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PERFORMANCE AND OPERATIONAL COSTS OF STRIPPING OVERBURDEN AT PT BUMI SEKUNDANG ENIM ENERGY

KINERJA DAN BIAYA OPERASIONAL PENGUPASAN OVERBURDEN PADA PT BUMI SEKUNDANG ENIM ENERGY

M. Puspita*[1], S. Wijaya[2], E. Oktarinasari[3], F. Mahdyrianto[4], Erwedi[5]
[1-3,5]Jurusan Teknik Pertambangan, Fakultas Teknik, Universitas Sriwijaya
[4]Program Studi Teknik Pertambangan Batubara, Politeknik Akamigas Palembang
[1-3,5]Jalan Raya Palembang-Prabumulih KM 32, Indralaya, Kabupaten Ogan Ilir, Telp (0711) 580739
[4]Area Diklat Plaju, Jl. Kb. Jahe, Komperta, Kec. Plaju, Kota Palembang, Sumatera Selatan 30268
e-mail: *[2]megapuspita@ft.unsri.ac.id

ABSTRACT

The plan for overburden stripping at PT Bumi Sekundang Enim Energy's Pit AB was 332,829.17 BCM/month, but the company was unable to achieve this target. This study aims to evaluate the performance of overburden stripping, identify obstacles that affect overburden stripping, and calculate the costs of overburden stripping before and after improvements are made to overcome these obstacles. This study uses a descriptive-analytical quantitative approach with a case study at PT Bumi Sekundang Enim Energy. The actual productivity of the transport equipment obtained is 20.5 BCM/hour, lower than the specified target of 22.37 BCM/hour. The failure to achieve this overburden stripping was due to obstacles that reduced effective working time and mechanical equipment efficiency. Improvements were made to delay time and idle time, successfully reducing total downtime by 40.64%. As a result, mechanical equipment efficiency increased to 77.82%. After the improvements were made, the productivity of the transport equipment increased to 25.67 BCM/hour and the overburden stripping target was achieved with a percentage of 114.76%. The operational costs of overburden stripping consist of excavation and transportation costs by mechanical equipment. The costs taken into account include fuel, lubricants and filters, tire and undercarriage replacement, ground engaging tools replacement, and operator wages. The operational cost of stripping overburden before the improvement was Rp 20,473/BCM, but after the improvement, the cost decreased by 20.14% to Rp 16,350/bcm.

Keywords: productivity evaluation, operational costs, overburden stripping, effective utilization, work obstacles

ABSTRAK

Rencana pengupasan overburden pada Pit AB PT Bumi Sekundang Enim Energy sebesar 332.829,17 BCM/bulan, namun perusahaan tidak mampu merealisasikan target tersebut. Penelitian ini bertujuan untuk mengevaluasi performa stripping overburden, mengidentifikasi hambatan yang mempengaruhi pengupasan overburden, dan menghitung biaya pengupasan overburden sebelum dan setelah dilakukan perbaikan waktu hambatan. Penelitian ini menggunakan pendekatan kuantitatif deskriptif-analitik dengan studi kasus pada PT Bumi Sekundang Enim Energy. Produktivitas aktual alat angkut yang diperoleh sebesar 20,5 BCM/jam, lebih rendah dari target yang ditentukan yaitu sebesar 22,37 BCM/jam. Tidak tercapainya stripping overburden ini disebabkan oleh hambatan-hambatan yang membuat waktu kerja efektif dan efisiensi alat mekanis rendah. Perbaikan waktu hambatan dilakukan pada delay time dan idle time, berhasil mengurangi total waktu hambatan hingga 40,64%. Akibatnya efisiensi alat mekanis meningkat hingga mencapai 77,82%. Setelah dilakukan perbaikan, produktivitas alat angkut meningkat menjadi 25,67 BCM/jam dan target stripping overburden tercapai dengan persentase 114,76%. Biaya operasional pengupasan overburden terdiri atas biaya penggalian dan pengangkutan oleh alat mekanis. Biaya yang diperhitungkan antara lain biaya bahan bakar, pelumas dan filter, penggantian ban dan undercarriage, penggantian GET, dan upah operator. Biaya operasional stripping overburden sebelum perbaikan waktu hambatan adalah Rp 20.473/BCM, namun setelah dilakukan perbaikan, biaya mengalami penurunan hingga 20,14% menjadi sebesar Rp 16.350/bcm.

