Study of the Effectiveness of Loading Digging Tools for Doosan SL 500 Excavators and Komatsu 300 Excavators Using the Overall Equipment Effectiveness (OEE) Method to Achieve Over Burden Stripping Targets at PT. Hasta Panca Mandiri Utama Job Site Cita Mineral Investindo, West Kalimantan

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Abstract. *PT. Hasta Panca Mandiri Utama Job Site Cita Mineral Investindo is a private company engaged in mining services.* PT HPMU has a production target for Overburden stripping of 100,000 bcm, while the actual production amount in the field using the Overall Equipment Effectiveness (OEE) method on the Dossan SL 500 Excavator and Komatsu 300 Excavator is only 89,483 bcm or 75% of the production target in February and amounted to 88,708 bcm or 74.8% of the production target in March. It can be concluded that production during Overburden stripping in the WP 79 area in February and March 2023 has not reached the production target that the company had planned After carrying out the analysis and improvement efforts, the total Overburden stripping production obtained using the Overall Equipment Effectiveness (OEE) method was 229,216 bcm in February and 253,657 in March, this means that the production target has been reached which has been set at 200,000 bcm/month. with the OEE values on the loading and unloading equipment respectively of 67% and 80% in February and 75% and 73% in March, however, this OEE value is still far below the world-class OEE value standard of 85%.

Keywords: *Digging Tool, Loss time, Overburden Stripping, OEE, Production*

1. Introduction

One of the valuable minerals found in Indonesia is bauxite. West Kalimantan has quite large bauxite content. Currently, there is increasing global demand, especially from China, for mineral ores, including bauxite ore. To meet domestic and export demand for bauxite, PT. Hasta Panca Mandiri Utama *Job Site* Cita Mineral Investindo, has targets that must be achieved every month.

To achieve production targets stripping layer *overburden,* one of the supporting factors in achieving production targets that must be considered and optimized is equipment mechanical ones used in the mining process. Mining operations PT. Hasta Panca Mandiri Utama *Job Site* Cita Mineral Investindo, which is located in the wp 79 area, uses *a Doosan SL 500 Excavator* and *Komatsu 300 Excavator* for excavation and loading.

PT Hasta Panca Mandiri Utama targets *overburden stripping production* of 100,000 bcm every month. However, actual production in December was 91,356 bcm and in January 2023 it was 87,881 bcm, it can be concluded that in January and December 2023 the stripping production target *Overburden* did not reach the targets set and planned by the company. To meet established overburden stripping production targets, it is very important to optimize the operational efficiency of excavation equipment. This requires a thorough analysis of equipment productivity, as well as identifying the root causes and implementing appropriate measures to achieve the desired goals. To overcome this problem, one effective approach is to use the *Overall Equipment Effectiveness* (OEE) technique.

2. Regional Geological Conditions

The Ketapang area is located within a large tract of limestone magma, which gave rise to the Schwaner Batholith formation. Erosion causes significant exposure of the underlying bedrock, while certain parts of the higher layers survive as constituents of the batholith, which is covered by the volcanic peak. The exposed rocks provide evidence of various stages of deformation in the process of magma or metamorphic production.

The following regional map of PT. HMPU can be seen in Figure 1.

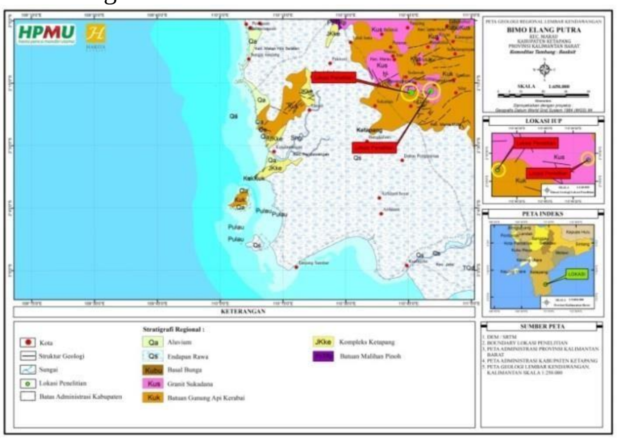

Figure 1. Reginal Regiology Map PT. HPMU

3. Theoritical Review

3.1 Mechanical Earthmoving

Mechanical soil movement includes *digging*, breaing, loosening, loading, hauling, dumping, filling, spreading, laveling, and compacting soil or rock with mechanical equipment.

3.2 Loading Digging Tool

Excavation and loading equipment refers to specialized tools used to excavate soft materials or handle debris resulting from blasting. Its main function is to efficiently load excavated material into the conveying system. *The excavator* is one of the digging and loading tools used by PT HMPU.

The circulation time of the digging-loading tool is the time required by this tool to carry out one excavation operation which consists of: *Digging Time* is the time required for *the bucket* to dig up the material to be loaded into the tool transport. *Swing Load Time* refers to the duration it takes for the digger to rotate while carrying the material in *the bucket*. *Dumping time* refers to the duration required for digging equipment to move material from *the bucket* into the transport *vessel*. *Swing Empty* refers to the duration it takes for the excavator to rotate with the bucket empty.

3.3 Factors Affecting Production

3.3.1 Position Loading Material

Position Loading is divided into 2 (two), namely *Top Loading* and *Bottom Loading. Top loading* refers to a scenario where *the backhoe* is positioned at a higher level than the truck, while *BottomLoading* is a condition where position *back ho* And *trucks* on One levels that's the same-same place above the level.

3.3.2 Material Factors

Prodjosumarto Partanto (1995: 23) categorizes material elements into two groups, namely soft materials, namely materials that are easy to dig, *such as top* soil, sand, sandy *clay*, and clayey *sand*.

