Experimental Study on the Performance of on-site Mixed Emulsion Explosives and Rock Impedance Matching

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ABSTRACT

The proportion of on-site mixed emulsion explosives in mining is getting higher and higher, in order to better use the explosive performance of mixed explosives to improve energy utilization. Based on the wave impedance theory, the wave impedance of mixed explosives is changed to make rocks The wave impedances are matched to achieve the purpose of improving the blasting effect and reducing the bulk rate. After field test, increasing the sensitizer content within a certain range is beneficial to the improvement of explosive performance. When the explosive sensitizer content is 1.15%, the best matching coefficient of mixed explosive and rock impedance is 2.51, the rock after blasting is large. The block rate is reduced and the rock crushing effect is better. After this matching test, it is shown that it is feasible to improve the blasting performance by adjusting the explosive performance of the explosive by the optimal wave impedance coefficient according to the hardness of the rock, which can provide reference for the peers.

Keywords: Impedance matching coefficient; Explosive performance; Blasting effect

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At present, although mechanical excavation is widely used, rock excavation by blasting still accounts for a large proportion of rock stripping. With the deepening of research on blasting theory and blasting equipment, more and more researchers understand There is a certain numerical relationship between explosive performance and rock blasting effect.

Wang Yongqing [1-3] and others believe that the quality of rock blasting is related to the energy density of explosives and the strength of the rock mass.

Establish the relationship between the energy density of the emulsified explosive and the blasting effect, and conclude that the explosive energy density and the blasting effect are not simple linear relationships. The blasting effect of the explosive with large energy density is not necessarily good, and the energy density of the explosive should match the strength of the rock mass. Li Xibing et al. [4-6] set the energy coefficient of the explosive propagating in the rock as the maximum target value, and established a comprehensive model that can reflect the interaction between the detonation of the explosive roll and the wall of the blast hole, which was determined through theoretical analysis. The optimal matching relationship between rock and explosive performance under certain conditions was established. Lai Yingde [7-8] et al. Based on the traditional impedance matching and studied the impedance and energy matching of explosives and rocks to find that the impedance of explosives is equal to The blasting effect is best when it is approximately equal to the wave impedance of the rock, and it is pointed out that the rock breaking effect can be improved by appropriately increasing or decreasing the charge. Zhang Qi [8-9] et al. The matching of the shock wave impedance of the explosive and the rock can be used as an approximate reference for the relationship between the energy of the rock and the explosive. Guidelines with relative energy relationships.

Engineering practice shows that for hard rocks with high rock strength and high wave impedance, explosive materials with higher detonation speed can be used to improve the blasting effect; for rocks with medium impedance, relatively low explosive speed can be used. For low-resistance soft rocks, because the joints between the rocks are well developed and the throwing capacity of the explosive is required, it can be used as an explosive with a large functional capacity and explosive capacity [9-10].

In recent years, with the improvement of safety technology and safety management level, on-site mixed emulsion explosives have been promoted and applied in more and more mine blasting projects. 22.45% of the "13th Five-Year" Development Plan for Civil Explosives Industry.

It is pointed out that in order to further optimize the product structure of the civilian explosive industry, the proportion of field explosives in industrial explosives exceeded 30% (from 2010 to 2015, the proportion of field explosives in industrial explosives increased from 14.82% to 22.45 % in 2015), So it is important to carry out research on the performance of field mixed emulsion explosives and rock compatibility.

1. Project Overview

Xinjiang Beskuduk Open-pit Coal Mine is located in Dahongliuxia Township, Balikun County, Hami District, a short distance from Urumqi.

About 560km, 150km away from Balikun County, it is one of the two open-pit mines in Xinjiang owned by Hami City and Xiang Industry and Trade Company of China Coal Energy. This area is located at the junction of Mount Kexelk and Zhifang Basin, and the overall terrain trend It is high in the north and low in the south, and high in the west and low in the east. The

landform is a mound-like denuded plain with an altitude of 1269m ~ 1339m and a height of 70m from east to west. The ore-bearing rocks in the mine mainly include granite and phyllite, which have a block structure and fine mineral particles Divided into three grades according to the blast ability of ore rocks: Grade Ⅰ, Platts coefficient f = 10-12, compact, hard, and difficult to blast: Grade Ⅱ, phyllite with higher pyrite content and weaker alteration, f = 6-8, hard and brittle,

medium blasting; class III, altered or weaker phyllite, the joints are developed, and it is easier to blast. The calculated statistical wave impedance of the rock is 110-130MPa / s. The explosive wave impedance is 45-49MPa / s.

1.1 Research on Rock Impedance Matching

In order to study the performance of mixed emulsion explosives and the impedance of rocks, the research based on impedance theory is based on:

$$p_1 c_1 = p_2 c_2 \qquad (1)$$

Where: p_1-rock density; p_2-explosive density; c_1-rock longitudinal wave velocity; c_2-explosive longitudinal wave velocity.