Kata kunci: *evaluasi produksi, biaya operasional, pengupasan overburden, effective utilization, hambatan kerja*

INTRODUCTION

According to the Mineral and Coal Mining Law No. 3 of 2020, mining is part or all of the stages of activities in the management and exploitation of minerals or coal. These stages include general investigation, exploration, feasibility studies, construction, mining, processing and refining, development and utilization, transportation and sales, as well as post-mining activities [1]. One part of the mining process is exploitation. Exploitation or mining activities in the context of mining cannot be separated from excavation, loading, and transportation. In coal exploitation, these three processes are carried out on coal material and overburden or interburden. In overburden material, these excavation, loading, and transportation activities are intended to expose valuable excavated material so that coal can be extracted or mined.

PT Bumi Sekundang Enim Energy is a coal mining company located in Talang Ubi District, Penukal Abab Lematang Ilir Regency, South Sumatra Province. The overburden stripping process at this company is carried out by direct excavation because the material is claystone with a rock compressive strength of less than 50 MPa. The overburden stripping plan at PT Bumi Sekundang Enim Energy is 332,829.17 BCM/month, but the company has been unable to achieve this overburden stripping target. This indicates that there are obstacles to overburden stripping activities, resulting in low productivity of loading and unloading equipment and/or transportation equipment.

These obstacles can be constraints that cause high circulation time for loading and/or transport equipment. Other obstacles can also be constraints on the use of equipment working time. Constraints that can affect equipment circulation time include increased waiting time, unsuitable transport route geometry, and so on. Meanwhile, constraints that can affect efficiency in the use of available working time include operators starting work late, operators taking breaks too early, operators starting work late after breaks, and operators engaging in other activities outside of work. This can result in low efficiency in the use of equipment and reduced productivity.

Similar research was conducted by Dwi Herniti, et al (2023), who evaluated the productivity of loading and transport equipment in overburden stripping in North Bengkulu Regency [2]. This study showed that the productivity of loading and transport equipment was not achieved due to long waiting times for loading because the match factor value was less than 1. Research by Taufik Hidayat, et al (2023) calculated the cost of overburden stripping at PT Internasional Prima Coal, East Kalimantan [3]. This study concluded that it costs IDR 1,206,354,904 per month for overburden stripping.

Another study by Mega Puspita, et al (2015) examined the technical and economic costs of overburden removal using the ripping method [4]. From a technical perspective, the production achievement rate was 87%. The cost of ripping/bcm of rock with an equipment rental scheme was IDR 5,593.95/bcm, while for the equipment purchase scheme it was IDR 3,193.47/bcm. Research by Muhammad Ilham Kadar, et al (2022) examined the effect of working conditions on the productivity of mechanical equipment in overburden stripping [5]. The results show that workplace conditions such as haul road width, road slope, mining front conditions, and so on affect the working efficiency of loading equipment (71.1%) and transport equipment (70.43%). Another study by Esthi Kusdarini, et al. (2023) analyzed the cost of overburden stripping in Central Sulawesi [6]. Using a combination of excavators and dump trucks in the pit and bulldozers and excavators in the disposal area, the stripping cost was calculated to be IDR 13,244,180,800.

Some previous studies evaluated the productivity of equipment in overburden stripping activities, but did not identify the obstacles that caused the productivity of the equipment to decline. In addition, this study also linked this to the operational costs of overburden stripping, which would be affected by the low productivity of the equipment in these activities. Low equipment productivity will result in increased overburden excavation and transportation costs. Thus, this study provides a more comprehensive view of the problem of low productivity in overburden stripping activities, identifies obstacles and solutions, and examines their relationship to the operational costs of these activities.

RESEARCH METHOD

Research Location

This research was conducted at PT Bumi Sekundang Enim Energy, located in Talang Bulang Village, Talang Ubi Subdistrict, Penukal Abab Lematang Ilir Regency, South Sumatra Province. The research location is approximately 15 km from the center of Talang Ubi. A map of the location of PT Bumi Sekundang Enim Energy.

Research Stages

The research was conducted in stages, starting from literature study, data acquisition, data processing, analysis and discussion, and conclusion.

1. Data Acquisition

   The primary data used included tool cycle time data and field obstruction time data. In addition, there was also secondary data obtained from literature studies, handbooks, or company archives, including specifications and number of tools, bucket fill factor, swell factor, excavator and transport operational costs, and working time data.