Digging with a medium level of difficulty (medium *hard digging*), such as clay or *clay* that is damp and sticky. Or, eroded rock (weathered *rock*).

to dig or resistant to excavation (hard *digging*), such as slate, sedimentary rock, compacted material, *breccia*, *conglomerate.*

Very *hard digging* involves the need to drill and blast before digging, such as in *fresh igneous rock* or *fresh metamorphic rock.*

3.3.3 Material Development Factor (swell factor)

According to Tenriajeng (2003: 1-2) Material development *(swell factor)* can be divided into original conditions (*bank conditions*), circumstances loose (*loose conditions*), And circumstances congested (*compact*). The formula for finding value *swell factors* You can use the equation below:

$$SF = \frac{Density\ Loose\ (\frac{ton}{m3})}{Density\ Bank\ (\frac{ton}{m3})}\ x\ 100$$

Swell factor values for different materials are provided in Table 1, as shown below:

Table 1. Swell Factor and Insitu Density Values for Various Materials

Type Material	Density Insitu (lb/cu yd)	Swell Factor (%)
Bauxite	2700 – 4325	75
Land clay dry	2300	85
Land clay wet	2800 – 3000	80 – 82
Anthracite	2200	74
Coal bituminous	1900	74
Ore copper	3800	74
Land normal dry	2800	85
Land normal wet	3370	85
Land normal mixed sand And gravel	3100	90
Gravel dry	3250	89
Gravel wet	3600	88
Granite broken – broken	4500	56 – 67
Hematite broken – broken	6500 – 8700	45
Ore iron broken – broken	3600 – 5500	45
Rock chalk broken – broken	2500 – 4200	57 – 60
Mud	2160 – 2970	83
Mud Already pressed	2970 -3510	83
Sand dry	2200 – 3250	89
Sand wet	3300 – 3600	88
Flakes *(shale)*	3000	75
Rock slate *(slate)*	4590 – 4860	77

Source : Partanto Prodjosumarto, 1996

3.3.4 Factors Charging buckets (bucket fill factors)

Bucket fill factor (bucket *fill factor*) namely the amount of material that can be transported in the bucket during each tool operation depending on the type and material.

A process to find the *bucket value fill factor* can use the equation below:

$$BFFs = \frac{Volume\ Bucket\ Actual\ (m^3)}{Volume\ munjung\ bucket\ (m^3)}$$

The volume comparison values of the bucket fill factor are displayed in table 2 as shown below.

Table 2. Bucket Fill Factor

No	Condition	Material	Buckets Factor
1	Easy Land	Land Clay, rather soft	1.20 – 1.10
2	Average/medium	Sand, Land, Clay	1.10 – 1.00
3	Rather difficult	Rock fine, Clay hard	1.00 – 0.80
4	Difficult	Rock Results Blasting	0.80 – 0.70

Source: Tenriajeng, 2003

3.3.5 Time Circulate Tool (Cycle Time)

Tool circulation time refers to the duration required for the tool to carry out a work cycle. Tool circulation time can also be defined as the time used by a heavy machine to carry out a series of movements, starting from the first movement and ending with the last movement (such as digging, loading, transporting, dumping, navigation and return).

3.4 Availability Tool Mechanical

The term "availability" is generally used to describe the presence and function of mechanical equipment. There are several types of instruments available that can indicate the condition of a mechanical device and how well it is being used. These tools include:

Mechanical Availability, Indonesianto, 2014 explains the meaning of *Mechanical Availability* as a metric that shows the operational readiness of a tool after the tool is lost due to damage or mechanical interference.

$$MA = \frac{Hours\ worked}{Hours\ worked + repair\ hours}\ x\ 100\ \%$$

Source: Yanto Indonesianto, 2014

Physical availability refers to the proportion of time an instrument is actively used during specified working hours. The total number of hours worked is equal to the sum of work hours, repair hours, and standby hours. *Physical* Value *Availability* can be recorded using the following equation:

$$PA = \frac{hours\ worked + standby\ haours}{scheduling\ hours}\ x\ 100\%$$

Source: Yanto Indonesianto, 2014

Use of Availability (UA) provides insight into the operational efficiency of a job. Apart from that, it can also be determined whether the tool management is functioning properly or not.

$$UA = \frac{hours\ worked}{hours\ worked + standby\ hours}\ 100\ \%$$

Source: Yanto Indonesianto, 2014

Effective Utilization (EU) refers to the proportion of total available work time that can be used effectively for productive work. The EU figure shows the operational efficiency of an instrument. *Effective* Value *Utilization* (EU) can be calculated using the following equation:

$$EU = \frac{wored\ hours}{Total\ hours}\ x\ 100\ \%$$

Source: Yanto Indonesianto, 2014

3.5 Transport Road Conditions

The production capacity of heavy equipment, especially transportation equipment, is greatly influenced by road conditions, including factors such as road condition, distance, road slope, and road carrying capacity. Some road geometries that are very important to support manufacturing operations include:

3.5.1 Width of haul road (Haul Road)

These haul roads should be checked to see if they are muddy, strong, or have a rough surface. All of this needs to be evaluated, because the condition of the haul road will have an impact on the level of *rolling resistance* (RR) produced by the haul road surface against the wheels of mechanical earth-moving equipment. (Yanto Indonesianto, 2005, II-4)

The width of the haul road is adjusted to accommodate the dimensions of the largest haulage used in mining operations. The road size commonly used for straight roads is 3.5 times the width of the largest unit used.

3.5.2 Slope road

grade refers to its slope, which has a significant impact on transportation efficiency. This is because the slope of the road increases the resistance that transportation equipment must overcome, which is known as *grade resistance* (Yanto Indonesianto, 2005).

