The rock fragmentation control in long hole blasting – case study Antam Pongkor underground gold mine

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Abstract. The increase of reblasting activities due to the significant number of oversize fragmentation result from blasting make escalation of explosive which decreases the productivity. The productivity decrease because the production cycle disrupted when the activity needs more time to get the same result. At Antam Pongkor Underground Gold Mine, the target of fragmentation is less than 40 cm. More than that size, the fragmentation need to be reduced with reblasting. From the observation, the oversize fragmentation in the long hole blasting system is 34%. This study is a concern on how to reduce the oversize fragmentation to optimize mine activity. By improving drilling technique like shorten the boreholes distance, changing the blasting pattern, installing plastic pipe and standardizing the explosives and delay pattern, the oversize fragmentation can be lowered. The result of the study, the oversize can be reduced to 14% which help the miner to do effective and efficient mine activity. The implication of the lowered oversize fragmentation is the fall off reblasting activity number into 11 times which before the study is 18 times. In conclusion, the drilling technique improvisation can be the key to control the rock fragmentation in Long Hole Blasting.

1. Introduction
1.1. Pongkor’s Geology Character
Pongkor Underground Gold Mine is situated at the northeastern flank of the Bayah dome, which is a product of volcanism in the Sunda-Banda Arc that was also responsible for other epithermal gold deposit. The age of the Pongkor deposit has been estimated to be 2.05 ± 0.05 Ma based on the 40Ar/39Ar dating. Primary mineralization is structurally controlled (NNW-SSE directions) and occurs within veins system. The Pongkor gold-silver deposit is the largest low-sulfidation epithermal precious metal deposit in Indonesia and is of Pliocene age. The deposit consists of nine major sub-parallel quartz – adularia – carbonate veins with very low sulfide content.

1.2. Pongkor’s Mine Character
Pongkor is the largest underground gold mining operations in Java and has a diverse underground mining method which owned By PT Antam, an Indonesian State Owned Mining Company. It lies at Mount Halimun National Park, about 90km from Jakarta, it covers a surface area of approximately 6.047 Ha. Topographically, Pongkor is a part of mountains morphology unit lied in between topographically of 500-900 m.

The production cycle in Pongkor begins with the drilling the blast holes, charging the explosives then blasting. Afterward is mucking ore and continue to supporting and drilling. The efficiency of a
bumping activity is determined by the degree of matching the required fragment size, tonnage and the dimension as blasting result. Blasting is the start of the mining cycle which will continue to mucking, crushing and supporting. The efficiency of this activity is directly related to the size distribution of fragmentation [1]. Kazem and Bahareh [2] stated that a good blasting operation leads to the productiveness of the mining cycle.

2. Fragmentation Consideration

a. Kuz-Ram Prediction

Evaluation of fragmentation is an important discussion in the mining as it is the first step towards productivity. Predicting and analyzing the result of blasting usually using software and methods which one of them is the Kuz-Ram model. Predictions were made based on the input of rock character to know how much the in range or oversized fragmentation. This result will be evaluated like the accuracy, spacing and burden distance and the explosive concentration. It will be observed on the field so we can compare the Kuz-Ram and the field result.

The Kuz-Ram model developed by Cunningham [3] which modified the Kuznetsov’s empirical equation to estimate the mean fragment size (x), and used the Rossin-Rammler distribution to describe the entire size distribution. The uniformity exponent of the Rossin-Rammler distribution is estimated as a function of the blast design parameters [4].

At 2005, Cunningham made an adjustment to the equations [5]. The major changes to the model developed as a result of the introduction of electronic delay detonators (EDs). The new equation set includes changes in the uniformity and means fragment size equations, which is as follows:

\[ X_{50} = A_{T} K^{-0.8} Q^{19} \left( \frac{115}{W} \right)^{20} C(A) \]  
\[ n = n_s \sqrt{\left( 2 - \frac{30R}{d} \right) \left( \frac{1 + S/B}{2} \right) \left( 1 - \frac{W}{B} \right) \left( \frac{L}{H} \right)^{0.3}} \]  

Where, ‘\( A_T \)’ is a newly introduced timing factor, which is applied to the first equation as a multiplier, and now incorporates the effect of inter-hole delay on fragmentation, ‘\( C(A) \)’ a correction factor for the rock factor, ‘\( n_s \)’ is the uniformity factor governed by the scatter ratio. ‘\( C(n) \)’ is a correction factor for the uniformity index. As with the rock factor A, it can happen that the uniformity index is just not what the algorithm suggests, in which case correction factor \( C(n) \) is provided to overlay the inputs and enable estimation of the effects of changes from a common base.

b. Desire Fragmentation

In Pongkor Underground Gold Mine, the desire fragmentation size is under 40 cm. It because our crushing can be optimized at 40 cm diameter. The oversize fragmentation will be re-processed. The re-processed activity including drilling, charging and blasting. Data from October-November 2017 said that the re-blasting activity happens 18 times per month. This activity consumes 18% more explosive compare the explosive for normal blasting. Not only that, the wasted working hour is up to 108 hours a month. From the re-blasting and wasted working hour we can conclude that the oversize fragmentation can increase the mining cost.
3. Case Study: Pongkor Underground Gold Mine

3.1. Long Hole Drilling
Long hole is a drilling technique that uses a long drilling rod or special drilling rod which connected until 8 meters or more. Usually, long holes point upwards to take the ore veins above. The ore is the last layer of the overhand cut and fill methods.

