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10.5937/IOC24077M

http://dr.rgf.bg.ac.rs/s/repo/item/0009393

The 55th International October Conference on Mining and Metallurgy
15 - 17 October 2024, Kladovo, Serbia
https://ioc.irmbor.co.rs

DOI: 10.5937/IOC24077M Original Scientific Paper-Mining

FRAGMENTATION SIZE PREDICTION OF BLASTED MATERIAL USING A SPECIALIZED SOFTWARE FOR DRILLING AND BLASTING

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Abstract

Design and optimizing the drilling and blasting parameters, should fill the requirements for the capacity, fragmentation size, and technical characteristics of loading and transport equipment, and enable a safe work at the open pit. Besides mentioned, it also achieves the minimal impact on the environment of the open pit and decreases the negative effects on the environment, especially in the blast vibration and flyrock. To obtain the best possible blasting effects and consider all the factors, a specialized software is used to optimize the drilling and blasting parameters. Currently, the few software is intended for optimizing the drilling and blasting works. This paper presents calculation in the O-Pitblast software, where the estimation of drilling and blasting parameters was performed. As the software has different possibilities for interpretation the results, the prediction of the fragment size distribution of the blasted material, based on the analysis of designed parameters at the open pit copper mine, is presented. The software provides the optimization of drilling and blasting parameters with a very simple change of the set parameters, regarding those, related to the rock mass properties, the characteristics of explosives during blasting, initiation system, delay time to output values such as the size of the blasted material, determination the safety zone of flyrock or negative blast vibration effects.

***Keywords**: optimization, O-Pitblast, drilling, blasting, fragmentation size*

1. INTRODUCTION

Drilling and blasting parameters at the open pit of the copper mine are optimized to the appropriate criteria in terms of fragmentation size, reducing negative effects such as the blasting vibration, and the flyrocks. Optimization of the drilling and blasting parameters was also done for the two different rock mass properties, where the corresponding rock mass properties were used in the software itself during calculation. Specialized software for optimization the drilling and blasting parameters, used for this purpose, is the O-Pitblast software [1].

By defining the drilling and blasting parameters, the software provides a prediction of fragmentation size for known drilling and blasting parameters. This procedure is also used as a modern way to adjust the drilling and blasting parameters because they enable the best possible results of the fragmentation analysis to be obtained changing the certain parameters (explosive charge, delay time, blast pattern, etc.). To estimate the fragmentation size of

blasted material for given parameters in the O-Pitblast, the software uses the Kuz-Ram model for prediction the fragmentation size. The model was developed by Kuznetsov (1973) and represents the correlation between the average fragmentation size of material and detonation energy applied per rock volume unit as a function of the rock mass properties [2].

2. DRILLING AND BLASTING PARAMETERS

Drilling and blasting parameters were optimized for two different rock mass properties, where the fragmentation size of blasted material was analyzed according to the designed parameters. The following Table 1 presents the rock mass properties that are important for drilling and blasting, and they were also used in creation the database in the O-Pitblast software.

Table 1. *Rock mass properties*

Rock mass	Andesite	Limestone
Density (g/cm^3)	2.630	2.640
Compressive strength (MPa)	104.855	106.012
Velocity of P-wave(m/s)	4 400	5 300

The designed drilling and blasting parameters, used during processing in the software to optimize and analyze the fragmentation size, are presented in Table 2, where calculations were made for two types of explosives and drilling diameters, and also for two different rock mass properties. During design of drilling and blast parameters at the open pit, a blast pattern with such delay time must be also selected (calculated) and carried out, to minimize the possible negative effects of blast vibration on the environment and some existing objects [3]. The blast pattern should ensure, in addition to the reduction of blast vibration, an increase in a degree of rock mass crushing, as well as obtaining the required shape of the muckpile.

Table 2. *Drilling and blasting parameters*

Parameters	Diameter d=150mm	Diameter d=250mm
Burden	5 m	8 m
Spacing	5.5 m	8.8 m
Inclination	75^0	75^0
Stemming	5 m	8 m
Bench height	15 m	15 m
Borehole length	17 m	18 m
Subdrill	1.5 m	2.5 m

During calculation, the borehole diameters of 150 mm and 250 mm were used, as well as the application of two types of explosive mixtures for mechanized charging: ANFO and DETOLIT, presented in Table 3.