3.6 Productivity Tool Dig Load And Tool Transport

excavator digging and loading equipment used by PT HMPU, namely the *backhoe excavator type*, is influenced by factors such as *bucket capacity*, filling factor, circulation time, and working efficiency of the tool. To determine backhoe production capacity, you can use the following equation:

$$Q = \frac{Kb\ x\ sf\ x\ k\ x\ 3600\ (\frac{detik}{jam})\ x\ eff}{ct}$$

Source: Yanto, Indonesia

Where:

Q = Productivity tool dig-load (bcm/hour)
Kb = Capacity buckets (m^3)
sf = *Swell Factor*
k = *Fill factors*

Eff = Efficiency Work

3.7 Method Overall Equipment Effectiveness (OEE)

According to one expert, Rizkia believes that OEE functions as a metric to assess the efficiency of machines or equipment by measuring machine availability, performance and output quality.

The benefits that can be obtained from OEE include the following:

Ensure *the starting point* of the company or equipment/machines, pinpoint bottlenecks that occur in equipment/machines, find true productivity losses, and prioritize efforts to increase OEE and increase production.

The OEE value can be calculated by flowing *Availability, Performance,* And *Quality Rates* are as follows:

OEE = *Availability* × *Performance* × *Quality Rate* (11)

The calculation of the OEE component is influenced by the following factors:

3.7.1 Availability Factor (A)

Availability factor (A) is a factor related to the function of an equipment or system. The value of the availability factor (A) can be calculated mathematically using the following equation:

$$A = \frac{AT}{TT}$$

Where:
AT = *Available time*
TT = Total *Calendar time*

3.7.2 Utilization Factor (U)

Utilization factor (U) indicates the efficient use of available hours. By Mathematically the Utilization factor (U) value can be calculated use equation below this:

$$U = \frac{UT}{AT}$$

Information:
UT = *Utilization time*
AT = *Available time*

3.7.3 Speed Factor (S)

Speed factor (S) is determined by dividing the desired cycle time by the actual cycle duration. This can be calculated using the following equation:

$$S = \frac{CTp}{CTa}$$

Information:
CTp = *Planned Cyle time*
CTa = *Actual cycles time*

3.7.4 Buckets Fill Factor (B)

Bucket fill factor (B) is a measure of efficient bucket capacity utilization, determined by comparing the number of buckets filled with actual output. This can be calculated using the following equation:

$$B = \frac{0ac}{0pc}$$

3.7.5 OEE of BELT Equipment

The OEE value for a digging-loading tool is calculated by multiplying the values of the availability factor, utilization factor, speed factor, and bucket fill factor, as shown in the formula below:

$$OEE = A \times U \times S \times B$$

Equation for calculate value production on time certaincan used formula below this :

$$O = OPC \frac{TT\ X\ 3600}{CTp} x\ OEE$$

With O is *output* production in periodtime certain (m³).

4. Research Methodology

4.1 Types of research

The research carried out is applied research, which involves carrying out experiments that combine theoretical knowledge with field data to address specific problems. The data exhibited is quantitative, consisting of numerical values and statistical analysis.

4.2 Object of research

The focus of research conducted at PT. HMPU is in mining equipment, namely the main equipment used in overburden stripping operations, namely the Doosan SL 500 Excavator and Komatsu 300 Excavator.

4.3 Research Instrument

- Stopwatches are used to determine the cycle times of digging and loading machines.
- Stationery is used to document data in the field.
- The camera is used to take photographic evidence during the research.
- Laptops are used to input and analyze data obtained during field observations.

4.4 Data collection technique

4.4.1 Studies Literature

Literature studies involve analyzing company data and previous research reports, as well as conducting literature searches to obtain information about specific difficulties. This includes examining production analysis in mining through various experiments, books, journals, or current research reports.

4.4.2 Data Collection in the Field

Data collection can be done by direct observation in the field, which involves carrying out field orientation with company personnel as an initial stage of research. This allows identification of problems and determination of data collection locations. This research uses several methodologies to collect information or data, with the aim of gaining a comprehensive understanding of the subject under study.

5. Research Result

5.1 Work schedule

Planned production schedule and working hours at PT. HPMU Cita Mineral Investindo's *Job Site for* February to March 2023 can be seen in Table 3 below:

Table 3. Work schedule for February - March 2023

Day	Shifts	Working hours	Activity	Number of Working Hours	Total Working Hours
Monday – Thursday, Saturday -Sunday	1	06.10 - 12.00	Working hours	350 minutes	640 minutes
		12.00 – 13.00	Rest	1 hour	
		13.00 – 17.50	Working hours	290 minutes	
		17.50 – 18.10	Shift Change	20 minutes	
	2	18. 10 –00.00	Working hours	350 minutes	640 minutes
		00.00 –01.00	Rest	1 hour	
		01.00 – 05.50	Working hours	290 minutes	
		05.50 –06.10	Shift Change	20 minutes	
Total Working Hours					1,280
Wednesday	1.	06.10–07.00	Safety Talk	50 minutes	590 minutes
		07.00 -12.00	Working hours	5 hours	
		12.00–13.00	Rest	1 hour	
		13.00-17.50	Working hours	290 minutes	
		17.50 – 18.10	Shift Change	20 minutes	
	2	18. 10 – 00.00	Working hours	350 minutes	640 minutes
		00.00 – 01.00	Rest	1 hour	
		01.00 – 05.50	Working hours	290 minutes	
		05.50 – 06.10	Shift Change	20 minutes	
Total Working Hours					1,230
Friday	1	06.10 -11.00	Working hours	290 minutes	580 minutes
		11.00–13.00	Rest	2 hours	
		13.00 – 17.50	Working hours	290 minutes	
		17.50–18.10	Shift Change	20 minutes	
		18.10–00.00	Working hours	350 minutes	640 minutes
		00.00–01.00	Rest	1 hour	
		01.00–05.50	Working hours	290 minutes	
		05.50 –06.10	Shift Change	20 minutes	
Total Working Hours					1,220

5.2 Loading Excavator Working Time

The following loading hours of excavators in February can be seen in Table

Table 4. Loading Excavator Working Hours in February

No	Tool	Hours Available (O'clock)	Work (O'clock)	Repair (O'clock)	Standby (O'clock)
1.	Exca Doosan 500	590	341.33	112.03	136.64
2.	Komatsu 300 excavator	590	334.83	20.78	234.39

The following loading hours of excavator in March can be seen in Table 5.

