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Technical Note

Controlling Backbreak and Improving Technical and Economic Parameters in Mishdovan Iron Ore Mine

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Abstract: One of the major problems related to blasting operations in open-pit mines is the formation of cracks on the benches behind the last row of blast holes or back breakes. Power Deck blasting has been introduced as a new and alternative method for conventional blasting, which improves blasting results by explosive energy utilization enhancement. In this technique, there is an air deck at the end of the blasting hole which decreases or eliminates sub-drilling. Power Deck blasting reduces charge per delay in the same conditions as conventional blasting and charge per delay is one of the most effective parameters of back break. In this study, back break caused by conventional and Power Deck blasting was evaluated in the Mishdovan iron ore mine. Back break in Power Deck blasting was reduced by 16.4% and 55% in iron ore and stone waste respectively as compared to back break in conventional blasting. Power Deck blasting could therefore be effectively used as a controlled blasting technique to obtain stable faces. Also after loading and hauling the fragment size, it was found that both methods have no significant differences in flat floors. Eventually, the Power Deck method reduced powder factor and specific drilling by 28.5% and 9%, respectively. In addition, holes productivity improved by 9% in Power Deck blasting compared to conventional blasting.

Keywords: Blasting, Back break, Power Deck, Mishdovan iron ore mine.

INTRODUCTION

In blasting operation, less than 20 percent of the produced energy is utilized to fragment and displace the rock mass. The rest of this energy is wasted to produce undesirable environmental impacts such as ground vibration, fly rock, and back break [1]. Back break is defined as the limit of damaged rocks beyond the last row of production holes [2]. If the back break is not controlled, a decrease in the overall pit-slope angle would be necessary which in turn causes an increase in stripping ratio [3]. The results of previous studies show that the higher amount of charging in blast-hole, creates more stress and increases damage zone around it, and finally leads to increasing back break caused by blasting operation [4,5]. Several factors leading to back break have been described by various researchers. Hustrulid and Lu (2002), proposed controlled blasting methods to reduce back break and damage [6]. Esmaeili et al. (2014), indicated that the last row's charge, number of rows, powder factor, and stemming length had the most effect and stiffness ratio (H/B), spacing to burden ratio (S/B), and rock density were less important [7]. Charge configurations play an important role in achieving required blasting performance. When a conventional explosive charge was fired, the rock in the vicinity of the blast hole was broken too finely. This nearby region tends to absorb much of the explosive energy. To reduce this great energy loss, Melnikov proposed a method to redistribute the explosive energy and reduce the initial pressure in detonation [8,9]. In an open-pit coal mine, Jhanwar and Jethwa use air deck, which was very useful in diminishing the back break [10].

AIR DECK (POWER-DECK) BLASTING

Mechanism of Air Deck

In brief, the basic roles of the Air Deck charge are: (1) to reduce the amplitude of the initial shock waves propagating into the rock surrounding the borehole (2) and to increase the total length of shock wave or stress wave traveling in the rock. The reason for the first role is that, when a charge contains an air gap, the products of the explosion can generate a lower pressure wave in the medium, since they can expand into the air gap. The reason for the second one is that one or multiple wave collisions can occur within a blast hole due to the existence of the air gap. The wave collisions can increase the total length of the stress wave caused by blasting [8,9].

Parameters of Air Deck charge

To use the Air Deck method, the most important parameter is Air Deck's length ratio. This ratio is equal to the length of Air Deck (L_a), divided by the total length of charge (L_e) and length of Air Deck.

$$R_a = \frac{L_a}{L_a + L_e} \tag{1}$$

Melnikov et al. Used empirical data to indicate that the Air Deck's length ratio should be defined between 0.15 and 0.35 [11].

Power Deck blasting

This technique uses a uniquely designed borehole plug, with a bottom hole air deck and a predetermined stemming mass on top of the plug. This combination is referred to as the Power Deck (Figure 1). This method can eliminate subgrade drilling, reduce ground vibration, improve fragmentation, and reduce explosive consumption. Power Deck blasting did not provide the optimum air deck's length ratio [12].

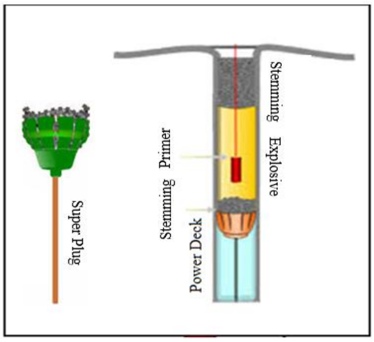

Figure 1. Sketch of Power Deck charging

CASE STUDY

Mishdovan iron ore mine is located 30 km north of Bafgh city in Yazd province. The ANFO is often used as the main explosive in blast holes. In this study, to investigate the back break caused by conventional and Power Deck blasting, two blasts (a conventional and a Power Deck) in iron ore and two combined blasts (conventional-power deck) in waste were fired. Finally, technical and economical parameters related to the two methods were calculated and compared with each other. Table 1 depicts the pattern parameters of blasting and mechanical properties of the rock mass. To carry out Power Deck blasting in the Mishdovan iron ore mine, sub drilling was completely removed. Then air gap was placed at the bottom of the borehole and the Length of the power deck was considered 0.5m (Air Deck's length ratio is 0.166).

