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USE OF BULK EMULSION EXPLOSIVE TO IMPROVE BLAST AND PRODUCTION PERFORMANCE AT JINGDUICHENG OPEN PIT

Introduction. At mid-1980s, many large and middle open pits in China began to equip bulk emulsion explosive trucks, and progressively realized site manufacturing and mechanical charging of mining explosives, which, to a great extent, increased the blast and mining production efficiency, and promoted Chinese mining blast technical progress. The site manufacturing and charging technology for bulk emulsion explosives may considerably simplify components and preparation process of mining explosives, realize mechanization of explosive preparation and charging blast hole, improve safety during manufacturing, transportation and handling of explosives.

When a mine uses bulk emulsion explosives at the first time, to achieve better results, it is very important to make site optimum trials refer to the original blast hole parameters and its process. This paper introduces the whole process and some results that Jingduicheng open pit uses TM bulk emulsion explosive and site manufacturing technology to improve blast and production efficiency.

Technical backgroung. Jingduicheng open pit is the largest open molybdenum mine in China, located at eastern Qingling Mountain (about 100 km east to the Xi'an city). Before 1995, this mine had been used Cartridge emulsion explosives purchased from a commercial explosive plant. The blast hole was loaded by blasters, charging efficiency is very low, blast performance is poor, and blast expense is high. At the end of 1995, this mine bought BCRH-15 explosive truck and a fixed station for preparation of water phase and oil phase solutions. But during practical application, there appeared some technical problems as following: due to poor stability and explosion properties of 1116 bulk emulsion explosive manufactured by the truck, in mining production, one or more blast holes, even the whole blast area failed to detonate, which resulted in re-drill and re-blast operation.

After use of 1116 bulk emulsion explosive in this mine, the parameters of blast hole layout was not adjusted and optimized. Therefore, powder factor for 1116 bulk emulsion explosive was once much higher than that of original cartridge emulsion explosives. In order to solve problems mentioned above, the mine decided to carry out a site trial program, develop a new bulk emulsion explosive and optimize parameters of blast hole layout, so as to increase blast and production efficiency.

TM bulk emulsion explosives. The 1116 bulk emulsion explosive manufactured by BCRH-15 explosive truck has some technical weakness, as following: emulsion matrix wasn't stable, the change of environment temperature often resulted in matrix failure. Since low strength of oil film in matrix, the sensitive gas bubbles go together and release from matrix, explosive density of each batch is quite different. The VOD of 1116 bulk emulsion explosive was very low, only 2.6~3.0 km/s (measure conditions: PVC pipe in diameter 100 mm, explosive density 1.15~1.20 g·cm^{-3}).

In accordance with technical problems of 1116 bulk emulsion explosive, adjusted the oil phase materials and increased its strength, we successfully developed new TM bulk emulsion explosives. The emulsion matrix of TM explosives has characteristics with low viscosity at high temperature and high viscosity at low temperature. But for emulsion matrix of 1116 explosive, relative viscosity was almost same at different temperatures. The relative viscosity values versus temperature for two emulsion matrixes are listed in table 1.

The feature of low viscosity at high temperature for TM emulsion matrix enables it met technical requirement of BCRH-15 explosive truck in pumping measure and charging bore hole. At the same time, its feature of high viscosity at low temperature ensures that emulsion matrix pumped into blast hole maintains higher oil film strength during the temperature drop, so prevent emulsion matrix from failure. The sensitive gas balloons can not easily go together and release from matrix. The quality and explosion properties of TM bulk emulsion explosives are very well.