Table 5. Loading Excavator Working Hours in March

No	Tool	Hours Available (O'clock)	Work (O'clock)	Repair (O'clock)	Standby (O'clock)
1.	*Doosan SL 500* excavator	652.16	341.30	66	244.87
2.	*Komatsu 300 excavator*	652.16	348.88	77	226.28

Using the data provided in table 5, the MA, PA, UA, and EU values of the digging-loading and hauling equipment in February can be seen in Table 6 and Table 7.

Table 6. Excavator Dossan SL 500 February

No	MA %	PA %	UA %	EU %
1	75.28	80.85	71.41	57.85

Table 7. *Excavator Komatsu 300 February*

No	MA %	PA %	UA %	EU %
1	94.15	96.47	52.82	56.75

The following mechanical equipment is available in February 2023 is listed in the table 8.

Table 8. Availability of Mechanical Equipment February 2023

No	Units	MA (%)	PA (%)	UA (%)	EU (%)
1	Excavator Dossan SL 200	75.28%	80.85%	71.41%	57.85%
2	Komatsu 300 excavator	94.15%	96.47%	57.82%	56.75%

Whereas mark MA, PA, UA, And E.U from tool dig load in March is as follows in Table 9 and Table 10.

Table 9. Excavator Dossan SL 500 March

No	MA %	PA %	UA %	EU %
1	83.79	89.87	58.22	52.33

Table 10. Excavator Komatsu 300 March

No	MA %	PA %	UA %	EU %
1	81.19	88.19	60.65	53.49

The following mechanical equipment availability in March 2023 is listed in the table 11.

Table 11. Mechanical Equipment Availability March 2023

No	Units	MA (%)	PA (%)	UA (%)	EU (%)
1	Dossan SL 200 excavator	83.79%	89.87%	58.22%	52.33%
2	Komatsu 300 excavator	82.19%	88.19%	60.65%	53.49%

5.3 Loading Excavator Circulation Time (Cycle Time)

5.3.1 Excavator Dossan SL 500 February

$CTgm = Tg + Tsi + Tt + Tsk$

= 9.21 + 7.03 + 5.47 + 7.06

= 28.79 seconds

5.3.2 Komatsu 300 excavator February

$CTgm = Tg + Tsi + Tt + Tsk$

= 6.96 + 5.79 + 4.46 + 6.25

= 23.47 seconds

5.3.3 Excavator Dossan SL 500 March

$CTgm = Tg + Tsi + Tt + Tsk$

= 7.43 + 6.9 + 5.3 + 7.05

= 26.68 seconds

5.3.4 Komatsu 300 excavator

$CTgm = Tg + Tsi + Tt + Tsk$

= 6.60 + 5.96 + 4.87 + 6.00

= 23.43 seconds

The following average circulation time for excavator loading and unloading equipment as shown in the table 12.

Table 12. Average Circulation Time for Excavator Loading Digging Tools

No	Month	Units	Digging(s)	Swing Content(s)	Spill(s)	Empty Swing(s)	Total
1.	Feb	Dossan SL 500 excavator	9.21	7.03	5.47	7.06	28.79
2.		Komatsu 300 excavator	6.96	5.79	4.46	6.25	23.47
3.	Mart	Dossan SL 500 excavator	7.43	6.90	5.30	7.05	26.68
4.		Komatsu 300 excavator	6.60	5.96	4.87	6.00	23.43

5.4 Production Target for Stripping Overburden Area WP 79 in February 2023

The following OB stripping production target for area WP 79 in February 2023 as shown in the table 13.

Table 13. OB Stripping Production Target for February and March 2023

Month	Number of Shafts	Area (m^3)	Thickness (m^3)	Volume (m^3)
February	50	1000	2	100,000
March	50	1000	2	100,000

6. Processing and Calculation

6.1 Calculation of Actual Productivity of Loading Digging Equipment

6.1.1 Excavator Dossan SL 500February

The following Dossan SL 500 Excavator producty data as shown in table 14.

Table 14. Dossan SL 500 Excavator Productivity Data February

Data	Symbol	Mark	Attachment
Bucket Capacity	Kb	2.15 m^3	Appendix E
Swell Factor	SF	0.82	Appendix G
Fill Fctor Bucket	Fff	1.0	Appendix H
Work Efficiency	Eff	0.57	Appendix I
Cycle Time	CT	28.79 seconds	Appendix A

$$Q = \frac{Kb \ x \ sf \ x \ Ff \ x \ 3600 \ (\frac{detik}{jam}) \ x \ eff}{ct}$$

$$= \frac{2{,}15 \ x \ 0{,}82 \ x \ 1{,}0 \ x \ 3600 \ (\frac{detik}{jam}) \ x \ 0{,}57}{28{,}79}$$

= 125.65 bcm/hour

Q = 125.65 bcm/hour × effective working time

= 125.65 bcm/hour × 341.33 hours/month

= 42,888 bcm/month

6.1.2 Excavator Komatsu 300 February

The following excavator productivity data komatsu 300 in February as shown in the table 15.

