

Estimation of Influence of Explosive Characteristics of Emulsion Explosives on Shotpile Width

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Abstract. The article deals with the question of the effect of explosive characteristics of emulsion explosives on the shotpile width. Currently, there are two main points of view to select an efficient type of explosive, which contributes to the qualitative destruction (fragmentation) of coarse clastic rocks. The first is based on the assumption that the detonation velocity of explosives must correspond to the break-down point of the rock (dynamic compression). Another point of view is that the detonation pressure of explosives determines only the head part of the pulse, on which the rock fragmentation is dependent only near the charge, in the contact zone around the borehole. The fragmentation of the entire rock volume within a given borehole array depends on the total magnitude of the explosion pulse, determined not by the detonation velocity, but by the total energy reserve of the explosive charge. Experimental explosions with some of the most common industrial explosives have been carried out in the current conditions of blasting of borehole charges by various types of industrial explosives from the point of view to select the most important parameter, which determines its influence on the shotpile width. The investigations have been carried out according to the data obtained to establish that the energy properties of explosives (heat of explosive transformation and density of explosives) determine the decisive influence on the shotpile width, and the operability, the volume of the released gases, the detonation velocity for the change in the shotpile width have very little effect and may not be taken into account in calculations for the prediction of the shotpile.

1 Introduction

Explosives used for the destruction of rocks are, for the most part, a mixture of two or more components. One of the directions is the influence of explosive characteristics on the shotpile width and the definition of the most important of them, which are necessary for an efficient explosion [1, 2].

Explosive destruction of rocks is a very complicated phenomenon. One of the main tasks of breaking rocks is the separation of the rock from the rock mass with its simultaneous crushing into pieces of a certain size and a compact arrangement of them on

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the bottom of the ledge. The effect of the explosion in the medium and the intensity of crushing of rocks depend on many factors that characterize both the properties of the medium and the properties of explosives, as well as the conditions of explosion, in particular, the parameters of borehole breakdown. The selection of the type of explosives and the prediction of the optimal parameters of drilling and blasting operations on a particular physical model of the action of the explosion of a borehole charge. Such models are built on the basis of general laws of continuum mechanics taking into account experimental data. The medium is usually characterized as isotropic with physicommechanical properties averaged over the whole volume [3, 4].

2 Theory

Currently, there are two main points of view to select an efficient type of explosive, which contributes to the qualitative destruction (fragmentation) of coarse clastic rocks. The first is based on the assumption that the detonation velocity of explosives must correspond to the break-down point of the rock (dynamic compression). The criterion for this indicator is the ratio of the impedances of explosives and rocks, which should be as close as possible to unity. Another point of view is that the detonation pressure of explosives determines only the head part of the pulse, on which the rock fragmentation is dependent only near the charge, in the contact zone around the borehole. The fragmentation of the entire rock volume within a given borehole array depends on the total magnitude of the explosion pulse, determined not by the detonation velocity, but by the total energy reserve of the explosive charge. In the matter of the effect of explosive characteristics of explosives on the shotpile width there are many more different opinions [4, 5].

Experimental explosions with some of the most common industrial explosives have been carried out in the present conditions of blasting of borehole charges by various types of industrial explosives from the point of view to select the most important parameter, which determines its influence on the shotpile width (Table 1). Of course, all the above explosive characteristics of explosives are interrelated and a decrease or increase in one of them can lead to a change in the other. However, under the standard conditions of charge explosion, which are sought to be as close as possible in the production conditions of explosion, the characteristics of explosives [4] are practically constant values, usually determined by reference books or technical specifications [5-7].

The accuracy of the experimental determination of the heat of explosion depends on the conditions of the explosion (the diameter of the charge, the material and the thickness of the shell), the dispersity of the components and the uniformity of their mixing, the density of explosives and many other factors.