3.2. Methodology

a. Blasting Holes Distance
The distance between blasting holes is too tenuous and not uniform. This condition makes oversize fragmentation happen. Therefore the distance of the blasting hole is uninform by measuring it with tapes and marking. With marked blasting hole make the Jumbo Drill Operator easier to drill. The blasting hole distance is flexible due to the rock strength. When the rock is stronger, the distance is narrower.

b. Drilling accuracy
From the diagram below, we can see that the drilling accuracy impacting the presence of oversize fragmentation. To increase the drilling accuracy, plastic pipe installed to carry out driller. The pipe guide the driller and increasing the accuracy.

Figure 1. Oversize Fragmentation Comparison.

Figure 2. Illustration of Oversize Fragmentation Potential because of the distance of blasting hole.
c. Drilling pattern
It is known that the staggered drilling pattern will reduce boulder compared to square one. This is because the square pattern has wider oversize fragmentation area than the staggered. Therefore, the pattern is changed to stagger.

Figure 4. Oversize Potential in Squared and Staggered Blasting Pattern.

d. Density of Explosives
The explosive is designed like the diagram below. We try to use efficient explosive by using one dynamite in the bottom of blasting hole and fill it with ANFO. The explosives effectively break the rock into desired fragmentation.

3.3. Experimental sites details
There are three sites in which we conduct the experiment. The site was chosen because their rock character which can be comparable to the other sites.

Table 1. Rock Characteristics.

| Front Name              | Specific Gravity (kg/m³) | Elastic Modulus (GPa) | UCS (MPa) | Spacing (m) | Dip (degree) | Dip Direction (degree) | In situ Block (m) | Oreo Thickness (m) |
|-------------------------|--------------------------|-----------------------|-----------|-------------|--------------|------------------------|------------------|-------------------|
| Upper hole Bloc IV Central | 2.5                      | 13.2                  | 119       | 5           | 45           | 94                     | 5                | 7                 |
| Upper hole XC 456 R     | 2.5                      | 9.56                  | 65        | 2.5         | 55           | 50                     | 5                | 9                 |
| Upper hole XC 31 VT     | 2.4                      | 3.36                  | 28        | 2.5         | 80           | 63                     | 3.5              | 5                 |
3.4. Data and Analysis

a. Photo Experiment

After blasting activity, the data collected by taking the picture fresh on the site.

![Photo after blasting with two balls for the scale](image1)

![Fragmentation calculation with the software](image2)

![The result of software calculation](image3)

Calculation of the results of the blasting fragmentation using software from the first stage (left) to the final result (right), the calculation did in each bucket of the mucking activity so that there is a more accurate calculation. The fragmentation calculation starts by taking the photo after blasting with two balls for the scale. Afterward, a number of photos processed with the software into a binary image. As a result, the cumulative curve shows us the percent cumulative of the fragmentation. From the result, the in range and oversize fragmentation can be known.

b. Oversize Fragmentation Data

From three sites where the experiment conducted, the oversize fragmentation can be measured as:

| No | Front Name              | Oversize Before | Oversize After |
|----|-------------------------|----------------|----------------|
| 1  | Upperhole Block IV Central | 38%            | 11%            |
| 2  | Upperhole XC 495 B      | 29%            | 12%            |
| 3  | Upperhole XC 3.1 VT     | 35%            | 19%            |

Overall, from all the fronts the boulder is decreasing. At Block IV Central, the boulder decrease from 38% to 11%. At the Upperhole XC 495 B, the boulder measured after the experiment is 12% which before the experiment 29%. The boulder decrease to 19% from 35% at upperhole XC 3.1 VT.

On the Upperhole Block IV Central front, Boulder could be reduced by 71% from 38% to 11%. This result is better than the predictions of 21%. On the Upperhole XC 495 B front, the boulder can be reduced to 12% from the initial condition of 29%. The decrease in the percentage of boulder if calculated is 59%. These results are better than the initial predictions of 14%. At the XC 3.1 VT upper hole to the North, Boulder fell by 45%, although at the end of the boulder it was 19% higher than the prediction of 10%.

4. Conclusions

This study has two main objectives, reducing the oversize fragmentation and decrease re-blasting activities. Before the study begins, the oversize fragmentation is 34% and the re-blasting activity is 18 times a month. From several experiments conducted, the oversize boulder percentage reduced to 14%
and the re-blasting activity decreased until 11 times. From the result, the objective of this study is accomplished.

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