Table 15. Excavator Productivity Data Komatsu 300 February

Data	Symbol	Mark	Attachment
Bucket Capacity	Kb	1.4 m^3	Appendix F
Swell Factor	SF	0.82	Appendix G
Fill Fctor Bucket	Fff	1.0	Appendix H
Work Efficiency	Eff	0.56	Appendix J
Cycle Time	CT	23.47 seconds	Appendix B

The following productivity of loading digging equipment in February as shown in the table 16.

Table 16. Productivity of Loading Digging Equipment in February

No	Units	Effective Working Time (Hours/month)	Work Efficiency	Production per hour (bcm/ O'clock)	Production per month
1.	*Dossan SL 500 excavator*	341.33	0.57	125.65	42,888
2.	*Komatsu 300 excavator*	339.90	0.56	98.60	33,017
Total Production in February 2023					75,905
Monthly Production Target					100,000
Achievement of Production Targets					75%

In February 2023, total production reached 75,905 billion cubic meters (bcm) per month, which is equivalent to 75% of the production target set at 100,000 bcm per month. The overburden stripping production target in the WP 79 area was not achieved.

6.1.3 Excavator Dossan SL 500 March

The following excavator productivity data dossan 500 SL in March as shown in the table 17.

Table 17. Excavator Productivity Data Dossan SL 500 March

Data	Symbol	Mark	Attachment
Bucket Capacity	Kb	2.15 m^3	Appendix E
Swell Factor	SF	0.82	Appendix G
Fill Fctor Bucket	Fff	1.0	Appendix H
Work Efficiency	Eff	0.52	Appendix K
Cycle Time	CT	26.68 seconds	Appendix C

6.1.3 Excavator Komatsu 300 March

The following excavator productivity data komatsu 300 in March as shown in the table 18.

Table 18. Excavator Productivity Data Komatsu 300 March

Data	Symbol	Mark	Attachment
Bucket Capacity	Kb	1.4 m^3	Appendix F
Swell Factor	SF	0.82	Appendix G
Fill Fctor Bucket	Fff	1.0	Appendix H
Work Efficiency	Eff	0.53	Appendix L
Cycle Time	CT	23.42 seconds	Appendix D

The following digging equipment productivity load in March as shown in the table 19.

Table 19. Digging Equipment Productivity Load March

No	Units	Effective Working Time (Hours/ month)	Work Efficiency	Production per hour (bcm/hour)	Production per month
1	Dossan SL 500 excavator	345.17	0.52	123.70	42,218
2	Komatsu 300 excavator	352.97	0.53	93.52	32,629
Total Production in February 2023					74,847
Monthly Production Target					100,000
Achievement of Production Targets					74.8%

Overall production in March 2023 reached 74,847 bcm/month which is equivalent to 74.8% of the production target set at 100,000 bcm/month. It can be concluded that overburden stripping production in February 2023 did not reach the target.

6.2 Calculation of Productivity Values for Loading Digging Equipment Using the Overall Equipment Effectiveness (OEE) Method

6.2.1 Excavator Dossan SL 500 February

The following calculation data for OEE values on Dossan SL 500 excavator loading digging equipment for February as shown in the table 20.

Table 20. Calculation data for OEE values on Dossan SL 500 excavator loading digging equipment for February

Units	TT (O'clock)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
Exca Dossan SL 500	672	590	341.3	24	28.79	2.15	2.15

- OEE value
  OEE = A × U × S × B
  OEE = 0.88 × 0.57 × 0.83 × 1.0 = 0.41
- Calculation of OB stripping production based on OEE values

$$O = Opc \times \frac{TT \times 3600\ detik/jam}{Ctp} \times OEE$$

$$O = 2.15\ m^3 \times \frac{672\ jam \times 3600\ detik/jam}{24\ detik} \times 0.41$$

$$O = 88.855\ m^3$$

6.2.2 Excavator Komatsu 300 March

The following calculation data for OEE values on komatsu 300 excavator loading digging equipment for February as shown in the table 21.

Table 21. Calculation data for OEE values for the Komatsu 300 excavator loading digging equipment for February

Units	TT (O'clock)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
Excavator Komatsu 300	672	590	334.83	21	23.47	1.4	1.4

The following calculation result of OEE values for dossan SL 500 excavator and komatsu 300 excavator February as shown in the table 22.

Table 22. Calculation Results of OEE Values for Dossan SL 500 Excavators and Komatsu 300 Excavators February 2023

Units	A	U	S	B	OEE	O	Oh actually
Exca Dossan SL 500	0.88	0.57	0.83	1.0	0.41	88,855	50,647
Exca Komastu 300	0.88	0.56	0.89	1.0	0.43	69,350	38,836
Total						158.205	89,483

Then value OEE on Dossan SL 500 Excavator and Komatsu 300 Excavator in February 2023, namely 0.41 and 0.43 respectively, this means lower than the class OEE standard value world that is, as big as 85%. In February 2023, the combined production of the Dossan SL 500 Excavator and Komatsu Excavator will reach 89,483 bcm per month. However, overburden stripping production did not reach the target of 100,000 bcm per month

6.2.3 Excavator Dossan SL 500 March

The following calculation result of OEE values for dossan SL 500 excavator and komatsu 300 excavator March as shown in the table 23.

Table 23. Calculation Data For OEE Values on Dossan SL 500 Excavator Loading Digging Equipment for March

Units	TT (O'clock)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
Exca Dossan SL 500	744	652.16	341.3	24	26.68	2.15	2.15

6.2.4 Excavator Komatsu 300 March

The following calculation data for OEE values for komatsu 300 excavator loading digging equipment for march February as shown in the table 24.