Table 3. *Technical characteristics of explosives [4]*

Characteristics of explosive	DETOLIT	ANFO J.1
Density (kg/l)	1.1-1.25	0.85-0.95
Velocity of detonation (m/s)	4000	2000
Gas volume (lit/kg)	1090	1045
Effective energy (kJ/kg)	2805	3875

Fragmentation size prediction of blasted material affects the further costs of processing the mineral raw materials, and degree of fragmentation size has a significant impact on further operations during production such as loading, transport, and crushing [5]. Applying the software for optimizing drilling and blasting parameters, such as the O-Pitblast, the correction can be made to obtain the best possible fragment size.

3. RESULTS AND DISCUSSION

The software can predict the fragmentation size through the analysis of entered drilling and blasting parameters, and the software uses the Kuz-Ram mathematical model for calculation and analysis the fragmentation size, taking into account several parameters in calculation. Entering the designed parameters into the software, the fragmentation size was analyzed, and the results are shown for diameters of blasthole for 150 mm and 250 mm, as well as two types of explosives and different rock mass properties, which can be seen in the following Figure 1.

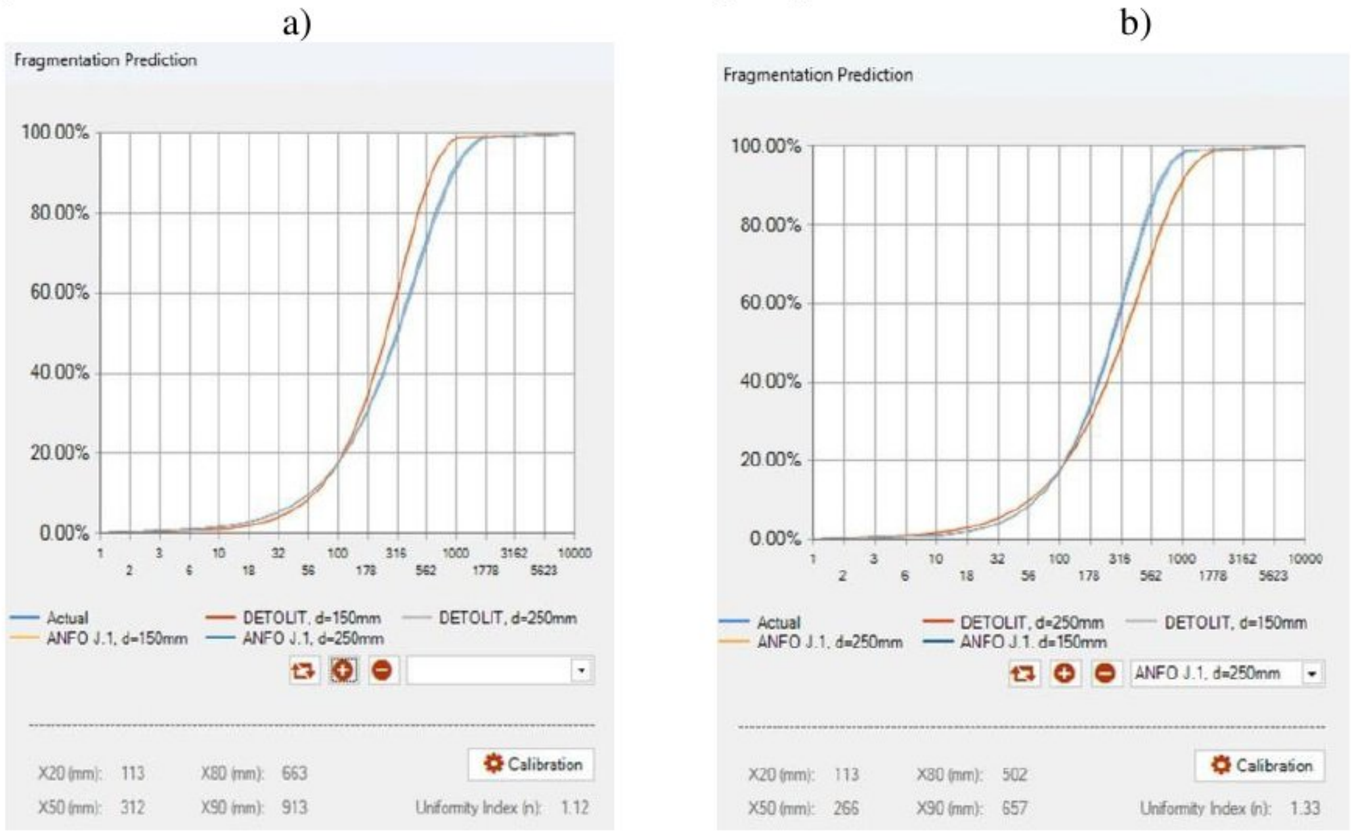

Figure 1. *Prediction of fragmentation size in O-Pitblast software; a) for limestone and b) for andesite*

From a fragmentation curve, it is possible to read any data related to the fragment size of the blasted material: the content of material below or above a certain size, and therefore the content of undersize in the blasted material for the specific conditions, i.e. the technology of further treatment the blasted material, and mean diameter of the general or total blasted material can be calculated.

Stronger damage to the rock mass around the blast field can create problems in drilling and blasting for the next series. In principle, it can be said that the better and more uniform the crushing of the rock mass ($\mathbf{X_{50}}$ - lower, and **n** - higher), the less damage to the rock mass around the blast field, i.e. safekeeping of the bench slope is better [6].

This paper presents the designed parameters, used during processing in the mentioned software. According to the entered data, a fragmentation prediction model was created, where according to the designed conditions of the crusher, the maximum diameter of pieces is D = 1000 mm. Figure 1a and Figure 1b show the results by a fragmentation curve, where it can be

seen that the parameter conditions for diameters of 150 mm and 250 mm, according to the selected type of explosive and rock mass properties, meet the designed parameters for drilling and blasting.

