2013

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EFFECT OF DYNAMIC ELASTIC PROPERTIES OF ROCK ON FRAGMENTATION IN CHOGHART IRONORE MINE, CENTRAL IRAN

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ABSTRACT: Blast fragmentation is a measure of efficiency in an open cast blast operation. Specific Charge (SC) plays an influential role on the fragmentation distribution, the quality of product and the production cost. Dynamic properties of rocks can be used for estimation of rock fragmentation and specific charge. Fragmentation analysis by digital image processing is a low cost and quick method. In this paper, the results of the seismic refraction technique are presented for Choghart Iron ore mine in central Iran. The P-wave velocity of the ore body has been measured at the site. The source of vibration generation was by hammering. The fragmentation resulting from blasting was monitored using a digital camera. Split Desktop software was used to quantify fragmentation size distribution. The mean fragmentation size of P50 was obtained as representative of the average fragmentation size. SC of ANFO was calculated. The relationship between SC with P50, Vp and Dynamic Elasticity Modulus (Edyn) were obtained. It was found that P50 and SC are increased with increased Vp and Edyn. P50, increases with increase of SC. These results can be utilised in blasting design in order to optimise fragmentation and SC for improvement in t the blast operation efficiency.

INTRODUCTION

Proper evaluation of rock fragmentationin blasting is a crucial aspect in mining. A desirable fragmentation enhances the production quality and efficiency. Many investigations have been carried out in order to quantify the effect of influential factors on blasting fragmentation. Amongst these factors are the dynamic properties of blasted rocks, which have been found to be a factor in fragmentation. Rakishev (1981), Latham (1999), Han, *et al.,* (2000) and Ramulu, *et al.,* (2012) are among those who have investigated the influence of dynamic rock properties on fragmentation, specific charge and explosive specifications.

In this research, the SC has been calculated as the amount of ANFO in kg per cubic meter of ore. The fragmentation due to blasting has been figured out through analysing the digital photos by Split Desktop (SD) software. The amount of P50 has been selected as the base for fragmentation assessment. P50 is the representative of the size, for which 50% of the blasted particles are smaller than it. P-wave Velocity (Vp) has been measured and analysed and Dynamic Elasticity Modulus (Edyn) of the rock has been calculated. The relationships between Sc and P50 with Vp and Edyn have been calculated, which can be used for rock fragmentation and SCplanning.

SITE DESCRIPTION

The experiments were conducted at 2^{nd} largest Iron ore mine, Choghart, which is located at 12 km from Bafq town and 125 km from Yazd city, the capital city of Yazd province, central Iran (Figure 1). Estimated deposit of Choghart mine is more than 200 mt of which around 3.5 mt are mined each year. Magnetite is the main mineral of the deposit, together with hematite, goethite, hydro-goethite and ologist. The overall average density of orebody is in the order of 4.1 t/m^3. The total blasted rocks, including overburden, mounts to 11 Mtpa. The main explosive used is ANFO with absolute energy of 2745 J/kg. Emulite with absolute energy of 3495 J/kg is used as booster or as the main charge in boreholes containing water. Staggered blast patterns are mostly applied in drilling and blasting.

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Figure 1 - Location of the mine

DYNAMIC PARAMETERS

The seismic refraction method was applied at iron ore benches. The source of vibration generation was by hammering. The instrumentation used for acquiring the data of seismic profiling was Terraloc MK8 along with 12 geophones of 10 Hz frequency. The seismic data collected in the field was analysed by software called REFLEXW. The statistical output from this analysis is presented in Table 1.

Table 1 - Statistical results of blocks dynamic parameters

	V_P (m/s)	E_{dyn} (GPa)
Maximum	2380.74	12.55
Minimum	1212.00	4.72
Mean	295.25	1.99
Standard deviation	1678.35	7.61
Variance	87 170.54	3.96

FRAGMENTATION ASSESMENT

Size distribution measurement

Size distribution of blasted rock was measured using the digital image processing software "Split-Desktop system". Recent fragmentation assessment techniques using digital image processing program allowed rapid and accurate blast fragmentation size distribution assessments. The fragmentation analysis by digital image processing was a low cost and quick method. Split system is one of the digital image processing software developed to compute the size distribution of fragmented rock from digital images. The digital image software was developed through the 1990s and at present is an accepted tool worldwide in the mining and mineral processing industries. Its main advantage is that it can be used on a continuous basis without affecting the production cycle, which makes it the only practical tool for evaluating fragmentation of the run of mine (Siddiqui, *et al.*, 2009).

Image preparation

There are two sampling methods available for image preparation, random and systematic. The systematic method has been used for this investigation to get the image of all portions of blasted rock muckp using a digital camera. To provide a scale of the images, two football size balls of 18 cm in diameter were used. The distance between the two ballswas kept as 2 m in all the cases. The images were taken by a camera of 16 Mega Pixcl resolution. Best efforts were made to observe all image taking rules recommended by the Split-Desktop manual (Split Engineering, LLC, 2010). Figure 2 shows typical image presented by Split-Desktop software. The images have been manually edited, where needed, and the divided large pieces are reintegrated so that the particle edges are clearly outlined in lines (Figure 3).

