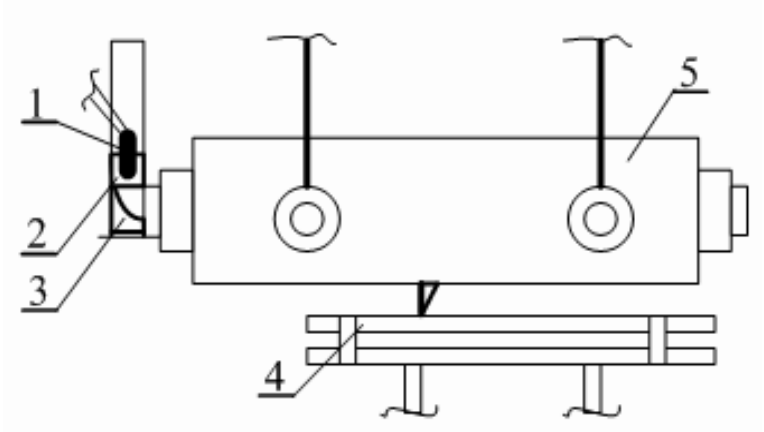

Fig.2 Testing machine: 1 – electric detonator; 2 - cartridge; 3 – refractor; 4 – measure rule; 5 - ballistic pendulum

Experiments were carried out with the use of various explosives. Therefore the correction factor (k_e) to reduce to a standard one (ammonite №6GV) is entered. The values of deviations of the ballistic pendulum were corrected accordingly. In testing the cartridge with a weight of 50 g and a diameter of 40 mm and an electric detonator were applied. The experiments show that the shock wave and products of a detonation flowing round a curvilinear surface of the CR change the direction of movement from axial (along a charge) to radial. It proves the following results to be true (Table 1).

Tab. 1 – Results of the experiments

Angle of CR rotation, degree	Deviation of pendulum, mm	Radial impulse of explosive, N·s	Difference related to the construction without CR		
			mm	N·s	%
0 (by curvilinear part)	48	13,056	+2	+0,544	+4,17
90 (by lateral part)	41	11,152	-5	-1,360	-12,20
180 (by rectilinear part)	38	10,336	-8	-2,176	-21,05
Without CR	46	15.512	0	0	0

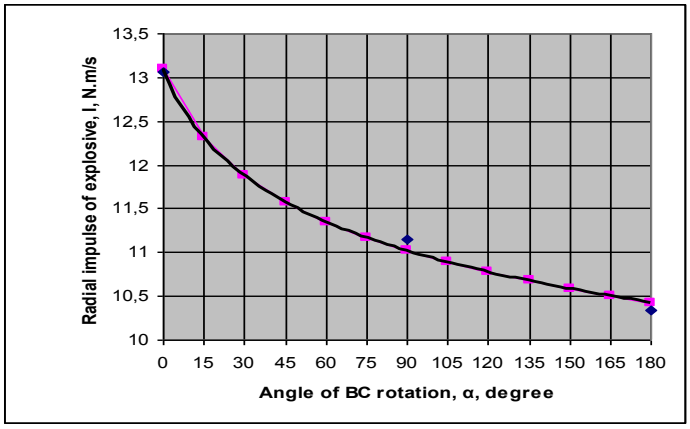

Fig.3. Functional depending of radial impulse of explosive from the angle of CR rotation

The application of CR changed the deviation of the ballistic pendulum as follows. If the CR will turn to the pendulum the curvilinear part deviation - 60 mm; if lateral - 43 mm; if rectilinear – 40 mm. The impulse of explosive is proportional to the deviation of the ballistic pendulum. A graphic interpretation of the dependence of the impulse on the CR rotation angle is a curve represented in Fig.3. It can be defined by the function (4). The analysis shows that the presence of CR exercises a significant effect on the value of the pendulum deviation.

$$I_{rad} = 16{,}649 \cdot (\alpha + 15)^{-0{,}0887}, \quad N \cdot s, \tag{4}$$

where I_{rad} -a radial impulse of explosive, $N \cdot s$;

α – an angle of CR rotation, rad.

4 INDUSTRIAL APPLICATION

On the basis of the theoretical researches and results of the laboratory experiments the “Management of perfection of explosive works when carrying out mountain developments and cutting of interfaces on mines of IC Donetskmine” is developed. It is approved by the Technical Director of the Industrial Corporation. The industrial testing and approbation of inert refractors has been executed on mines "Ilovayska” and "Trudovska" of IC Donetskmine. As the result the blast-hole charge activity factor has raised from 0,77 up to 0,99 (+22%), and the quantity of blast-holes was reduced from 78 up to 66 (-15,4 %) [5].

5 CONCLUSION

As the result of the researches it was established that application of an inert refractor reduces the axial impulse of explosion 1,39 times and increases the radial impulse 1,18 times. A redistribution of PD to the radial

direction provides to extend a spacing interval between the neighboring blast-holes. Thus the most part of energy of explosion can be used to perform a useful work.

FUTURE DIRECTIONS

Directions of the further researches are: to develop the refractors' design for an application in non-uniform rocks: to select materials for their manufacture which are supposed to raise safety of conducting of explosive works; to continue the industrial applications of the refractors.

REFERENCES

[1] Баум Ф.А. и др. *Физика взрыва* / Под. ред. Ф.А. Баума. – 2-е изд., перераб. и доп. – М.: Наука, 1975. – С. 304…316, 329…337.

[2] Герасимов А.В., Кректулева Р.А., Михайлов В.Н**.** *Математическое моделирование воздействия ударных волн на образцы различной геометрии из градиентных материалов.* / VI Забабахинские научные чтения. – Снежинск, 2001. Тез. докл. – С. 90-91.

[3] Лебедев М.А., Лебедев Д.М. *Влияние формы преграды на ее стойкость к действию взрыва* / VII Забабахинские научные чтения. – Снежинск, 2003. Тез. докл. – С. 140-146.

[4] Shkumatov A. *New technical solution in conducting mining excavations* // Transactions of the VSB – Technical Uneversity Ostrava Mining and Geological Series, №1 – 2003. - P. 137-140.

[5] Шкуматов А.Н., Черкасов И.А. *Совершенствование буровзрывных работ на шахтах украинского Донбасса* // Глюкауф на русском языке, № 4, 2008. - С. 25-27.

RESUMÉ

Výsledkem výzkumů bylo zjištění, že použití nehybného refraktoru snižuje axiální ráz exploze 1,39 x a zvyšuje radiální ráz 1,18 x. Přerozdělení produktu exploze radiálním směrem umožňuje zvětšit rozestup mezi sousedícími vývrty pro nálože. Největší část energie exploze se tak může použít na provádění užitečné práce.