According to the diagram from the figures, it can be seen that the filling of the designed input for the crusher is about 95%. Better drilling and blasting optimization in this way ensures a better fragmentation of rock material and also reduces the drilling costs [7].

4. CONCLUSION

The use of the specialized software O-Pitblast to predict the fragment size enables a simple analysis of designed parameters in terms of obtaining the best possible fragmentation of the blasted material. It allows the input of data on the rock mass properties, the geometry of the blast field, and easier correction of parameters to obtain the best possible output data, but also the possibility of inputting a 3D terrain model, for easier optimization according to the real conditions on the field. The advantage of the software is that, in addition to using the designed parameters, the software can use a model from the field giving a real picture of situation on the bench. There is a possibility in the software itself of combination the different drilling and blasting parameters or correction the designed ones so that in the end the Kuz-Ram model gives the best possible result in terms of fragmentation size.

The development of modern technologies and use of specialized software enables easier and simpler data processing, analysis, and later review the results of the designed drilling and blasting parameters. In addition to the software such as the O-Pitblast, which can predict the fragment size of blasted material, today there are several developed software in the world for analyzing the fragmentation size after blasting according to the photograph of a muckpile.

ACKNOWLEDGEMENTS

The authors thank the Serbian Ministry of Education, Science, and Technological Development for their support and provided funds based on Contract No. 451-03-66/2024-03/200126.

REFERENCES

[1] O-Pitblast-Rethinking the Drill and Blast Industry, (2024), https://www.o-pitblast.com/
[2] D. Fonseca De Castro, Underground Mining Engineering, 39 (2021) 29-42 https://doi.org/10.5937/podrad2139029F
[3] L. Kričak, Seismic of Blasting, Faculty of Mining and Geology, Belgrade, (2006), (In Serbian).
[4] Trayal Korporacija, Explosives and pyrotechnics, (2024), https://trayal.rs/ (In Serbian)
[5] M. Negovanović, L. Kričak, S. Milanović, J. Marković, N. Simić, S., Ignjatović, 9th International Conference Mining and Environmental Protection, Faculty of Mining and Geology, Belgrade, 2023, pp. 98-104.
[6] M. Savić, Blasting at the Open Pits, Copper Institute, Bor (2000), (In Serbian).
[7] S. Milanović, N. Simić, L. Kričak, M. Negovanović, N. Djokić, Underground Mining Engineering, 44 (2024) 51-67, https://ume.rgf.bg.ac.rs/index.php/ume/article/view/195.