2. Data Processing
   Data processing was carried out after the primary and secondary data were obtained. The following are the stages of data processing:
   a. Primary data in the form of equipment cycle time and work efficiency were then used to calculate equipment productivity. Data processing was carried out by inputting primary data into Microsoft Excel, thereby obtaining the actual productivity of overburden excavation and transportation in the field.
   b. Next, actual costs for overburden excavation and transportation are calculated using secondary data. Actual costs are obtained by dividing the hourly operating cost of equipment (Rp/hour) by the actual productivity of excavators and dump trucks. Next, the total actual cost of overburden excavation and transportation is calculated per BCM (Rp/BCM).
   c. Identify obstacles that cause low actual productivity. Efforts are then made to overcome these obstacles so as to reduce and minimize work time wasted due to various work obstacles.
   d. After work obstacles are minimized, the productivity of loading and transport equipment is calculated after efficiency and work time have increased.
   e. Then, the operational costs of overburden stripping are calculated after the productivity of the equipment has been improved.
3. Analysis and Discussion
   Analysis and discussion were conducted on the data processing results obtained in the previous stage. The discussion section will discuss the actual productivity of loading and transport equipment. Next, an evaluation of this productivity will be discussed to assess whether it has met the target or not. The next discussion relates to the identification of obstacles that arise in overburden stripping activities. Then, obstacles that can be minimized to increase efficiency will be discussed. After that, the operational costs of overburden stripping activities (excavation and transportation) will be discussed based on actual productivity and productivity after the elimination of obstacles.

Productivity of Excavators and Transport Vehicles

The mechanical equipment commonly used for overburden removal activities are excavators and dump trucks. The productivity of each of these machines and the compatibility between excavators and transport vehicles will affect the production process. Excavator productivity can be calculated using the following equation [7, 8, 9].

$$P = \frac{Kb \ x\ Fb\ x\ SF\ x\ Eff\ x\ 3600}{CT} \qquad (1)$$

Description:
P = Excavator productivity (BCM/hour)
KB = Bucket capacity (m3)
Eff = Work efficiency
FB = Bucket factor
SF = Swell factor
CT = Digging-loading cycle duration (seconds)

Dump truck productivity is obtained using the following equation [7, 8].

$$P = \frac{n\ x\ Kb\ x\ Fb\ x\ SF\ x\ Eff\ x\ 3600}{CT} \qquad (2)$$

Description:
P = Productivity of dump truck (BCM/hour)
n = Number of fillings
KB = Bucket capacity (m3)
Eff = Work efficiency
FB = Bucket factor
SF = Swell factor
CT = Excavator loading cycle duration (seconds)

The compatibility between the excavator and the transport vehicle can be evaluated by calculating the match factor as follows [8].

$$MF = \frac{n\ x\ Ctm\ x\ Na}{Cta\ x\ Nm} \qquad (3)$$

Description:
MF = match factor
Na = number of transport vehicles
Nm = number of loading vehicles
Cta = transport vehicle circulation time (seconds)
Ctm = loading equipment circulation time (seconds)
n = truck loading frequency

The above equation describes three possible results for the match factor, namely:
1. When MF > 1, it indicates that the transport equipment is idle because it has to wait for the loading equipment.
2. When MF < 1, it indicates that the loading equipment experiences idle time or stops working because it has to wait for the transport equipment.
3. When MF = 1, it indicates that the work of the loading and transport equipment is balanced, where both have the same level of activity and neither has to wait.

Mechanical Equipment Availability

Equipment availability is a factor that indicates the condition of mechanical equipment used in mining activities, taking into account lost time during operation. The level of availability and effective use of equipment can be parameters that affect the productivity of mechanical equipment. The following are the types of mechanical equipment availability [10]:

1. Mechanical Availability
   Mechanical Availability is an availability factor that indicates the mechanical readiness of a tool compared to total working time and repair time. Mechanical availability can be calculated using the following equation.

$$MA = \frac{W}{W+R} \times 100\% \quad (4)$$

   Description:
   W = working hours
   R = repair hours

2. Physical Availability
   Physical Availability is an availability factor that measures the physical availability of equipment in the field. Physical availability can be calculated using the following equation.

$$PA = \frac{W+S}{W+R+S} \times 100\% \quad (5)$$

   Description:
   W = working hours
   S = standby hours
   W+R+S = total available time