It can be known from formula (1) that to increase the explosive impedance of explosives, we can start from the two aspects of increasing the energy density and detonation speed of explosives, but these two have limit values and cannot be blindly increased. Therefore, in engineering blasting, the explosive and It is difficult to achieve equal resistance of rocks, and the best

proportion coefficient can only be obtained through relevant experiments to meet the maximum economic and blasting effects. In order to reduce the bulk rate during the blasting of class Ⅰ rocks, according to the principle of impedance matching Firstly, the density and P-wave velocity of this type of ore are counted, and then the volume method and block rate are used. In the statistical time domain, the block rate of the mine is calculated by formula (2):

$$D = (\sum_{i=1}^{n} \frac{N_i V_i}{Q_i}) \times 100\% \qquad （2）$$

In the formula: D-large block rate; N_i-large block volume that needs to be blasted after the i-th initiation; V_i-average volume of large rocks in the i-th blast, m^3; n-the number of blasts in the statisi-

tical area. According to the similarity of block size, the block distribution diameters k_{40} and k_{70} after rock blasting can be calculated by the following formula:

$$K_{40} = X_j (\frac{1}{2})^{\frac{1}{3-a}} \qquad (3)$$

$$K_{70} = X_j (\frac{4}{5})^{\frac{1}{3-a}} \qquad (4)$$

Where: x_j-the maximum diameter of rock blasting block;

α-block population dimension

1.2 Mixing explosive formula and impedance matching test

According to the actual production of other min-

es, the mixed-pack emulsification production uses Jinneng technology mixed-car technology. The mixed-car model is bchrx, and the production line capacity is 6000 tons / year. The bchrx-type mixed car can achieve the on-board milk production function, that is, The raw materials

are prepared on the car and milked, sensitized, and transferred to the construction site. The process parameters of mixed explosives are:

Oil phase parameters: composite emulsifier (polymer, s-80 and other mixed products), 25% in oil phase, 2.2% in latex explosives, diesel oil: emulsifier = 3: 1: 1 or 2: 2: 1

Water phase parameters: water: ammonium nitrate (particles) = 12:88, crystallization point: 68 °C water phase: oil phase ratio = 94: 6, catalyst: aqueous nitric acid solution, sensitizer: aqueous sodium nitrite solution.

Song Jinquan [9] and other researchers found that the explosive density increased within a certain range with the increase of explosive density and reached a certain value. After reaching a certain value, the detonation speed decreased with the increase of the density and even refused to detonate. Hu Chaohai [11] etc.

After research on the impact of explosives, it was found that when sodium nitrite was used as a sensitizer, the performance of the sensitized explosive was better than that of glass microspheres and expanded perlite as sensitizers. Zhang Hu [11] et al. When the powder content is related to the performance of explosives, it is proposed that the detonation speed of aluminum-containing emulsified explosives decreases with the increase of aluminum powder content.

In this test, the content of the sensitizer (aqueous sodium nitrite solution) was changed by equal increments without changing the corresponding proportion of the original composite oil phase and the ammonium nitrate aqueous solution. A total of eight groups of tests were performed. As shown in Table:

Table 1 Effect of different sensitizer contents on the performance of explosives

Sequence number	Sensitizer content (%)	Explosive density (g / cm^3)	Explosive velocity (m / s)	Wave impedance （MPa/s）
1	0.70	1.18	Refusal	-
2	0.80	1.17	Half burst	-
3	0.90	1.16	4200	45.92
4	1.00	1.13	4300	46.07
5	1.10	1.12	4200	46.78
6	1.15	1.08	4300	46.89
7	1.20	1.06	4100	44.30
8	1.25	1.04	4200	46.72

It can be seen from Table 1 that when the sensitizer content is less than 0.9%, explosives are prone to explode and affect product performance,

So the sensitizer content must be strictly controlled during the test.

2. Research on Explosive Performance and Rock Impedance Matching

Based on the above theories 1.1 and 1.2, combined with the actual situation of mixed explosives at the mine site, six sets of wave impedance matching tests were carried out for explosives with different densities and rock matching. The test results are shown in Tables 2 and 3

Table 2 Explosive performance and rock matching test

Sequence number	Rock density （g/cm³）	Explosive density (g / cm³)	P-wave velocity （m/s）	Wave impedance （MPa/s）	Matching coefficient (k)
1	2.64	1.16	4450	118.92	2.52
2	2.63	1.13	4500	119.95	2.51
3	2.65	1.12	4400	116.50	2.49
4	2.65	1.08	4650	124.22	2.60
5	2.64	1.06	4600	121.20	2.63
6	2.67	1.04	4700	125.80	2.67