Table 1. Explosive characteristics of some of the most common industrial explosives

Name of explosive	Heat of explosion, J	Density of explosive, g/cm ³	Working capacity, cm ³	Detonation velocity, km/s	Volume of gases, l/kg	Volumetric energy of explosive, kJ
Granulotol	4100	0.95-1.0	290	5.5-6.5	1945	3895
Grammonit 79/21	4300	0.9-0.95	360	3.5-4.2	850	4085
Ammonite 6ZhV	4300	0.9-0.95	360-380	3.6-4.8	895	4085
Igdanit 94/6	3300	0.8-0.85	320-330	2.2-2.7	990	3230
Iphzanite T-20	3300	1.34-1.38	290	4.2-4.5	937	4488
Poramit	3200	1.25-1.35	300-310	4.5-5.0	890	4160

3 Results

Below are the results of an experimental determination of the heat of explosion (relative operability) of some industrial explosives (Table 2).

Table 1. Experimental and calculated values of the heat of explosion for various explosives

Explosive	Oxygen balance, %	Heat of explosion, kcal/kg			Density g/cm ³
		Q _{max}	Q _v	Q _{ex}	
TNT	-74	1300	985-1000	850	0.85
«-»	-74	1300	985-1000	1000-1160	1.5-1.6
Hexogen	-22	1510	1240-1330	1270-1325	1.5-1.6
Ten	-10	1550	1405	1400	1.5-1.6
TNT/hexogen (50/50)	-48	1405	1146	1140	1.5-1.6
Granulotol	-74	1300	975	870	1
Alumotol	-76.2	1831	1260	1130	1.1
Zernogranulite 30/70	-45.9	1200	950	870	1-1.1
Zernogranulite 50/50	-27.5	1120	985	910	0.9-1
Zernogranulite 79/21	0	1030	1030	967	0.9-1
Granulite AC-8	+0.3	1242	1242	1260	0.9-1
Granulite AC-4	+0.4	1080	1080	1128	0.9-1
Granulite M	+0.1	920	920	904	0.9-1
Aquatol 65/35	-12.5	837	767	707	1.45
Aquatol M-15	-21	1366	1167	1107	1.4

Thus, on the basis of the studies carried out, it is possible to draw conclusions that are very important for practical application:

- the energy properties of explosives (the heat of explosive transformation and the density of explosives) are critical for the shotpile width;
- the operability, the volume of released gases, the detonation velocity for the change in the shotpile width have a very small effect and can not be taken into account in calculations for the prediction of the shotpile.

The design characteristics of explosives in boreholes for carrying out experimental explosions at the open-pit mines of the Pervouralskoe Mine Administration are given in Table 3.

Table 3. Results of statistical comparison of measurement data for the shotpile width with basic characteristics of explosives

Comparable values	Number of measurements	Average value of compared values	Dispersion	Calculated value of coefficient T_{0n}	Tabular value $T_{0*0.5; n+m-2}$	Conclusion
Working capacity, cm ³	7	303	100.4	10.89	2.18	Significant difference
	7	311	53.2			
Detonation velocity, m/s	7	5132	988	10.13	2.18	Significant difference
	7	3663	4015			
Volume of gases, l/kg	7	1743	3726	10.37	2.18	Significant difference
	7	940	1868			
Heat of explosion, J	7	4136	851	10.92	2.18	Significant difference
	7	4284	435			
Load density of explosive, g/cm ³	7	0.966	0.00004	8.25	2.18	Significant difference
	7	0.935	0.00005			
Volumetric energy of explosive, J/kg	7	3998	72	0.76	2.18	Significant difference
	7	4002	1156			
Shotpile width, m	7	21.7	4.23	0.71	2.18	Significant difference
	7	22.6	4.49			

The values of the explosive characteristics of the emulsion explosives in the boreholes and the measurements of the shotpile width were compared among themselves in pairs by the Student-Gorset criterion. Calculation of the Student-Gorset design criteria was performed by comparing them with a tabular account of the significance level $t(\alpha)$ 0.05 and the degree of freedom $n_1+n_2 = 2$ [8, 9].

4 Conclusions

The obtained experimental parameters allow to establish the compliance of explosives with quality control standards, technical conditions and optimize rational parameters of drilling and blasting operations.

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