Table 24. Calculation data for OEE values for Komatsu 300 excavator loading digging equipment for March

Units	TT (O'clock)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
Exca Komatsu 300	744	348.88	128.5	21	23.43	1.4	1.4

The following calculation result of OEE values for dossan SL 500 excavator and komatsu 300 excavator in Mrch as shown in the table 25.

Table 25. Calculation Results of OEE Values for Dossan SL 500 Excavators and Komatsu 300 Buan Excavators March 2023

Units	A	U	S	B	OEE	O	O actual
Exca Dossan SL 500	0.88	0.52	0.89	1.0	0.40	95,978	49,908
Exca Komastu 300	0.88	0.53	0.89	1.0	0.41	73,209	38,800
Total						169,187	88,708

Calculations using the Overall Equipment Effectiveness (OEE) method show that the combined production results of the Dossan SL 500 Excavator and Komatsu Excavator in March 2023 reached 88,708 bcm/month. However, overburden stripping production did not reach the target of 100,000 bcm/month.

The negative impacts resulting from failure to meet production targets are shown in table 26 below:

Table 26. Losses Caused by Not Achieving Production Targets

Month –	Actual	Plans	Deviation	OB Removal (BCM)	Total Losses (Rupiah)
Feb	89,483	100,000	10,517	16,827	1,935,105,000
Mart	88,708	100,000	11,292	18,067	2,077,705.000

After carrying out calculations as in the table above, the calculation results for the total loss caused by not achieving the production target were 1,935,105,000 rupiah with a price of 115,000, whereas in March it was 2,077,705,000 rupiah.

6.3 Calculation of Overall Equipment Effectiveness (OEE) and Six Big Losses Values

6.3.1 Calculation of Overall Equipment Effectiveness (OEE) Dossan SL 500 Excavaor Loading Digging Equipment February

The following component data calculates the overall equipment effectiveness (OEE) value as shown in the table 27.

Table 27. Component data calculates the Overall Equipment Effectiveness (OEE) value

Loading Time	Downtime	Operating	Production	Reject	Reduced yield	CTP
35,400	14,920.20	20,480	42,888	7,112	0	0.40

- OEE = *Availability×Performance×Quality Rate*
  = 55.02 % × 83.76% × 83.41 %
  = 38.43 %

The following dossan 500 OEE value percentage calculation is shown in table 28.

Table 28. *Dossan 500* OEE Value Percentage Calculation

No	OEE	Mark
1	Availability	55.02%
2	Performance	83.76%
3	Quality Rate	83.41%
Total OEE		38.43%

6.3.2 Calculation of the Value of the Six Big Losses for Dossan SL 500 Excavator Loading Digging Equipment, February

The following data to calculate components of the six big losses dossan 500 is shown in table 29.

Table 29. Data to calculate the components of the Six Big Losses Dossan 500

Available working time (minutes)	Standby time (minutes)	Set up time (minutes)	Total production (bcm)	Total rejects (bcm)	CTP (minute)	Call (minutes)
35,400	14,920	6,722	42,888	7,112	0.40	0.48

The following measures the value of six big losses dossan SL 500 is shown in table 30.

Table 30. Measuring the Value of Six Big Losses Dossan SL 500

No	Six Big Losses	Mark
1	Equipment Failure Losses	42.15%
2	Set up and adjust losses	19%
3	Defect losses	8.03%
4	Reduced speed	9.69%
5	Idle and minor stoppage	8.03%
6	Reduced yield	0%

6.3.3 Calculation of the Overall Equipment Effectiveness (OEE) value of Komatsu 300 Excavaor Loading Digging Equipment February

The following components data calculates the overall equipment effectiveness (OEE) value is shown in table 31.

Table 31. Component data calculates the Overall Equipment Effectiveness (OEE) value

Loading Time	Downtime	Operating	Production	Reject	Reduced yield	CTP
35,400	145,310	20,090	33,017	16,983	0	0.40

The following calculation of komatsu 300 OEE value percentage is shown in table 32.

Table 32. Calculation of Komatsu 300 OEE Value Percentage

No	OEE	Mark
1	Availability	56.75%
2	Performance	57.52%
3	Quality Rate	48.69%
Total OEE		15.89%

6.3.4 Calculation of the value of Six Big Losses for Komatsu 300 Excavaor Loading Digging Tools February

The following data for calculate the components of the six big losses komatsu 300 is shown in table 33.

Table 33. Data for calculating the components of the Six Big Losses Komatsu 300

Available working time (minutes)	Stand by time (minutes)	Set up time (minutes)	Total production (bcm)	Total rejects (bcm)	CTP (minute)	Call (minutes)
35,400	15,310	1,247	33,017	16,983	0.35	0.39

The following measures the value of six big losses komatsu 300 is shown in Table 34.

Table 34. Measurement of the Value of Six Big Losses Komatsu 300

No	Six Big Losses	Mark
1	Equipment Failure Losses	43.24%
2	Set up and adjust losses	3.52%
3	Defect losses	16.80%
4	Reduced speed	3.73%
5	Idle and minor stoppage	48%
6	Reduced yield	0%

6.3.5 Calculation of Overall Equipment Effectiveness (OEE) Dossan SL 500 March Excavator Loading Digging Equipment

The following component data calculates the overall equipment effectiveness (OEE) value is shown in table 35.

Table 35. Component Data Calculates the Overall Equipment Effectiveness (OEE) value

Loading Time	Downtime	Operating	Production	Reject	Reduced yield	CTP
39,130	18,652	20,478	42,218	7,782	0	0.40

The following percentage calculation of dossan 500 OEE value is shown in the table 36.

