

Evaluation of Blasting Geometry and Flyrock to Determine Safe Distance in Overburden Stripping Activities

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ABSTRACT

Blasting activities in open-pit mining are the main method for breaking up hard rocks, but they also have significant potential hazards, one of which is Flyrock. This study evaluates the blasting geometry towards Flyrock to determine the safe distance in overburden blasting activities at PT. Kuansing Inti Makmur, Bungo Regency, Jambi Province. This study uses a quantitative approach with field observation and regression analysis methods to evaluate the sensitivity of each parameter to the Flyrock distance that occurs by assessing the relationship between blasting geometry parameters, such as burden, spacing, stemming, blast hole depth, and powder factor, to the Flyrock throw distance. The analysis used a predictive model from Ebrahim Ghasemi (2012). The results of the study indicate that Flyrock is significantly influenced by the powder factor and other geometric variables, and indicate that the minimum safe distance for heavy equipment and humans is 300 meters and 500 meters, respectively, according to the provisions of the Minister of Energy and Mineral Resources Decree No. 1827 K / 30 / MEM / 2018. These findings are expected to be a reference in designing safer blasting in mining areas.

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1. INTRODUCTION

Blasting is a common method in open-pit mining to break up hard rock. However, this process poses safety risks, one is flyrock, which is rock ejected by the explosion and can exceed safe limits, potentially causing equipment damage, injury, and even death. Several technical factors, such as the ratio of burden to blasthole diameter, stemming conditions, and weak rock zones, can cause excessive flyrock. To control this, an evaluation of the blasting geometry is necessary.

The flyrock distance prediction model developed by Ebrahim Ghasemi (2012) was used in this study to analyze the effect of powder factor on the safe distance of actual flyrock thrown by blasting and to identify whether other factors influence the flyrock throw distance. This study aims to determine

the appropriate safe distance, considering that the Ministry of Energy and Mineral Resources regulations require a minimum safe distance of 300 meters for equipment and 500 meters for humans.

PT. Kuansing Inti Makmur is a company focused on coal mining and trading. PT. Kuansing Inti Makmur (PT. KIM) is a national private company engaged in coal mining, established on January 18, 2006, based on Notarial Deed No. 13 dated December 7, 2005, in Pekanbaru. The company is located in Tanjung Belit Village, Jujuhan District, Bungo Regency, Jambi Province, with a total Mining Permit (IUP) area of 2,610 hectares, divided into two mining blocks (West and East) and managed by nine related business entities. PT. KIM employs an open-pit mining system (surface mining), with all mining activities conducted above ground level. The contractor, PT, carries out technical mining operations. Cipta Kridatama (CK), while PT. KIM acts as both owner and supervisor. Given the growing potential of coal as an alternative energy source, PT. KIM continues to expand and develop its mining area to meet global market demand and address the decline in other fossil fuel reserves.

This research is important because it directly relates to determining the safe distance for blasting, which is regulated by ESDM Ministerial Decree No. 1827 K/30/MEM/2018, namely 300 meters for heavy equipment and 500 meters for humans. By accurately evaluating blasting geometry, companies can reduce the risk of accidents and improve the effectiveness and safety of their operations.

Focusing on the blasting sequence at PT. Kuansing Inti Makmur, this research is expected to contribute to determining safe distances during blasting operations and considering flyrock throw distances during future blasting operations. The benefits of this research are understanding and experience gained directly from the field in blasting activities. To calculate blasting geometry, thus determining safe flyrock throw distances during blasting activities. To be used as a comparison or consideration in evaluating blasting geometry and flyrock throw distances. By accurately identifying flyrock and determining safe distances, the Company can minimize the risk of workplace accidents, injuries, and equipment damage and create a safer work environment.