3. Use of Availability
   Use of Availability indicates the percentage of time that equipment is used to operate when it is available for use. The calculation of use of availability can be seen in the following equation.

$$UA = \frac{W}{W+S} \times 100\% \quad (6)$$

   Description:
   W = working hours
   S = standby hours

4. Effective Utilization
   Effective utilization is availability that shows the level of effective use of equipment compared to total available time. Effective utilization can be calculated using the following equation.

$$EU = \frac{W}{W+R+S} \times 100\% \quad (7)$$

   Description:
   W = working hours
   W+R+S = total available time

Mechanical Equipment Operating Costs
Mechanical equipment operating costs are expenses incurred while the equipment is being used in the field. The amount of operating costs depends on the condition of the equipment, the length of time it is used, and the efficiency of the equipment [11]. These costs include all forms of costs directly related to the operational activities of the equipment, such as [12]:

1. Fuel
   Fuel consumption per hour varies for each type of equipment. The higher the horsepower (hp) of the equipment, the greater the fuel requirement. Fuel consumption will also increase if the engine is working hard. Simply put, the cost of fuel consumption per hour for mechanical equipment can be calculated by multiplying the amount of fuel required per hour (liters) by the price of fuel per liter [13].
2. Lubricants and filters
   Lubricant requirements for each tool also vary depending on engine power, crankcase capacity, and lubricant replacement intervals. Lubricant costs are calculated by multiplying the lubricant requirement per hour (liters) by the price per liter. Filter replacement costs can be assumed to be 50% of lubricant costs.
3. Maintenance or repairs
   These maintenance or repair costs include tire replacement, replacement of worn components, battery replacement, or undercarriage and attachment repairs. Tire and track replacement is estimated based on the working conditions. The cost of tire and track replacement can be calculated by dividing the price of the tire/track by the length of time it is used in hours.
4. Operator wages
   Operator wages vary from company to company. Some companies pay operators hourly wages, while others hire operators as permanent employees and pay them a fixed monthly salary. Hourly operator wages can be calculated by dividing the total monthly salary by the number of hours worked per month.

RESULT AND DISCUSSION

Evaluation of Overburden Stripping Achievement
The overburden stripping process was carried out on four fleets using mechanical equipment, namely Komatsu PC400LC excavators and Hino 500 FM 280JD dump trucks. Each fleet consisted of one loading machine and five transport machines. The productivity of the loading and transport equipment was calculated based on actual conditions and cycle times in the field. The following is a calculation of the productivity of the loading and transport equipment (Table 1).

Based on the results of the calculation of the productivity of the loading and transport equipment in Table 1, an evaluation of the achievement of overburden stripping activities was then carried out. By adding up the production of the four fleets, it is known that the actual monthly production of the excavator is very good, reaching 153.15% of the set target (Table 2). However, the actual production of the transport equipment is below the set production target, reaching only 91.65%.

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The company has adjusted the monthly production targets to the production capacity of the mechanical equipment used. The failure to achieve the production target for transport equipment indicates that there are obstacles that cause low productivity of transport equipment and ultimately prevent the overburden stripping target from being achieved.

Table 1. Actual Productivity of Excavators and Haulers

Mechanical Tools	Parameters		Productivity (BCM/hour)
Excavator Komatsu PC400LC	Bucket capacity (m^3)	2.20	171.28
	Fill factor	0.82	
	Swell factor	0.80	
	Cycle time (s)	20.59	
	Efficiency (%)	68.26	
Dumptruck Hino 500 FM 280 JD	Bucket capacity (m^3)	2.20	20.5
	Fill factor	0.82	
	Swell factor	0.80	
	Cycle time (s)	789.34	
	Efficiency (%)	62.63	
	Numbers of fills	5	

Table 2. Achievement of *Stripping Overburden*

Mechanical Tools	Parameters	Outcome
Excavator Komatsu PC400LC	Productivity (BCM/hour)	171.28
	Tools quantity (unit)	4
	Total productivity (BCM/hour)	685.12
	Production target (BCM/month)	332829.17
	Actual production (BCM/month)	509729.28
	Achievement (%)	153.15
Dumptruck HINO 500 FM 280JD	Productivity (BCM/hour)	20.5
	Tools quantity (unit)	20
	Total productivity (BCM/hour)	410
	Production target (BCM/month)	332829.17
	Actual Production (BCM/month)	305040
	Achievement (%)	91.65

Obstacles to Overburden Stripping Achievement

The failure to achieve the overburden stripping target was due to low transport equipment productivity. Thus, obstacles were identified in overburden transport activities. Based on the observations, several obstacles were identified in overburden stripping activities, consisting of avoidable obstacles (delay time) and unavoidable obstacles (idle time).