Table 36. Percentage Calculation of Dossan 500 OEE Value

No	OEE	Mark
1	Availability	55.33%
2	Performance	82.46%
3	Quality Rate	81.56%
Total OEE		37.21%

6.3.6 Calculation of the Value of the Six Big Losses for Dossan SL 500 Excavator Loading Digging Equipment in March

The following data calculating the components of the six big losses Dossan 500 is shown in Table 37.

Table 37. Data for calculating the components of the Six Big Losses Dossan 500

Available working time (minutes)	Stand by time (minutes)	Set up time (minutes)	Total production (bcm)	Total rejects (bcm)	CTP minute)	Call (minutes)
39,130	18,652	3,960	42,218	7,782	0.4	0.44

The following measures the value of six big losses dossan SL 500 is shown in Table 38.

Table 38. Measuring the Value of Six Big Losses Dossan SL 500

No	Six Big Losses	Mark
1	Equipment Failure Losses	47.66%
2	Set up and adjust losses	10.12%
3	Defect losses	7.95%
4	Reduced speed	4.31%
5	Idle and minor stoppage	7.95%
6	Reduced yield	0%

6.3.7 Calculation of the Overall Equipment Effectiveness (OEE) value of the Komatsu 300 March Excavator

The following components data calculates the overall equipment effectiveness (OEE) value is shown in table 39.

Table 39. Component Data Calculates the Overall Equipment Effectiveness (OEE) value

Loading Time	Downtime	Operating	Production	Reject	Reduced yield	CTP
39,130	18,197	20,933	32,629	17,371	0	0.35

The following calculation of komatsu 300 OEE value percentage is shown in table 40.

Table 40. Calculation of Komatsu 300 OEE Value Percentage

No	OEE	Mark
1	Availability	53.49%
2	Performance	54.55%
3	Quality Rate	46.77%
Total OEE		13.64%

6.3.8 Calculation of the value of Six Big Losses for March 300 Komatsu Excavaor Loading Digging Equipment

The following data calculating the components of the six big losses Dossan 500 is shown in Table 41.

Table 41. Data for calculating the components of the Six Big Losses Dossan 500

Available working time (minutes)	Stand by time (minutes)	Set up time (minutes)	Total production (bcm)	Total rejects (bcm)	CTP (minute)	Call (minutes)
39,130	18,197	4,599	32,629	17,371	0.35	0.39

The following measures the value of six big losses komatsu 300 is shown in Table 42.

Table 42. Measurement of the Value of Six Big Losses Komatsu 300

No	Six Big Losses	Mark
1	Equipment Failure Losses	46.50%
2	Set up and adjust losses	11.75%
3	Defect losses	12.85%
4	Reduced speed	3.33%
5	Idle and minor stoppage	17.75%
6	Reduced yield	0%

6.4 Production Calculations for Overburden Stripping Using the Overall Equipment Effectiveness (OEE) Method After Loss Time Improvements

6.4.1 Excavator Dossan SL 500 February

The following data for calculating OEE values Dossan SL 500 excavator after repair is shown in Table 43.

Table 43. Data for calculating OEE values Dossan SL 500 Excavator After Repair

No	TT (Hours)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
1	672	590	454.97	24	24	2.15	2.15

- Calculation of OEE Value
  OEE = A × U × S × B
  OEE = 0.88 × 0.77 × 1.00 × 1.00 = 0.67
- Production calculations based on OEE values
  $O = Opc \times \frac{TT \times 3600\ detik/jam}{Ctp} \times OEE$
  $O = 2.15\ m^3 \times \frac{672\ jam \times 3600\ detik/jam}{24\ detik} \times 067$
  $O = 145.202\ m^3$

6.4.1 Excavator Komatsu 300 February

The following data for calculating the OEE value of the Komatsu 300 excavator after repair is shown in Table 44.

Table 44. Data for Calculating the OEE Value of the Komatsu 300 Excavator After Repair

No	TT (Hours)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
1	672	590	539.13	21	21	1.4	1.4

The following results of OEE values for the Dossan SL 500 Excavator and Komatsu 300 Excavator after repair are shown in Table 45.

Table 45. Results of OEE values for the Dossan SL 500 Excavator and Komatsu 300 Excavator After Repair

Units	A	U	S	B	OEE	O	Oh actually
Dossan SL 500 excavator	0.88	0.77	1	1	0.67	145.202	111.805
Komastu 300 excavator	0.88	0.91	1	1	0.80	129,024	117.411
Total						274,934	229,216

The table shows that the OEE value for loading and unloading equipment, after increasing overburden stripping production, reached 229,216 bcm. This exceeded the target of 100,000 bcm/month

6.4.2 Excavator Dossan SL 500 March

The following results of OEE values for the Dossan SL 500 Excavator and Komatsu 300 Excavator after repair is shown in Table 45.

Table 45. Data for Calculating the OEE Value of the Dossan SL 500 Excavator After Repair

No	TT (Hours)	AT (Hour)	UT (Hours)	CTp (Seconds)	Cta (Seconds)	Opc (m^3)	Oac (m^3)
1	744	652.1	560.92	24	24	2.15	2.15

6.4.3 Komatsu 300 excavator

The following results of OEE values for the Komatsu 300 Excavator after repair is shown in Table 46.

Table 46. Data for Calculating the OEE value of the Komatsu 300 excavator After Repair

No	TT (Hours)	AT (Hour)	UT (Hours)	CTp (Seconds)	ta (sec)	Opc (m^3)	Oac (m^3)
1	744	652.16	372.93	21	21	1.4	1.4

The following results of OEE values for the Dossan SL 500 Excavator and Komatsu 300 Excavator after repair is shown in Table

Table 47. Results of OEE values for the Dossan SL 400 Excavator and Komatsu 300 Excavator After Repair

Units	A	U	S	B	OEE	O	Oh actually
Ex Dossan SL 500	0.88	086	1	1	0.75	179,955	154,761
Exca Komastu 300	0.88	0.84	1	1	0.73	130,384	109,522
Total						310,339	264,283

In the table above, the overall production value of overburden stripping from the Dossan Sl 500 Excavator and Komatsu 300 Excavator is 264,281 bcm, which means that the production target has been achieved.

