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OPERATING COST COMPARISON SURFACE MINER AND DRILL & BLAST

PERBANDINGAN BIAYA OPERASIONAL SURFACE MINER *DAN PENGEBORAN & PELEDAKAN*

RADEN H. HANDAYANA[1*], PANJI PRATAMA[2], JIHAN F. LUBIS[2] and SANI SALAHUDIN[2]
[1] Indonesia Blasting Engineers Society (IBES)
[2] Hanwha Mining Service Indonesia (HMSI)
* Corresponding e-mail: haris.handayana@gmail.com

ABSTRACT

The method of rock breakage is commonly blasting. A few mining companies in Indonesia with facilities near community residences use alternative methods to breaking rock; one of them is using a surface miner. Aspects considered when choosing the method include economic aspects, especially operating costs. In this study case, the size of material that can continue on the next process is ≤ 400 mm; material from surface miner production is at the target; on blasting results, the fragmentation above the target is reduced using a hydraulic breaker; the initiating systems use an electronic detonator (HEBS II) and a non-electric detonator. This difference will affect the cost of the drill and blast. Based on calculated project data, surface miner operating costs are more costly, with an operating cost per ton of USD 1.16 compared with drill and blast methods including hydraulic breaker costs on the initiation system using an electronic detonator (HEBS II) of USD 0.88 per ton and non-electric operating costs of USD 0.83 per ton.

Keywords: operating cost, surface miner, fragmentation, drill and blast, initiation system.

ABSTRAK

Metode pemberaian batuan umumnya menggunakan peledakan, beberapa perusahaan tambang di Indonesia dengan kondisi dekat tempat tinggal warga menggunakan metode alternatif untuk memberai batuan, salah satunya menggunakan surface miner*, aspek untuk memilih metode salah satunya ialah aspek ekonomi, terutama biaya operasional. Pada studi kasus ini ukuran material yang dapat berlanjut ke proses berikutnya adalah ≤ 400 mm, material hasil produksi* surface miner *memenuhi target tersebut, pada hasil blasting fragmentasi melebihi target dikurangi ukurannya menggunakan hidrolik* breaker*, sistem inisiasi yang digunakan* electronic detonator *(HEBS II) dan* non-electric detonator*, perbedaan ini akan berdampak pada biaya pengeboran dan peledakan. Berdasarkan perhitungan dari data proyek biaya operasional* surface miner *lebih mahal dengan biaya operasional per ton $ 1,16 dibandingkan dengan pengeboran dan peledakan sudah termasuk biaya hidrolik breaker pada sistem inisiasi menggunakan detonator elektronik sebesar $ 0,87, pada detonator* non-electric *biaya operasional sebesar $ 0,83 per ton.*

Kata kunci: biaya operasional, surface miner*, fragmentasi, pengeboran dan peledakan, sistem inisiasi.*

INTRODUCTION

Operating costs are the costs needed to produce a product and are associated with the maintenance and administration of the business on a daily basis. There are many different methods used in progress mining; every method will have different equipment, effectiveness, efficiency, and processing, which all have different operating costs. Mining is the process of extracting useful materials from the earth with various rock strengths. There are methods to break rock, and two of them commonly used are the mechanical method and conventional methods like drilling and blasting (Zhou, Xie and Feng, 2018). The mechanical method uses mechanical tools to break rock; surface mining is one of them. Drilling and blasting are categorized as conventional methods for breaking rock that use explosives. Each method has a different operation cost that

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must be considered in many aspects. This study focused on analyzing the operating cost comparison based on the actual condition provided by a limestone mine company in Indonesia with the utilization of two methods of rock breakage: surface mining as a mechanical method and drilling and blasting as a conventional method. The drilling and blasting processes are applied with two different initiation system: an electronic detonator (HEBS II) and a non-electric detonator. The required material size target result is ≤ 400 mm. The surface miner is capable of directly producing the required size. Compared to the drilling and blasting methods, the result size of the material exceeded the requirement size; the oversize material needed to undergo a reduction process using a hydraulic breaker. In this comparison, breaker costs are also included in drilling and blasting costs.