2. METHODS

This research uses a quantitative method, which, according to Sugiyono (2019), is based on the philosophy of positivism and aims to test hypotheses through data collected from a specific population or sample using research instruments, then analyzed statistically. Primary data was obtained through direct observation and measurement in the field, while secondary data came from PT. Kuansing Inti Makmur (KIM) and various references such as journals, e-books, reports, and internet sources. This research falls into the applied research category, which aims to produce practical solutions to real-world problems. Applied research utilizes scientific knowledge and practical experience to develop effective solutions that positively impact real life. Furthermore, this research involves collaboration with relevant parties, such as industry or government agencies, to ensure the solutions developed can be implemented effectively and are relevant to field needs.

The location of the final project research is planned at PT. Kuansing Inti Makmur (KIM). The research period is scheduled for January–February 2025 and will last approximately one month. This research uses two types of data: primary and secondary data. Primary data was obtained directly from field observations and measurements, including the coordinates of the blasthole (initiation point), the coordinates of the furthest flyrock throw, blasting geometry data (such as burden, spacing, stemming, hole depth and diameter, powder factor, and average fill), and documentation using a drone. Meanwhile, secondary data was supporting data obtained from PT. Kuansing Inti Makmur (KIM) and other literature such as journals, e-books, reports, and the internet. Secondary data included design maps, blasthole reports, blasting equipment, explosive types, and rock characteristics.

The research began with a literature review, which involved reviewing various references related to blasting and safety distances. Next, field observations were conducted to directly observe all stages of the blasting operation, from planning and drilling to explosive loading, and to evaluate the blasting results. Data was collected directly in the field by measuring the blasting geometry using a roll meter, recording coordinates using a drone, and observing blasting activity to determine the furthest flyrock

throw. Secondary data was obtained from internal company documentation and other literature sources to support the analysis.

Data processing and analysis were conducted after all data were collected. Using Microsoft Excel, the goal was to evaluate the flyrock throw distance based on Ebrahim Ghasemi's theory. The data processing phase began by calculating the distance between the initiation and flyrock impact points using the Pythagorean Theorem. Next, the flyrock throw distance was calculated using Ebrahim Ghasemi's dimensional analysis method, considering parameters such as burden, spacing, stemming, blasthole depth and diameter, powder factor, and average charge. Subsequently, the actual flyrock throw distance was compared with the theoretical calculation results. Statistical analysis used correlation and determination coefficients to determine the relationship between blasting geometry parameters and flyrock distance. This research also included an analysis of the influence of each parameter on flyrock throw distance and an evaluation of the results of trials on the data obtained.

3. FINDINGS AND DISCUSSION

Blasting operations at PT. Kuansing Inti Makmur is carried out six times a week except Fridays. Blasting activities take place between 12:30 and 1:30 p.m. WIB. The following are the stages of the blasting operation at PT. Kuansing Inti Makmur:

Blasting Area Planning and Design

Planning and designing of the blasting area at PT. *Drill and Blast Engineering* PT carries out Kuansing Inti Makmur. Cipta Kridatama, which carries out planning and designing the blasting area, determines the blasting pattern, geometry, sequence, and the blasting production target expected by the company. *Drill and Blast Engineering's* purpose of this planning and design is to ensure that the blasting process is carried out safely, efficiently, and by established regulations.

Blasting Area Preparation

The *drill and blast engineer* begins to prepare the blasting area by leveling and cleaning the blasting area using a *bulldozer*. The construction of a safety embankment followed this, the installation of warning signs for the blasting area and barricade tape, and the installation of drill point markers. The following is documentation of the blasting area preparation:



Figure 1. Blasting Area Preparation

The blasting area preparation activities were carried out the day before the blasting and after the planning was completed *Drill and Blast engineer*.

Drilling

Drilling was carried out according to the previously installed drill points. During the drilling process in the blasting area, the HANWHA team used a vertical drilling method with the following drilling pattern: *Staggered Pattern*. The drilling machine used is a *Sepiroc XCR3045* with a drill bit type *clau bit* and the tip of the drill bit is using a pic. The following is documentation during the drilling process:



Figure 2. Mesin Boron Epiroc XCR3045

The type of rock that will be drilled is *sandstone*. Rock characteristics serve as a guideline in determining the design and geometry of the blasting.