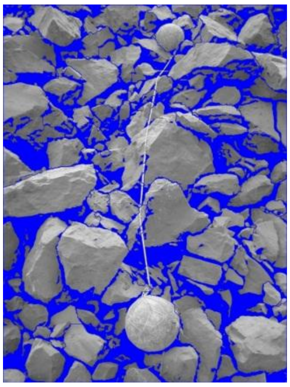


Figure 2 - An image recorded by the software

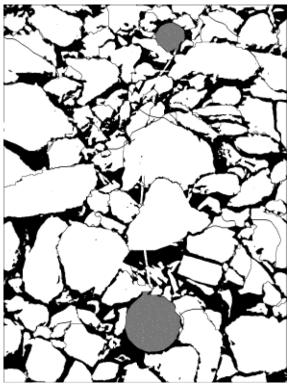


Figure 3 - An edited image saved for software analysis

Size distribution computation

Computation of size distribution is the last step and the most crucial part of the fragmentation assessment. The distribution of fine particles in each image has been figured out using the Rosin-Rambler distribution approach. Statistical detail of P50 size is presented in Table 2. The calculated size distribution curve and related table are shown in Figure 4.

Table 2 - Statistical parameters of P50 and specific charge

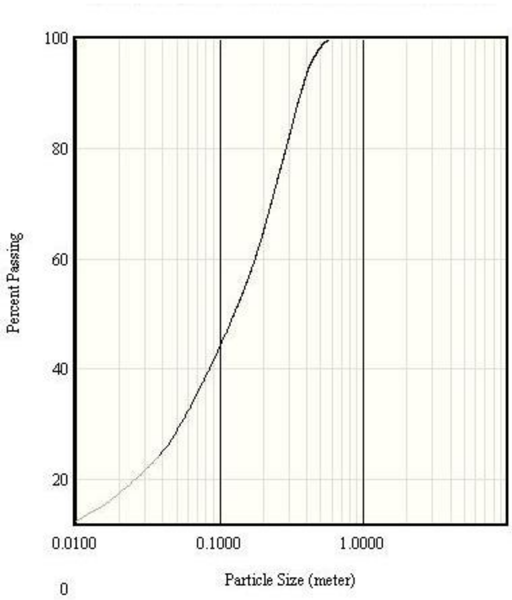
	P50 (mm)	Specific charge (kg ANFO/m^3)
Maximum	623.70	1.63
Minimum	88.89	0.49
Mean	154.00	0.31
Standard deviation	291.29	0.93
Variance	23716.11	0.10

RELATIONSHIPS BETWEEN THE SPECIFIC CHARGE WITH FRAGMENTATION AND DYNAMICS PARAMETERS

Analysing the data produced and monitored for the purpose of finding relationships between the rock specifications and the blasting results leads to the dependency of the SC and fragmentation on dynamic properties. As SC is increased the P50 size is increased as shown in Figure 5. This might look somehow against the expectations. But it can be due to the discrepancy between the way of increasing SC and the properties of blasted rock. This discrepancy might be considered as a problem for which a solution has to be searched. In practice, various amounts of specific charges are used in various portions of Ghoghart mine. This is because the properties of the blasted mineral are not the same everywhere in the mine.

The increase of SC with increase in Vp and Edyn are shown in Figures 5 and 6. The coefficients of determination (R^2) for these correlations are 0.6711 and 0.9523 respectively. Figure 7 shows the relationship between SC and Edyn.

Correlation has been found between fragmentation with (Vp) and Edyn of the blasted mineral for which the coefficients of determination (R^2) are 0.6042 and 0.9312 respectively as shown in Figures 8 and 9.



size (mm)	%
4000.00	100.00
2000.00	100.00
1000.00	100.00
750.00	100.00
500.00	98.42
250.00	74.18
125.00	49.97
88.00	41.02
63.00	33.43
44.00	26.50
31.00	21.97
22.00	18.45
16.00	15.68
11.00	12.94
7.800	10.86
5.500	9.09
4.000	7.75

P20 size (mm) 25.78
P50 size (mm) 125.13
P80 size (mm) 287.24
Top size (mm) 549.46