METHODOLOGY

The research method for this study case uses quantitative analysis methods. The data was gathered from the actual site conditions.

Primary data is taken from direct measurements of fragmentation; secondary data includes blast geometry, reports on the use of explosives, initiation system that was used; secondary data from the surface miner includes maintenance costs, fuel usage, hours meter, manpower costs, and production of the surface miner. In summary, the following chart explains the study case methodology.

Operating Cost

Operating costs are an amount that should be paid or spent to obtain production or income and then re-used as re-income. In business, one of the costs that has to be spent is the operating cost, which is the cost associated with the operation of a device, component, piece of equipment or facility. It is the cost of operational production. Operating costs fall into three categories (Singh *et al.*, 2017):

1. Fixed Cost
   Fixed costs are costs that do not vary with production; these costs are incurred regardless of the production level during the period.
2. Variable Cost
   Variable costs are costs that are tied directly to physical production and are only incurred if there is production.
3. Combined Cost
   The costs are incurred whether there is production or not.

Operating costs from different methods and equipment will have different variables that influence the fixed and variable costs. Figure 2 below explains the variables of operating cost for the surface miner (SM) and drilling and blasting.

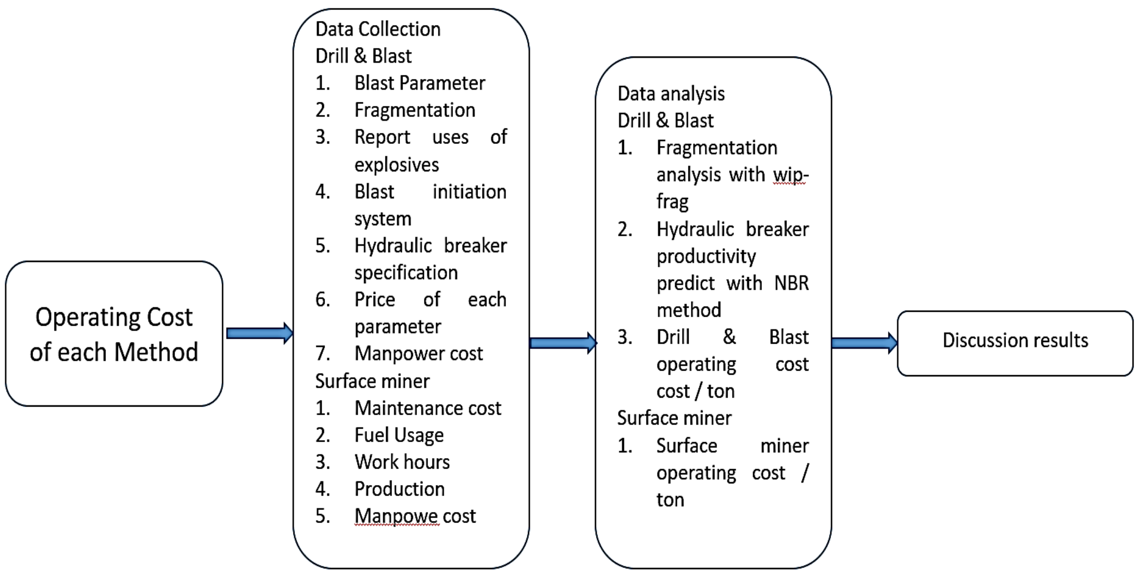

Figure 1. Study case methodology

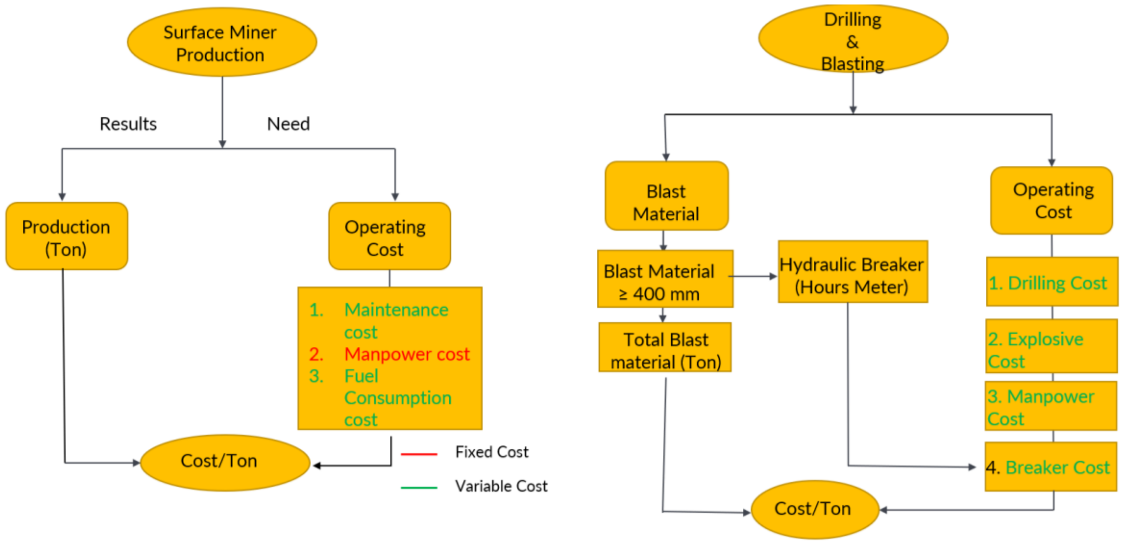

Figure 2. SM & Drill – Blast cost element on operating cost (K, Kishore. Nawal)

Following the Figure above, the operating cost of a surface miner and drilling and blasting equations for each method can be seen as follows:

$$SM=\frac{\text{Mtc cost+Fuel cost+manpower cost}}{\text{Production}} \quad (1)$$

$$DB=\frac{\text{(drill+explosive+manpower+breaker) cost}}{\text{Production}} \quad (2)$$

Net Breaking Rate

The productivity of the hydraulic breakers depends on the geomechanical properties and technical specifications of the machines (Aksoy, 2009). The breaking rate, or productivity, is the most reliable factor determining the duration of the rock mass excavation (Tumac and Hojjati, 2016). The net breaking rate (NBR) is the rate that could be produced from the machinery's computed power and the so-called rock mass cuttability index (RMCI). NBR is calculated based on the following formula (Bilgin, Yazici and Eskikaya, 1996; Ocak, Seker and Rostami, 2018), such as below:

$$NBR = 4.24 \times P \times RMCI^{-0.567} \quad (3)$$

Where

NBR = Net Breaking Rate in M^3/hour

P = Power of the hydraulic breaker in horsepower

RMCI = Rock Mass Cuttability Index which is computed as in Equation 4.

$$RMCI = UCS \times \left(\frac{RQD}{100}\right)^{2/3} \quad (4)$$

The quality and condition of machinery shall be justified; the efficiency of the machinery in this case is assumed at 75%, and the power of the machine in horsepower is computed below.

$$P = 1.714 \times 0.75 \times q_o \times \sigma_{oil} \quad (5)$$

Where

q_0 = the oil flow rate in gallon per minute

σoil = Operating Oil Pressure in Psi

Rock hardness has an impact on fragmentation and net breaking rate of hydraulic breaker (Kujundžić *et al.*, 2008); the UCS test is a key parameter that provides information about the material's strength and stability (Pandey and Praksh, 2020). The UCS values were taken from the average data result obtained from intact boreholes core data. The RQD variable was taken from Table 1, with conditional RQD values assumed to be of good quality using the RQD Index (Abzalov, 2016).