The total actual obstacle time recorded reached 278.03 hours per month (Table 3). Delay time reached 113.57 hours or about 40.8% of the total obstacle time. The longest delay time occurred during the loading queue, followed by front preparation and other general needs. Actual idle time contributed to more than 59% of the total obstacle time. The main causes were rest time, slippery conditions, and unscheduled maintenance.

Table 3. Total Downtime Before and After Repairs

No.	Type of Obstacles	Loss Time Before Repairs (hours)	Loss Time After Repairs (hours)
Avoidable Obstacles (*Delay time*)			
1	Late start	10.33	1.03
2	Work front preparation	13.95	2.58
3	Refueling	11.59	5.68
4	Pray and general needs	13.18	2.07
5	Loading queue	38.68	6.79
6	Rest too early	9.26	1.03
7	Late start after rest	6.98	1.03
8	Ending work too quickly	9.60	1.03
Unavoidable Obstacles (*Idle time*)			
9	P2H & warming-up engine	12,33	4,13
10	Rest	77,5	77,5
11	Raining	11,81	11,81
12	Slippery	23,62	23,62
13	Unschedule maintenance	15,2	15,2
14	Friday Pray	3,76	3,76
15	Shift Change	10,19	2,58
16	P5M Safety Talk	10,04	5,17
Total *Delay Time*		**113,57**	**21,26**
Total *Idle Time*		**164,46**	**143,78**
Total		**278,03**	**165,04**

The main improvement in delay time was made to the delay time. The total delay time decreased to only 21.26 hours after the improvement, or by 81.28%. The reduction in delay time was made in all aspects, one of which was the loading queue time, which initially took up to 39 hours per month and was reduced to 6.8 hours (Table 3). In idle time, the reduction in bottleneck time was not very significant. After the improvement, the bottleneck time in idle time decreased by 12.57%. Idle time in the form of breaks, rain, slippery conditions, unscheduled maintenance, and Friday prayers cannot be avoided. Idle time can only be reduced during P2H and equipment warm-up, shift changes, and safety talks. Improvements in delay time and idle time overall resulted in a significant reduction in total downtime of 40.64%.

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The decrease in total downtime will increase the amount of effective working time as well as the efficiency value of equipment usage. Effective working time increased significantly to 578.96 hours. In addition, the efficiency value of mechanical equipment increased to 77.82% from the previous 62.63% (Table 4).

Table 4. Efficiency and Effective Working Time After Repairing

Description	Value	Unit
Available working hours	744	hours
Delay time	165.04	hours
Effective working hours	578.96	hours
Efficiency	77.82	%

Overburden Stripping Achievement After Obstacle Time Improvement

After the obstacle time improvement, the productivity of the Hino 500 FM 280JD dump truck increased to 25.67 BCM/hour (Table 5). Thus, the actual monthly production of the truck became 381,972.81 BCM/month. The achievement of overburden stripping after the improvement was 114.76%. This shows that after improving the obstacles that arose in the overburden transportation process, the overburden stripping target could be achieved.

Table 5. Overburden Stripping Achievement After Improvement

Mechanic Tools	Parameters	Outcome
Dumptruck HINO 500 FM 280JD	Productivity (BCM/hour)	25.67
	Tools quantity (unit)	20
	Total productivity (BCM/hour)	513.40
	Production target (BCM/month)	332829.17
	Actual production (BCM/month)	381972.81
	Achievement (%)	114.76

Overburden Stripping Operating Costs

The calculated overburden stripping operating costs are fuel, lubricants and filters, tire and undercarriage replacement, ground engaging tools replacement, and operator wages (Table 6).