Table 1 relative viscosity of 1116 and TM emulsion matrixes

Emulsion matrix	Temperature, °C	Relative viscosity p_a.s
1116	30	13,6
	56	11,5
	66	12,4
TM	32	32,4
	53	17,8
	60	17,5

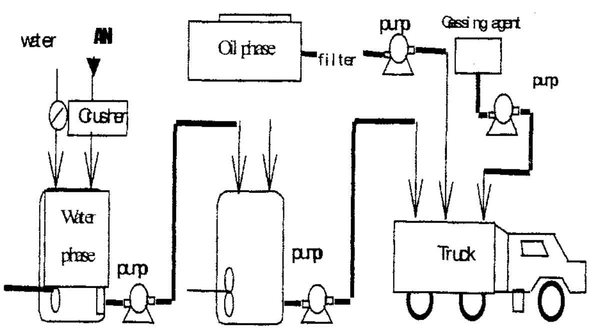

Fig.1. Preparation flow sheet of TM bulk emulsion explosives

The manufacturing process of TM bulk emulsion explosives consists of oil phase/water phase preparation at fixed station, and manufacturing emulsion matrix and charging it into blast holes at site. The preparation of water phase, oil phase and chemical gassing agents are finished at fixed station, then correspondingly pumped into their storage cells in explosive truck. The truck with these explosive raw materials drives to blast site, and manufactures emulsion matrix. Then matrix added chemical gassing agent is sensitized and pumped into blast holes according to blast designs.

The maximum manufacturing and charging capacity for BCRH-15 explosive truck is 11.5 tons, charging efficiency 220~280 kg·min^{-1}. The production flow sheet of TM bulk emulsion explosives is illustrated in fig.1. Their Emulsion matrixes are yellow brownish gels, to be sensitized to make them become explosives. TM bulk emulsion explosives are no detonator sensitiveness, their density usually 1.1~1.2 g·cm^{-3}, and the main technical indexes are listed in table 2.

Table 2 main technical indexes for TM explosives

Type of explosive	TM-1	TM-2
Density, g·cm^{-3}	1,10 ~ 1,15	1,10 ~ 1,20
VOD(original), m·s^{-1}	45(1)	5070
VOD(storage), m·s^{-1}	5181/15(2), 4778/30	4950/7, 4819/14, 4872/29
Detonation length, m	> 4	> 4

Note: (1) measure condition: packing by hard PVB pipe, diameter 100 mm;
(2) VOD/days after manufacturing

Optimum trials on blast holes layout. Jingduicheng molybdenum ore body is enclosed by granite porphyry and andesite porphyrite, covered by alluvium and mantlerock. The main mineral rocks include, andesite porphyrite, granite porphyry, quartsize and slate. There exists transition zone between the ore and waste without interface.

The total annual excavate ore and waste are 17~22 millions tons. Blasted ore and rock are classified into three types, i.e. hard, middle hard and soft rocks. Mining bench is 12 m high. Diameter of blast hole is 250 mm. The mining equipment includes YZ-35 geared drill and 195B shovels.

At the initial stage that site manufacturing and charging truck for 1116 bulk emulsion explosive was applied to Jingduicheng open pit, since quality of explosive was not stable, powder factor was high to 0.30 kg/t, blast vibration was enlarged. In order to take full advantage of new site manufacturing and loading technology and decrease operation expense in drill, blast and shovel operation, it is necessary to do site optimum trials on blast hole layout.

As shown in table 2, VOD of TM emulsion explosives is much higher than that of cartridge and 1116 emulsion explosives. In addition, bulk emulsion explosive makes it possible to fill blast hole fully, the explosive charged per blast hole increases. With original blast hole layout, there would be excessive explosive energy in each hole, which often results in negative blast effect, such as excessive fly rock and blast vibration.

To ensure better blast performance and lower overall expense in drill, blast and shovel operations, optimum trials were done through enlarge space and burden of blast hole. At first, an optimum powder factor was assigned for each of three typical blasted ores and rocks respectively by means of engineering comparative method. Then their blast hole layouts were adjusted according to the results of blast tests, so the optimum blast hole layouts (space and burden) could be finally obtained. The reasonable powder factor is 0.12~0.14 kg/t for soft rock, 0.14~0.16 kg/t for middle hard rock and 0.16~0.18 kg/t for hard rock. The optimum test results on blast hole layout are given in table 3. For all three typical ores (or rocks), blasted ore area per hole increased in a different extent. For hard rock, the average value raises approximately 50 %, and size distribution of blasted fragment and profile of muck pile were very well.