Table 1. RQD Index and UCS

Rock Quality	RQD Index (%)	UCS (Mpa)
Very poor	0 – 25	
Poor	25 – 50	
Fair	50 – 75	55.4
Good	75 – 90	
Excellent	90 – 100	

RESULTS AND DISCUSSION

The surface miner's operating cost

Surface miner operating costs mostly come from parts (Dey and Ghose, 2008). Surface miners need primary parts such as cutting picks (teeth) installed in the shearer drum to operate normally. The cutting picks are usually easy to tear due to the damage produced from grinding and cutting rock. The other part of SM that continually needs replacement, besides the cutting pick, is the block. All of these parts are included in the operating costs. Table 2 shows the numbers of parts and other variables that were calculated as continuous variable costs and included in operating costs.

Fuel consumption data collected from a 7-month production can be seen in Figure 3. Maintenance, a set of processes and practices that aim to ensure the continuous and efficient operation of equipment, is important and certainly requires costs. Maintenance is commonly divided into two types: routine and major breakdowns. Cutting picks and blocks are parts included in maintenance costs; as per the rule, lubrication costs are 30% of diesel consumption; in this case, lubrication costs are included in maintenance costs. Surface miner operating costs per ton are assumed to be based on the average cost that was spent for production in 7 months. The average operating cost per ton to operate a surface miner can be seen in Figure 4.

Table 2. Variable for operating surface miner

Continuous Variable for Operating		
Routine Parts		Fuel
Teeth	Block	

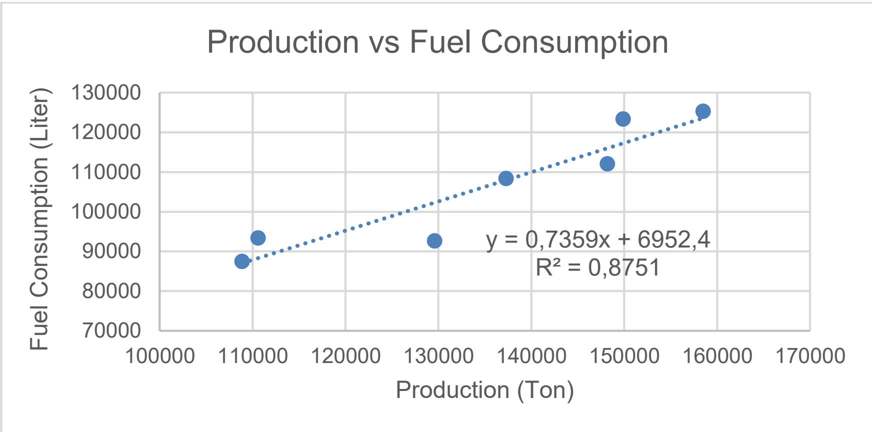

Figure 3. Effect fuel consumption on production of surface miner

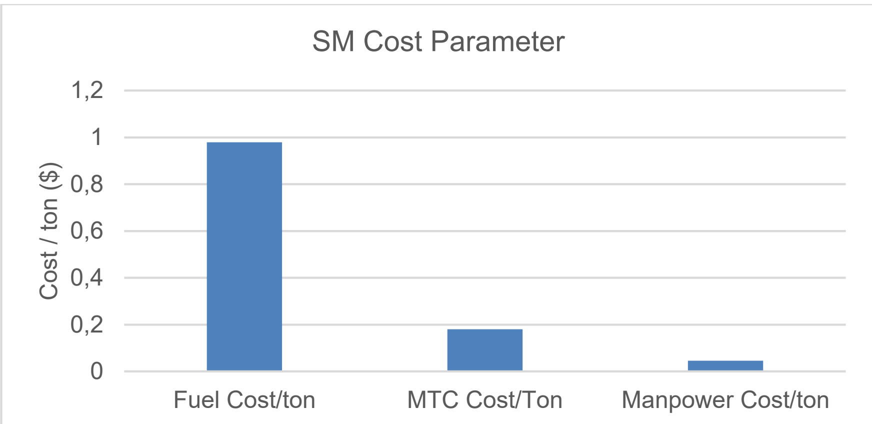

Figure 4. Surface miner operating parameter cost per ton

Drilling & Blasting Operating Cost

Drilling and blasting are activities that cannot be separated, and the costs must be spent to operate drilling and blasting (Malbašić *et al.*, 2015). In this case, drilling is undertaken by a contractor, and manpower costs on drilling and blasting fall under variable cost categories because manpower costs are paid if there is production. The main operating cost on blasting is the explosives cost that is spent on the initiation system. In this case study, the initiation system used is an electronic detonator (HEBS II), a non-electric detonator blasting agent, and dynamite. The price preference for drilling from drill and blast services used CRD as drilling machines, with a cost per meter for drilling service. The blast parameters that are used on site can be seen in Table 3.