Figure 4 - Size distribution results of fragmentation

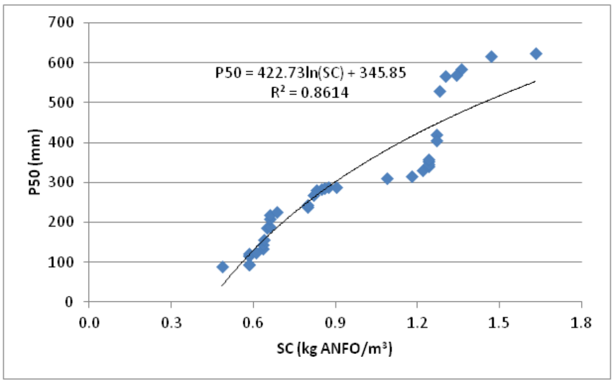


Figure 5 - Fragmentation versus specific charge

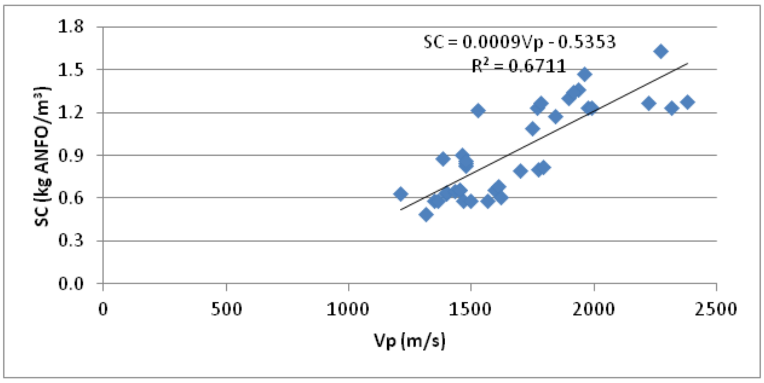


Figure 6 - Specific charge versus P-wave velocity

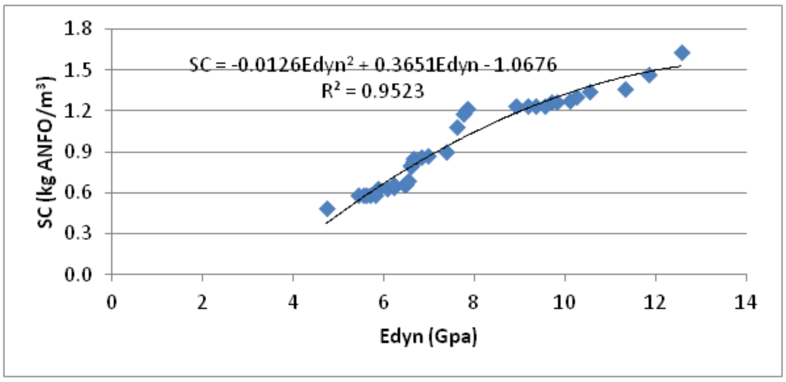


Figure 7 - Specific charge versus dynamic elasticity modulus

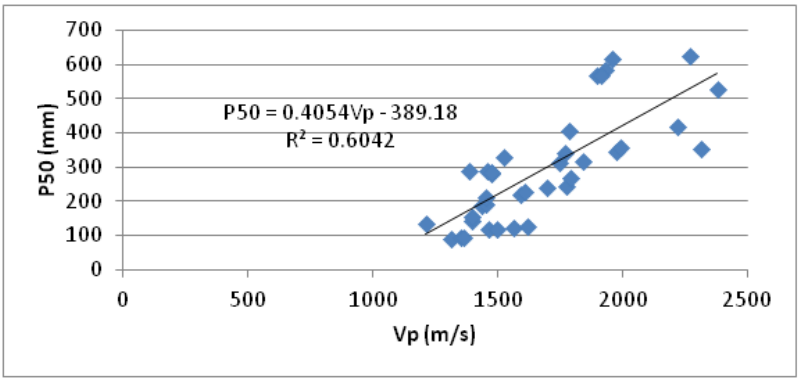


Figure 8 - Fragmentation versus P wave velocity

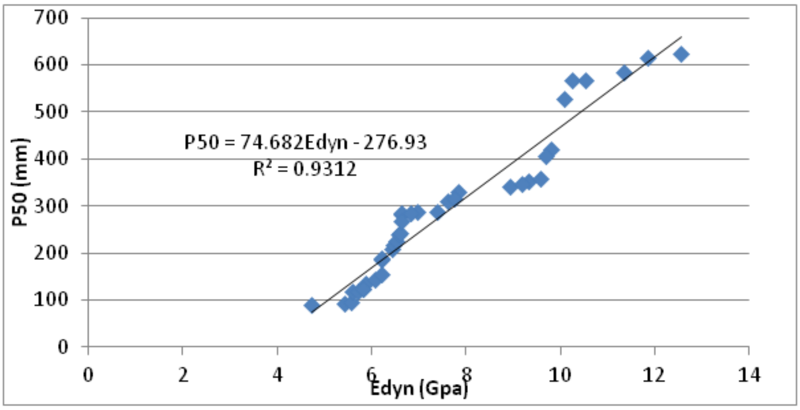


Figure 9 - Fragmentation versus dynamic elasticity modulus

CONCLUSIONS

Blast fragmentation of Ghoghart iron mine has been analysed and fragmentation distribution has been defined through muckpile images using Split-Desktop. The value of P_{50} obtained were in the range of 88.89 to390.8.

Relationship between $P_{50}$and specific charge has been defined for which a coefficient of determination was 0.95. This correlation shows that in Ghoghart mine the amount of $P_{50}$is increased with increasing SC

Both SC and P_{50} depend on dynamic properties of rock and increased with increase in P wave velocity and Edyn. The relationships between these factors have been introduced for the mine blasting practice.

The results of this investigation can be used in blast design and fragmentation arrangement in accordance with the properties of the rock in Choghart mine.

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