Explosive Materials Escort

Transporting explosives requires careful attention to safety, legal regulations, and strict procedures. This process involves the control team from PT. Kuansing Inti Makmur, PT. Cipta Kridatama, PT. HANWHA and the security department ensure safe packaging, use of special vehicles, continuous monitoring, and compliance with the road to be passed to ensure that no dangerous incident occurs. Complete documentation and secure temporary storage are also important to ensure the process runs smoothly. Therefore, safety and regulation compliance are the most important aspects of transporting explosives.

Explosives Filling

Charging explosives is a very important process and requires careful attention. It begins with inserting a *plastic liner* into the blast hole, then combining the detonator and dynamite into *first*. After that, the blast hole is filled with primer and a mixture of *Ammonium Nitrate* and *Fuel Oil* according to the required amount. The following is documentation for filling explosives:



Figure 3. Explosives Filling

The Hanwha team may only carry out the process of filling explosives into the drill hole, because this process is very dangerous and requires strict security.

Charging Stemming

Stemming is the activity of closing blast holes using solid materials to withstand the energy from the blast (Septiawan, 2012). Charging *stemming* is done using a hoe, which is then compacted using a *stick*. The following documentation shows how to fill in the stemming:



Figure 4. Charging Stemming

The stemming material used comes from drilling cuttings and split rock with the following composition: *cutting-split-cutting*. Charging *cutting* first used to avoid tearing the plastic liner.

Tie Up

Tie Up is a networking activity that *surfaces a delay* (Christian et al., 2022). Networking is done by *blaster*. In accordance with the planned blasting pattern, the first hole to be exploded is also determined to determine the direction of the blast. After being combined using *hairer wire*, check again that the detonator connection is as planned. The tool used to insert the detonator *delay* is a *planner*. The following is the documentation of the process:



Figure 5. *Tie Up*

After all the series are ready, then *blaster* will connect *remote blaster* to the *hairline wire*. Then the *remote blaster* was left near the blasting area, which is considered safe.

Final Check

When all stages have been carried out, it will be implemented *clearing the area* by the *coordinator* *blasting* by the specified safe distance. The following is the final inspection documentation:



Figure 6. Final Check

After all stages have been completed, it is carried out *with a road block* on every road leading to the blasting area. The *blaster* is in a safe area for firing activities.

Post-Blasting Inspection

After the blasting operation, the inspection *blaster* returns to the blasting area to ensure *no misfires* and safe conditions. Operational activities can be resumed if the blasting area has been declared safe. However, if there *are misfires* or unsafe conditions, the *blaster* must take corrective action before mining activities continue (Sulistiyono, B. 2022). The following is documentation of post-blasting checks:



Figure 7. Post-Blasting Inspection

Using this electronic method, the *blaster* can find out where a problem occurs, but the company's SOP requires it. *Blast* to recheck the blasting area.

Analyzing Fragmentation Results

Once the blasting area has been declared safe, then *Drill and Blast Engineering* Documenting the blasting results to analyze the fragmentation results. The following is documentation of the fragmentation observation results:



Figure 8. Fragmentation Observation Results

Influence Powder Factor Regarding the Safe Distance for Throwing Flyrock

Blasting geometry is one of the parameters that influences the results of a blasting operation. A blasting operation can be successful if it conforms to the planned geometry and produces the expected fragmentation size (Adam et al., 2021). The blasting geometry applied to analyze the causal factors: *flyrock* covering *burden*, *spacing*, *stemming*, blast hole depth, blast hole diameter, *powder factor*, average blast hole filling, and *burden* initial. The parameters that have a major influence on blasting operations at PT. Kuansing Inti Makmur are *powder factor*. Here is a comparison between *powder factor* and throwing distance, *flyrock*, minimum, average, and maximum.

