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Simulating the influence of blast geometry and rock geology on rock fragmentation

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ABSTRACT

Drill and blast is a critical process in the size reduction of rock. The process uses explosive energy to reduce rock into manageable fragment size before the rock fragments are transferred to other mining activities. The size reduction of rock by mechanical energy is generally accepted as a relatively expensive process due to the cost of energy required to break the rock. For this reason, it is essential to reduce the energy requirements in the plant by sending optimal blast fragments. However, rock geology, blast design geometry and explosives properties can influence the degree to which optimal fragment size would be achieved.

This study aimed to determine the degree to which these parameters influence the blast fragment size and the associated blasting costs by simulating various blast conditions. The objective of the study was to implement a blasting simulation model at Ruashi mine to solve the challenges experienced with blast fragmentation and blasting in general. Based on a review of diverse literature and theories on blasting, the Kuz- Ram model was chosen as the basis for the study. Three test sites of varying geological conditions were selected, and different blast design patterns and simulation conditions were used to answer the research questions. Image analysis was utilised to compare actual fragment results against simulated fragment size results to refine the model and ensure the simulation model can better predict the fragment size.

Analysis of the findings indicated that the Blastability Index, which is a measure of the difficulty in blasting rock, for the rock types encountered in the mine ranged between 4 and 8 which indicated weak to moderately competent rockmass. This index was primarily influenced by rock density and joint dip angle. The higher the rock density, the greater the difficulty was in blasting rock. Also, the steeper the joint sets (joint spacing less than 0.1m), the more difficult it was to blast the rockmass.

The Uniformity Index, which measures the uniform nature of the blast fragmentation distribution, was found to range between 0.9 and 1.5 for South-East and South-West. This index value indicated that muck piles in these areas were mostly non- uniform. This result was expected given that the rockmass in these areas was less competent and relatively more fractured while the South blast Uniformity Index was between 1.5 and 2.2 which depicted a more uniform muckpile achieved from competent rockmass.

The burden and spacing were the influential parameters on the Uniformity Index value in a variable blast pattern design. While in a fixed burden and spacing pattern, the index value depended mainly on the change in the stemming length.

In a fixed blast pattern design, the blasting costs were mainly influenced by the change in the stemming length. The higher the stemming length, the lower the unit blasting costs. Also, the higher the Blastability Index, the greater the blasting costs. The uniform nature of the muckpile was found not to have an impact on the blasting costs.

Two standard blast patterns were chosen for ore and waste material. Firstly, for waste blasting, final blasting pattern of 2.5m by 2.5m was selected together with a powder factor of 0.35 kg/Bcm. Secondly, for ore blasting, a 2m by 2m blast pattern was chosen along with the powder factor of 0.35 kg/Bcm. These selected parameters were found to produce reasonably good results in terms of fragmentation size and blasting costs for the rock types encountered in the mine.

Due to the cross-sectional nature of the study and limited resources such as blasting software, mill data and digging data, the study was restricted to cover only the blasting operations by utilising the Kuz-Ram model. Further studies on the comminution system would be necessary to quantify the overall impact of the fragment size on total mining costs. One other important recommendation from the study is that the mine needs to establish the blasting department to deal with issues of performance, quality assurance, and control, and the development of blasting standards. This is key given that the mine does not have technical capability for extensive blasting operations that will be required as a consequence of working in hard strata.