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Research article

Investigating the relationship between the chemical, physical, and mechanical properties of the iron blocks of Chagharat Mine, with the D50 value of the comminution resulting from blasting

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Keywords

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English Extended Abstract

Summary

Blasting operation is one of the most important and costly operations in the mining process. Blasting is the beginning of the rock comminution system in the mine. The dimensions of the blasted product will play a significant role in the ability of stone crushing and grinding, for this reason, to produce a product with suitable dimensions, it is first necessary to obtain sufficient knowledge of the physical, mechanical, and chemical conditions of mineral blocks. In this research, by studying 26 iron ore blocks of the Chogharat mine, after the blasting operation, the physical, mechanical, and chemical characteristics of the ore blocks were taken. In the following, after blasting operation, by taking pictures from surface of the exploded block, an image analysis of the dimensions of blasting product was carried out. In the next step, stone samples were taken from the surface of the fired block to conduct geomechanical and chemical tests. After conducting the tests, the relationship between the physical, chemical, and mechanical characteristics of the tested stones with the dimensions of the Blast products (D50) was investigated. The characteristics examined in this study include uniaxial compressive strength, modulus of elasticity, Poisson's ratio, indirect tensile strength, cohesion, internal friction angle, and percentage of silica, iron, and iron oxide in the Blasted block. Finally, using univariate and multivariate linear regression statistical analysis, equations to estimate the dimensions of the product (D50) resulting from the blasting using the physical, mechanical, and chemical characteristics of the rock masses of the explosive product. With coefficients of determination (R2) 92.48% for D50 were predicted.

Introduction

Blasting is a critical component of mining operations used to separate rock from ore bodies and fragment it to acceptable sizes. This process requires a comprehensive understanding of all influencing parameters and optimal design. Inadequate ground conditions or poor design can lead to undesirable outcomes such as rock ejection, ground vibration, air shock, backbreak, noise, dust generation, large block formation, and inappropriate product size [1]. Effective blasting operations produce fragmented rock that meets the required size and distribution for loading and transport by existing equipment and processing by crushing facilities, minimizing the need for further size reduction [2]. The blastability of rock is a crucial factor in designing blasting operations for mining and construction activities. It is closely linked to rock mass

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characteristics, the blasting system, and environmental conditions, ultimately affecting the fragmentation size and distribution [2].

Parameters related to the nature of the rock mass include the physical and mechanical properties of intact rock and discontinuities, the governing laws of their resistance and behavior, and environmental conditions such as stresses, dynamic loads, and hydro-systems, which are considered uncontrollable factors affecting blasting [3]. Blasting system parameters are generally controllable and can be adjusted to achieve optimal blasting results [4]. Among the most critical blasting parameters, after selecting the explosive material and blasting method, are the geometric dimensions of the blast design. Key controllable geometric parameters include the hole diameter, bench height, burden, row spacing, hole over-drilling, stemming length, and blast direction (Figure 2) [5]. Even when the factors affecting blastability related to rock mass characteristics and blasting system are well understood and the design is appropriately executed, overlooking the presence of water in the rock mass, the temperature of the study area, and certain human factors can invalidate the calculations [6].

Optimizing and achieving effective blasting design and execution, which ultimately leads to increased productivity and reduced costs, requires a thorough understanding of the area designated for blasting. In many cases, the blasting system and explosive models are fixed, while the variable parameter is the characteristics of the rock mass in the blast blocks, which influences the blasting conditions and quality [22]. Accurate assessment of the physical and mechanical properties of the in-situ rock is a time-consuming and costly process [23]. In the present study, considering the project goals of understanding how various physical, chemical, and mechanical characteristics of the rock mass influence the dimensions of the blast product, linear regression analysis has been employed to examine these relationships.

Methodology and Approaches

This research was conducted at the Choghart mine, one of the largest iron ore mines in Iran, to establish the relationship between measured parameters and the dimensions of the blasting product. Initially, images of the blast pile surfaces were captured, and the particle size distribution of the blasted product was analyzed. Rock samples were then collected for rock mechanics testing and assay, and these samples were sent to the laboratory.

Subsequent testing included indirect tensile strength and triaxial compressive strength to determine cohesion and internal friction angle. Additionally, specific gravity measurements were performed on the samples. Finally, rock samples were analyzed for iron content, iron oxide, iron-to-iron oxide ratio, and silica percentage at the assay laboratory. The relationships between the physical, mechanical, and chemical properties of the rock and the dimensions of the blasting product were examined using linear regression analysis.

Results and Conclusions

This study investigated factors influencing the dimensions of blasting products (D50) at the Choghart mine. Significant relationships were found between the physical, chemical, and geomechanical properties of the blasting rock and D50. Increased specific gravity, uniaxial compressive strength, elastic modulus, and cohesion were associated with larger D50 values. Conversely, higher silica content, Poisson's ratio, and internal friction angle resulted in smaller D50 values. Additionally, the iron-to-iron oxide ratio positively correlated with D50.

A multiple linear regression model, with an R^2 of 0.9248, identified uniaxial compressive strength, iron-to-iron oxide ratio, and specific gravity as key factors influencing D80. The study's findings suggest that high cohesion, compressive strength, tensile strength, specific gravity, and iron-to-iron oxide ratio increase D50, while higher silica content, Poisson's ratio, and internal friction angle decrease it.

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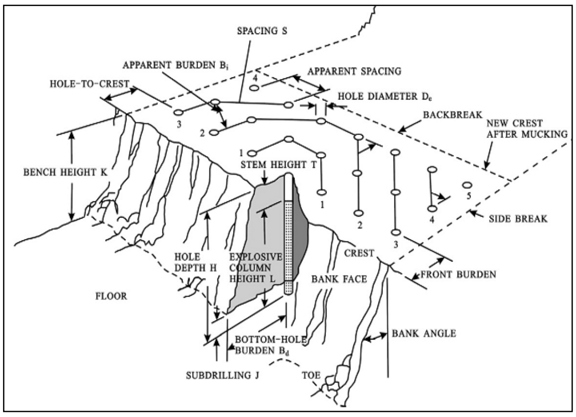

Fig. 1. Blast geometric parameters

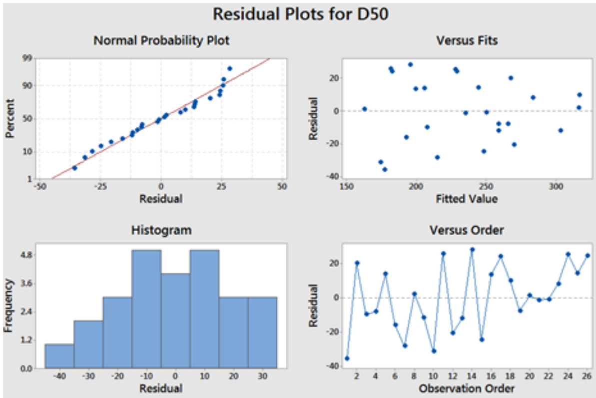

Fig. 2. Residuals plot of the regression model for D50 fitting

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