Table 1. Comparison Between Powder Factor and Throwing Distance Flyrock

No	Keterangan	Powder Factor	Lemparan Flyrock Aktual	Aman/Tidak
1.	Minimum	0,14 kg/bcm	3 meter	Aman
2.	Rata-rata	0,156 kg/bcm	5,6 meter	Aman
3.	Maksimum	0,18 kg/bcm	8 meter	Aman

Blasting activities at PT. Kuansing Inti Makmur Overall, although *flyrock* is a phenomenon that cannot be completely avoided in blasting, with careful planning and appropriate technology, the risks can be controlled to ensure optimal work safety. To prevent *flying rocks*, careful calculations, appropriate explosives, and strict supervision are required (Firmansyah, M. 2023). With the right technology and good management, the risk of *rock* can be minimized, ensuring a safer and more controlled blasting.

Findings *flyrock* At PT. Kuansing Inti Makmur, based on field observations, the results showed that the throwing of *flyrock* furthest is less than 50 meters, according to the Decree of the Minister of Energy and Mineral Resources No. 1827/K/30/MEM/2018, as far as 300m can be reduced the safe evacuation radius distance, with the consideration of minimizing evacuation costs. It can be concluded that implementing a safe distance of 150 meters can be done with the supervision of drilling and blasting operations. This study was only conducted to determine the safe distance for mechanical equipment up to 150 meters. In contrast, the safe distance for humans still refers to the "Decree of the Minister of Energy and Mineral Resources Number 1827 K/30/MEM/2018", which is 500 meters from the outermost boundary of the blasting area.

Other Factors That Affect Throwing Distance Flyrock

Apart from the geometric parameters of the blasting, of course, other factors influence the throw, *flyrock*. In field conditions, researchers found other factors, such as using materials *stemming* in the form of results, *cutting*, drilling is less effective when used in wet holes, and using a *stick* to compact *stemming*, which is not optimal, causing shallowing *stemming* usage *free face* at the time of blasting, and the use of blasting per segment.

The occurrence of *flyrock* is caused by the geometry of the blast. For example, "Burden(B), Space (S), Stemming (St), Hole depth (H), Hole diameter (D), Powder Factor (PF), Powder Column (PC)". The impact of the occurrence of *flyrock* is directly proportional to *powder factor*; the lower the value of *powder factor*, the closer the throw of *flyrock* (Maromon, A. et al. 2023). Other factors that affect the maximum throwing distance in the field are the conditions of the water holes, the use of materials *stemming*, suboptimal stemming compaction, *free face* at the time of blasting, and blasting per segment.

4. CONCLUSION

According to the research objectives, it significantly influences the throwing distance. *flyrock*, which is influenced by the blasting geometry factor, and other factors such as rock conditions and blasting methods. Evaluating the safe distance also shows the importance of strict supervision in reducing potential hazards due to blasting. Based on the influence of the results and discussions described, it can be concluded that: Blasting operations at PT. Kuansing Inti Makmur include: Planning and designing the blasting area including determining the area to be blasted, how large the area will be blasted, and making a blasting design; Preparation of the blasting area including arranging the area, marking the area, determining the points where drilling will be carried out, and preparing safety and safe distances; Drilling; Charging explosives; Charging stemming; Tie up; Blasting; Post-blasting and checking of blasting results.

It is recommended that road use be prioritized when transporting explosives from the explosives warehouse to the blasting site. This will minimize any untoward incidents during transport. Monitoring the quality of the explosives is essential, stemming and using hoes and sticks during stemming compaction. Supervision and monitoring are carried out during the process stemming. To ensure the processing results meet the desired objectives, install warning signs at every access road leading to the blasting area. Warning signs should be strategically located and visible, with a short, concise, and easy-to-understand message.

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