Table 3. Drill and blast parameter (site condition based Anggara (2017))

Parameter	HEBS II	Nonel
Burden (m)	2.8	2.8
Spasi (m)	3.5	3.5
Hole Diameter (mm)	89	89
Hole Depth (m)	9	9
Stemming (m)	2	2
Charge length (m)	7	7
Volume (BCM)	88.2	88.2

The following parameters used on site, drill and blast operating costs on HEBS II and non-electric detonators can be seen in Table 4.

Table 4. Drill and blast operating cost at TSS

Parameter	HEBS II	Nonel
Drilling $/m	3.3	3.3
Drilling $/Hole	30	30
Drilling $/Ton	0.34	0.34
Total Explosive $/hole	151.81	140.82
Total Explosive $/BCM	1.72	1.60
Total Explosive $/Ton	0.69	0.64
Man Power $/BCM	0.06	0.06
Drill Blast Cost $/BCM	2.12	1.99
Drill Blast Cost $/Ton	0.85	0.80
Breaker Cost per Hour ($)	34.7	34.7

Using the equation above, with the assumed rock parameter of RQD value and hydraulic breaker specification, the net breaking rate hydraulic breaker value in this case can be seen in Table 5.

Table 5. NBR parameters (calculated by site condition)

RMCI		P (Horsepower)		
RQD (%)	UCS (MPa)	qo (m^3/h)	σoil (Mpa)	NBR (m^3/h)
80	55.4	10.74	19	99.3

The data that has been collected with a stemming length of 2.5 m on the HEBS II eight-blast event and a five-blast event on Nonel, as well as fragmentation results with different stemming lengths and initiation systems, can be seen in Table 6. Fragmentation analysis uses digital image analysis of rock photograph to determine grain size distribution (Nanda and Pal, 2020). The average oversize material from blast using HEBS II and Nonel and predicted hydraulic breaker work hours using the NBR method per volume blast per hole can be seen in Table 6. Drill and blast operating costs, which include hydraulic breaker costs can, be seen in Figure 5 and 6. The operating cost of a surface miner and drill and blast, which includes a hydraulic breaker, can be seen in Figure 7.

Table 6. Breaker work hours prediction calculated based equation on Ismael *et al.* (2021)

Oversize Material in 88.2 BCM (1 Hole)		
	HEBS	Nonel
% oversize	21.03	24.594
Breaker WH	0.19	0.22

Table 7. Percentage oversize material

Oversize Material on Blast Used HEBS II			
No	Date	> 400 mm (%)	Blast Volume (BCM)
1	10/10/2022	22.45	4233.6
2	13/10/2022	19.87	3528
3	17/10/2022	28.18	3528
4	24/10/2022	23.04	3704.4
5	31/10/2022	21.03	5203.8
6	03/11/2022	20.48	4586.4
7	21/11/2022	14.79	3792.6
8	29/11/2022	18.4	3969
9	12/12/2022	13.55	3263.4
10	14/12/2022	15.96	3704.4
Average		19.775	3951.36

Oversize Material on Blast Used Nonel			
No	Date	> 400 mm (%)	Blast Volume (BCM)
1	09/11/2022	33.85	4233.6
2	22/11/2022	26.69	3704.4
3	28/11/2022	15.33	4410
4	01/12/2022	25.92	3528
5	05/12/2022	21.18	3528
6	19/12/2022	20.22	3969
7	23/02/2023	36.55	3704.4
8	08/03/2023	12.46	4057.2
	Average	24.594	3880.8