Table 3 Rock blockiness and correlation coefficient

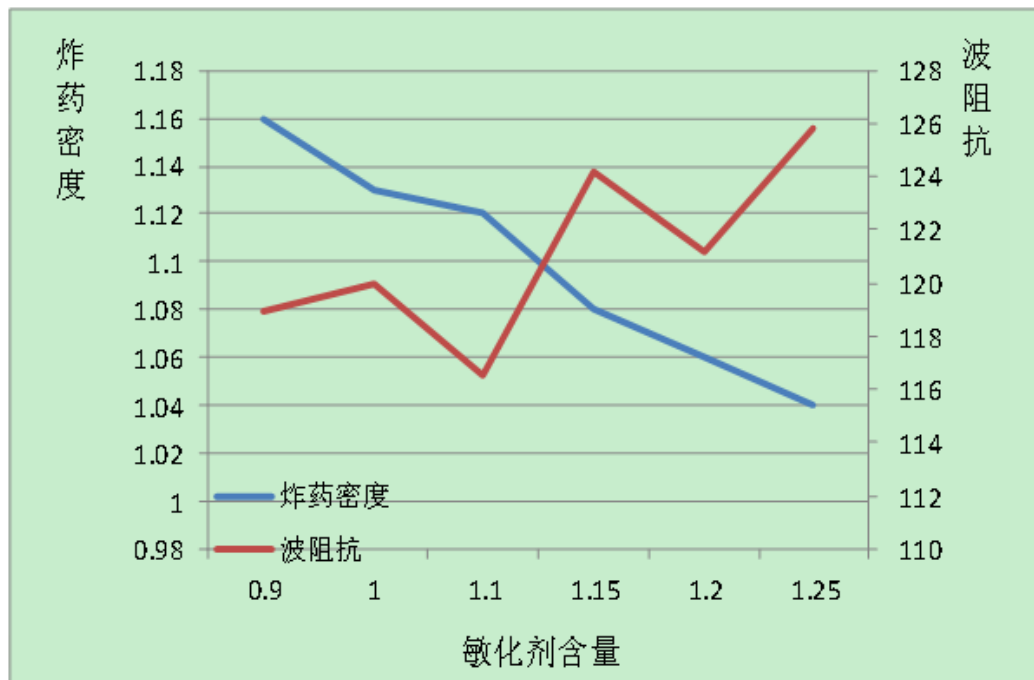| Sequence number	Block size （X_i/mm）	K_{40} mm	K_{70}	Bulk rate （%）	Correlation coefficient （R）	broken effect
1	130.82	79.34	111.38	7.58	0.95	in
2	115.83	58.22	92.82	0.00	0.96	excellent
3	138.88	84.02	118.03	18.14	0.92	difference
4	127.52	74.78	107.37	17.59	0.93	in
5	133.05	75.86	111.04	11.98	0.94	in
6	135.62	83.37	115.09	16.00	0.93	difference

Figure 1 Relationship between explosive density and wave impedance

Description: the abscissa represents the sensitizer content, the ordinate (left) represents the explosive density, and the ordinate (right) represents the wave impedance

3. Results analysis

It can be seen from Tables 2 and 3 that the second group of tests has the best crushing effect when the matching coefficient reaches 2.51. The large block rate after the explosion is 0, and the maximum block size of the rock is only 115.83mm. The fitted curve The correlation coefficient reach- ed 0.96, indicating that the rock block distribution is more uniform.

From the relationship curve drawn in Figure 1, it is known that the block rate after blasting decreases first and then increases with the increase of the matching coefficient.

This shows that the bulk rate of rocks does not have a simple linear relationship with the matching coefficient. For hard rocks, it is not possible to blindly pursue the equal or approximate wave impedance of explosives and rocks, but to obtain the most through relevant experiments based on the characteristics of rocks and explosives. Best matching coefficient.

It can be known from Figure 1 that the explosive density has a non-linear relationship with the increase of the sensitizer content, and the change trend of the wave impedance value and the density is basically the same. Only through the corresponding experiments can the optimal value range that meets the actual needs be obtained.

4. Conclusion

Based on the theory that the impedance of the explosive wave and the impedance of the rock are as close as possible, the sensitization parameters of the field mixed explosive are adjusted through the impedance matching test between the rock and the explosive, combined with the actual situation, and the following conclusions are drawn:

(1) Based on the matching theory of explosive wave impedance and rock wave impedance, the process parameters that affect the performance of the explosive are adjusted to match the rock as much as possible. This method is convenient to carry out, and the performance parameters of the explosive are easy to obtain. Quick judgment of the value;

(2) Determine the appropriate explosive resistance and rock resistance ratio coefficient can improve the blasting effect of the rock;

(3) The test procedure is simple and easy to operate. The process parameters that affect the performance of explosives can be carried out in the laboratory, and after a reasonable range is determined, verification is performed on the mine, thereby improving the test efficiency and reducing production costs;

(4) It is known from the impedance matching test that when the explosive impedance of the explosive is 46.89, the rock breaking effect is the best. From the relationship curve in Figure 1, it can be known that the sensitizer content should be 1.13%. After the blasting test, the rock mass was relatively uniform after the blasting, and the large block rate was below 4.5%, which greatly reduced the secondary crushing and excavation costs and improved the efficiency of mechanical excavation.

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