1. Fuel
   Fuel consumption for the Komatsi PC400 LC excavator is 42 liters/hour, while for the Hino 500 FM 280JD dump truck it is 17 liters/hour. The total fuel cost for loading equipment is IDR 567,000/hour and for transport equipment is IDR 229,500/hour.
2. Lubricants and Filters
   Lubricant and filter costs for loading equipment and transport equipment are incurred at specific intervals (250 hours, 500 hours, and 1000 hours). The lubricant and filter requirements for excavators and dump trucks are Rp 26,237/hour and Rp 9,618/hour, respectively.
3. Tire and undercarriage replacement
   The cost of replacing tires for transport equipment is carried out every 3000 hours, amounting to IDR 55,000,000. Thus, the cost of replacing tires per hour is IDR 18,333. Meanwhile, the replacement of the undercarriage of loading equipment is carried out every 6000 hours at a cost of IDR 858,375,000. The cost of undercarriage replacement per hour is IDR 143,062.50.
4. Ground engaging tools (GET) replacement
   The spare parts of ground engaging tools buckets that need to be replaced are teeth, claw pins, adaptors, and bucket pins. GET replacement is carried out every 2000 hours with a total cost of IDR 6,204,000. Thus, the cost of GET replacement per hour is IDR 3,102.
5. Operator salary
   The operator's salary at PT Bumi Sekundang Enim Energy consists of a basic salary (regional minimum wage) and additional salary based on the machine's hour meter (HM). The basic salary (UMR) in South Sumatra Province is IDR 3,456,874 per month and the additional salary based on HM is IDR 5,000 per HM. Based on the calculation results, it was found that the salary of the loading and unloading equipment operator and the transport equipment operator is IDR 11,685.38/hour and IDR 12,029.25/hour, respectively.

Table 6. Operating costs for loader and hauler

Mechanic Tools	Cost Description	Value (IDR/hours)
Excavator Komatsu PC400LC	Fuel	567.000,00
	Lubricant and Filter	26.237,00
	Tires and undercarriage	143.062,50
	Ground Engaging Tools	3.102,00
	Operator salary	11.685,38
	Total operational cost	**751.086,38**
Dumptruck Hino 500 FM 280 JD	Fuel	229.500
	Lubricant and Filter	9.618
	Tires dan undercarriage	18.333
	Operator salary	12.029,25
	Total operational cost	**269.480,25**

The operational cost of overburden stripping per BCM consists of excavation and transportation costs. Each of these excavation and transportation costs is then divided by the productivity of each tool to obtain the operational cost per BCM. Before the delay time was improved, the cost of overburden stripping per BCM was Rp 20,473 (Table 7). However, after implementing the delay time improvement, the operational cost of overburden stripping was Rp 16,350. The operational cost recorded a decrease of up to 20.14%. This shows that increasing equipment productivity as a result of delay time improvement will reduce the operational cost of overburden stripping.

Table 7. Operational Costs of Overburden Stripping Before and After Improvement

Mechanics Tools	Cost	Value
Excavator Komatsu PC400LC	Operational cost (IDR/hour)	751.086
	Tools quantity (unit)	4
	Total operational cost (IDR/hour)	3.004.344
Dumptruck HINO 500 FM 280JD	Operational cost (IDR/hour)	269.480
	Tools quantity (unit)	20
	Total operational cost (IDR/hour)	5.389.600
Total operational cost of digging and hauling (IDR/hour)		8.393.944
Operational Cost of Stripping Overburden Before Improvement		
Productivity of stripping OB (BCM/hour)		410
Cost of stripping overburden (IDR/BCM)		20.473
Operational Cost of Stripping Overburden After Improvement		
Productivity of stripping OB (BCM/hour)		513,40
Cost of stripping overburden (IDR/BCM)		16.350

CONCLUSION

Based on the research results, it can be concluded that the overburden stripping target was only achieved at 91.65%. This target was not achieved due to low transport equipment productivity. The actual productivity obtained was 20.5 BCM/hour, which was lower than the specified target of 22.37 BCM/hour. The failure to achieve the overburden stripping target was due to obstacles that reduced the effective working time and efficiency of the mechanical equipment used. Improvements made to the delay time and idle time reduced the total obstacle time by 40.64%. As a result, the efficiency of the mechanical equipment increased to 77.82%. After the improvements were made, the productivity of the transport equipment increased to 25.67 BCM/hour and the overburden stripping target was achieved with a percentage of 114.76%.

The operational costs of overburden stripping consist of excavation and transportation costs by mechanical equipment. The costs taken into account include fuel, lubricants and filters, tire and undercarriage replacement, GET replacement, and operator wages. The operational cost of overburden stripping before the downtime improvement was IDR 20,473/BCM, but after the improvement, the cost decreased by 20.14% to IDR 16,350/bcm.

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