Table 1. Pattern parameters of blasting and mechanical properties of rock mass

parameter	Diameter (mm)	Burden (m)	Spacing (m)	Bench height (m)	Sub drilling (m)	Stemming (m)	Compressive strength (MPa)	Tensile strength (MPa)	Density (Kg/m^3)
Iron ore	76	2.3	2.7	5	0.5	2	154.6	7.6	4.1
Waste (Dolomite)	76	2.4	2.8	5	0.5	2	92.5	4.6	2.85

FINDINGS AND ARGUMENT

Blasting operation in iron ore

For the same effect of tectonic conditions, conventional blasting and Power Deck blasting were carried out in adjacent blocks. The comparison results of a back break due to blasting in iron ore are illustrated in Figure 2. Finally, by using the Power-Deck method in iron ore, the back break was decreased by16.4 percent.

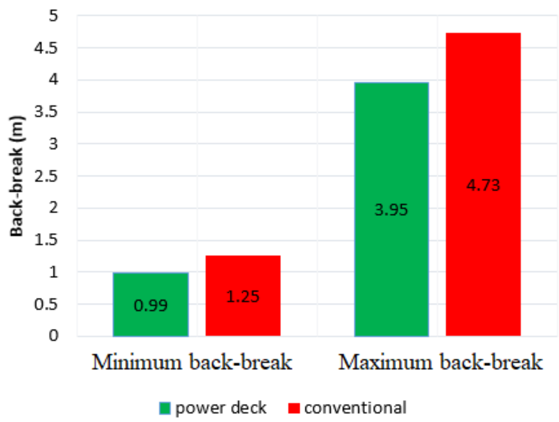

Figure 2. Comparison results of back break due to conventional and Power Deck blasts in iron ore blocks

Blasting operation in waste (Dolomite)

For the same effect of tectonic conditions, conventional blasting and power deck blasting were carried out as a combined blasting (In each section, the back break was measured separately). The comparison results of a back break due to blasting in waste are illustrated in Figure 3. Finally, by using the Power-Deck method in waste, the back break was decreased by 55 percent.

By applying the Power-Deck method in wastes and ore materials, no problem was observed in creating "toes".

COMPARISON OF TECHNICAL AND ECONOMIC RESULTS

According to table 3, the Power Deck method in the Mishdovan iron ore mine has reduced the powder factor and specific drilling, and the holes productivity has improved compared to conventional blasting.

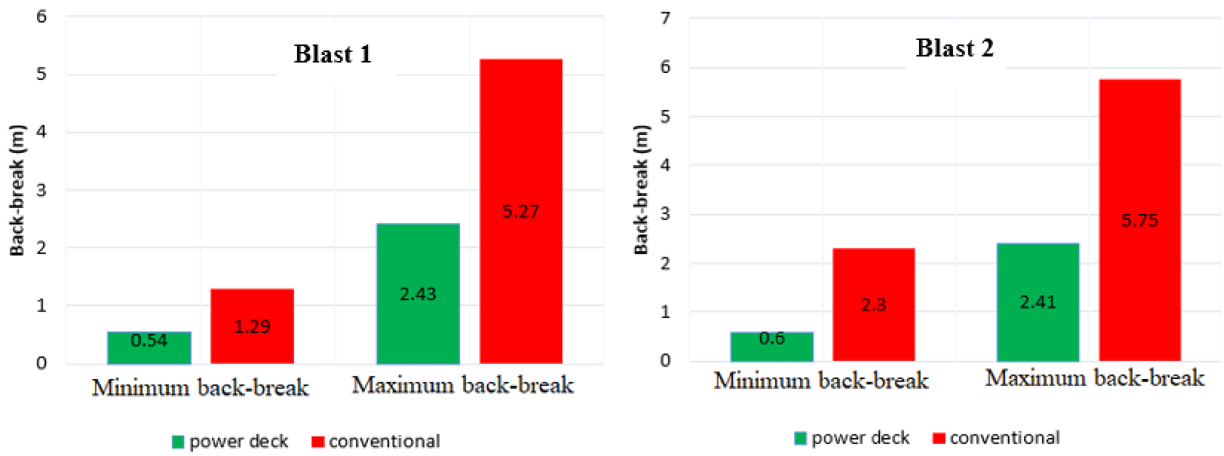

Figure 3. Comparison results of back-break due to combined blasts in waste blocks

Table 2. Investigation of technical and economic factors caused by conventional and Power Deck blasts in Mishdovan mine

Blocks	Method	Powder factor (Kg/m^3)	Specific drilling (m/m^3)	Holes productivity (m^3/m)
İron ore	Conventional	0.434	0.177	5.64
	Power Deck	0.310	0.161	6.21
	Recovery (%)	28.5	9	9
Waste (Dolomite)	Conventional	0.401	0.163	6.13
	Power Deck	0.286	0.148	6.75
	Recovery (%)	28.5	9	9

Therefore, this method in addition to improving back breaks, can decrease blasting costs. By using the same delay in two methods, Power Deck blasting decreases charge per delay. This can be one of the reasons for reducing back-break.

CONCLUSIONS

In this paper, the effect of the Power Deck method on the back break phenomenon compared to the conventional method in the Mishdovan iron ore mine was investigated. Then powder factor and specific drilling parameters related to each method were analyzed and the following results were obtained.

(1) By utilizing the Power Deck blasting method in Mishdovan iron ore mine, in iron ore and waste blocks the back break were decreased by 16.4% and 55% respectively, That indicates this method is more effective in waste blocks.

(2) After loading and hauling the fragment size, it was found that both methods have no significant differences in flat floors

(3) Power Deck method reduced powder factor and specific drilling by 28.5% and 9%, respectively. In addition, holes productivity improved by 9% in Power Deck blasting compared to conventional blasting.

(4) Reduction of the back break in Power Deck blasting can be due to the reduction charge per delay (under the same conditions) and decreasing borehole pressure due to movement of the gas pressure toward the air deck.

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