Figure 5. Drill and blast and hydraulic breaker cost

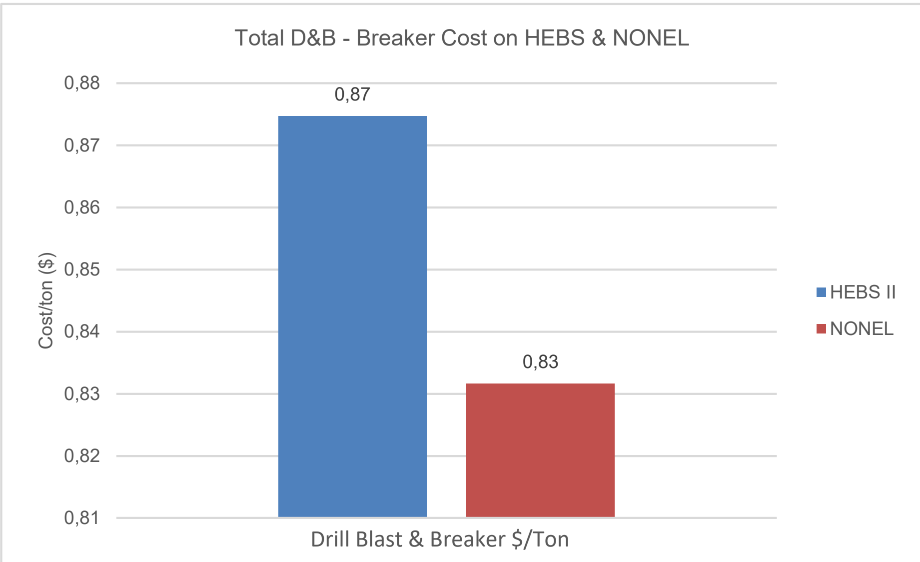

Figure 6. Total operating cost on drill and blast

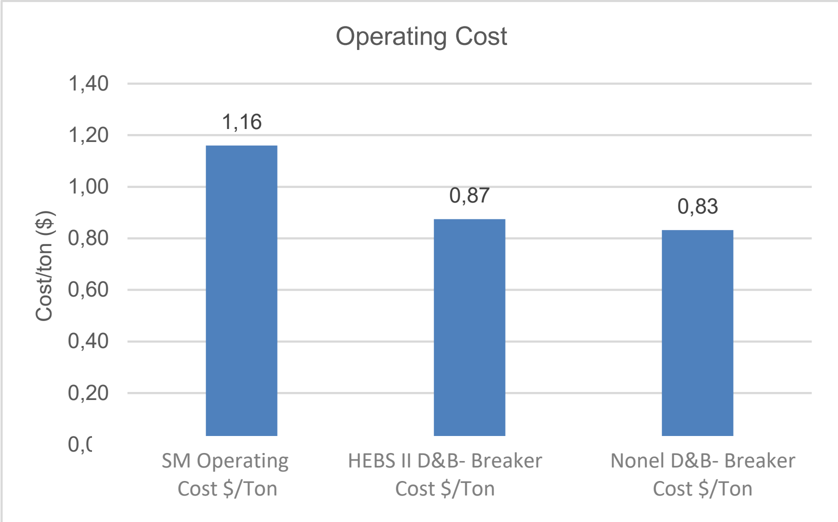

Figure 7. The surface miner – drill and blast operating cost per ton

CONCLUSION AND SUGGESTION

Conclusion

The above calculation shows that the operating cost of surface miner is higher than that of drill and blast method, even without the need for secondary breakage the material from surface miner production, with operating cost per ton is USD 1.16 per ton. Compared to conventional method using drilling and blasting plus secondary breakage method, the operating cost is only USD 0.87 per ton using HEBS II and USD 0.83 per ton using non-electric detonators. The cost is more efficient, saving USD 0.29 with using drilling and blasting method.

Suggestion

The net breaking rate to approximate productivity of hydraulic breaker, with the factors that influence it, are machine power and geomechanical properties. This method does not calculate the detail of breaker productivity if there is a size material target. More data collection is required for the specifics and actual duration of the hydraulic breaker.

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