Table 3 optimum trial results of blast hole layout

Type of ore	Blasted area per hole, m^2		Raise, %
	Before trial	After trial	
Hard	30 ~ 42	50 ~ 60	42,9 ~ 66,7
Middle hard	40 ~ 60	60 ~ 80	33,3 ~ 50
Soft	60 ~ 70	80 ~ 90	28,6 ~ 33,3

At Jingduicheng open pit, initiating system used in blast operation is consisted of NONEL signal tube in hole and detonating code on ground. The reasonable delay interval determined through tests is 50 ms. The measure and analyze data indicated that with this delay interval, blast performance was very well, blast vibration obviously decreased.

Improve blast and production efficincy. By combining site manufacturing and charging bulk emulsion explosive technology with optimum blast trials, the efficiency in drill, blast and shave raised in large scale. Jingduicheng open pit has obtained excellent technical and economic benefits. Before 1995, this mine used cartridge emulsion explosive in excavate blast operation, the average powder factor was 0.135 kg/t, and average blast ore amount per meter hole about 160 t/m. In 1996, the site manufacturing and charging truck with 1116 emulsion explosive was introduced into production blast operation. During initial application stage, due to unstable quality of 1116 emulsion explosive, there are sometimes one or more blast holes unfired, which resulted in re-drill and re-blast operation. Overall average powder factor was therefore high to 0.30 kg/t. Drill amount accordingly increased, the blast ore amount per meter hole decreased to 125 t/m. After June in this year, the explosive truck began to manufacture new TM emulsion explosives. The stability and explosion properties were considerably improved. So, the overall average powder factor of production blast came down to 0.17~0.19 kg/t, and the average blast ore amount per meter hole increased to about 180 t/m.

The optimum trials on blast hole layout also produced positive affect on drill and shave operation. As we know, the technical and economic factors such as blast amount per meter hole, consumption of the quick wearing parts in shaver, etc, in a certain extent, can reflected blast technology and rock fragmentation effect. At Jingduicheng open pit, the statistic data from practical production shown that site manufacturing and charging technology with TM bulk emulsion explosive considerably improved blast and production efficiency. Table 4 comparatively lists the comprehensive technical and economic results in drill, blast and shave with TM, 1116 and cartridge emulsion explosives. Compared TM explosive with 1116 explosive, the drill amount per ten thousands tons ore, shave expense per ton ore and powder factor decreases respectively 28.0 %, 16.3 % and 22.7 %.

Compared TM explosive with cartridge explosive, except for powder factor, the other two indexes decreased 6.4 % and 24.6 % respectively. Although the powder factor of TM bulk emulsion explosive is higher than that of original cartridge explosive, due to the fact that the cost of TM explosive is approximately 74 % lower than that of cartridge explosive, total explosive expense per ton ore still comes down. In addition, it could also save other expenses associated with blast operation, such as ones in parking materials, transportation and storage of explosive, etc.

Table 4 technical and economic results in drill, blast and shave with three explosives

Type of explosive	Aver. Powder factor kg/t	Drill, m/10^4t	Shave, yuan/t
TM	0,170	58,5	0,118
1116	0,220	81,2	0,141
Cartridge	0,135	62,5	0,156

With site manufacturing and charging TM bulk emulsion explosive technology, Jingduicheng open pit achieved remarkable allover economic benefit. The results from financial reports are listed in table 5. With TM bulk emulsion explosive, this mine annually saved over 3 millions yuans.

Table 5 economic benefits for three explosives

Type of explosive	Drill	Blast	Shave	Total
TM	0	0	0	0
1116	97	156	64	312
Cartridge	17	265	39	318

Conclusion. To increase mining industry's technical and economic benefits, we always develop, select and use advanced technology and equipment. In China, the bulk emulsion explosives and site manufacturing (and charging blast hole) technology has been successfully used in many large and middle open pits. This new mining explosive technology could not only improve mining production efficiency, but also change the traditional idea of mining explosives and safety management way during transportation, storage and handling of explosives. It would considerably eliminate explosion danger of mining explosives. Blasters could do their job in safer environment conditions.