6.5 Time Optimization Analysis of Losses Time to Achieve Production Targets

6.5.1 Excavator Dossan SL 500 February

The following Dossan SL 500 excavator loss time data before and after repair is shown in Table 48

Table 48. Dossan SL 500 Excavator Loss Time Data Before and After Repair

No	*Loss Time*	Before repairs	After Repair
Delay Time			
1	Waiting for instructions	2.87	0.58
2	Late at the start	8.75	4.33
3	Too soon at the end	8.75	4.33
4.	Internal problems	2.75	0.58
5.	Greasing	8.22	6.50
6.	Fuel filling	3.00	2.17
7.	No Job&Shutdown	17.75	0
8.	Use of the unit for other activities	84.55	4.50
Total Delay Time		136.64	22.99

The following OEE comprasion table before and after improvements at loss time Dossan 500 is shown in Table 49.

Table 49. OEE Comparison Table Before and After Improvements at Loss Time Dossa 500

No	Parameter	OEE value before	OEE value after
1	Availability factor	0.88	0.88
2	Utilization factor	0.57	0.77
3	Speed Factor	0.83	1
4	Bucket Factor	1	1
5	OEE value	0.41	0.67

6.5.2 Excavator Komatsu 300 February

The following Komatsu 300 excavator loss time data before and after repair is shown in Table 50.

Table 50. Loss Time Data Before and After Repairs on the Komatsu 300 Excavator

No	Loss Time	Before repairs	After Repair
Delay Time			
1	Waiting for instructions	6.50	1.00
2	Late at the start	8.67	4.33
3	Too soon at the end	8.67	4.33
4.	Internal problems	4.62	2.25
5.	Greasing	7.49	6.50
6.	Fuel filling	2.62	2.17
7.	No Job & Shutdown	28	0
8.	Use of the unit for other activities	168.00	9.50
Total *Delay Time*		234.57	30.08

The following OEE comprasion table before and after during Komatsu 300 is shown in Table 51.

Table 51. Comparison of OEE before and after repairs during Komatsu 300 loss time

No	Parameter	OEE value before	OEE value after
1	Availability factor	0.88	0.88
2	Utilization factor	0.56	0.91
3	Speed Factor	0.89	1
4	Bucket Factor	1	1
5	OEE value	0.43	0.80

6.5.3 Excavator Dossan SL 500 March

The following Dossan SL 500 Excavator Loss Time Data is shown in Table 52.

Table 52. Dossan SL 500 Excavator Loss Time Data

No	Loss Time	Before repair (hours)	After Repair (hours)
Delay Time			
1	Waiting for instructions	6.67	0.92
2	Late at the start	8.92	4.33
3	Too soon at the end	8.92	4.33
4.	Internal problems	7.72	2.00
5.	Greasing	8.75	6.50
6.	Fuel filling	3.02	2.17
7.	No Job & Shutdown	86.30	0
8.	Use of the unit for other activities	168.00	5
Total Delay Time		43.98	25.25

The following comprasion of OEE before and after repair at loss time Dossan 500 is shown in Table 53.

Table 53. Comparison of OEE Before and After Repair at Loss Time Dossan 500

No	Parameter	OEE value before	OEE value after
1	Availability factor	0.88	0.88
2	Utilization factor	0.52	0.86
3	Speed Factor	0.89	1
4	Bucket Factor	1	1
5	OEE value	0.40	0.75

6.5.3 Excavator Komatsu 300 March

The following Komatsu 300 Excavator Loss Time Data is shown in Table 54.

Table 54. Komatsu 300 Excavator Loss Time Data

No	Loss Time	Before repair (hours)	After Repair (hours)
Delay Time			
1	Waiting for instructions	7.70	1.67
2	Late at the start	9.05	4.33
3	Too soon at the end	9.05	4.33
4.	Internal problems	7.52	1.67
5.	Greasing	8.72	6.50
6.	Fuel filling	3.02	2.17
7.	No Job & Shutdown	104.83	0
8.	Use of the unit for other activities	76.75	5
Total Delay Time		226.64	25.67

The following comprasion of OEE before and after repair improvements Dossan 500 is shown in Table 55.

Table 55. Comparison of OEE Before and After Improvements at Loss Time Dossan 500

No	Parameter	OEE value before	OEE value after
1	Availability factor	0.88	0.88
2	Utilization factor	0.53	0.84
3	Speed Factor	0.89	1
4	Bucket Factor	1	1
5	OEE value	0.41	0.73

7. Discussion

The Dossan SL 500 Excavator loading digging equipment is 42,888 bcm/month, while for the Komatsu 300 Excavator loading digging equipment it is 33,017 bcm/month then total actual productivity for 1 month is 75,905 bmc/month or 75% of the production target.

In March the actual productivity of the Dossan SL 500 Excavator loading digging equipment was 42,218 bcm/month while for the Komatsu Excavator it was 32,629 bcm/month then total Actual productivity in March was 74,847 bmc/month or 74% of the production target. This shows that production during overburden stripping did not reach the target planned by the company.

The productivity value using the Overall Equipment Effectiveness (OEE) method in February, namely on the Dossan SL 500 Excavator, obtained an OEE value of 0.41 or 41%. For the actual productivity of overburden stripping using the OEE method, namely 50,647 bcm/month. Meanwhile, the Komatsu 300 Excavator obtained an OEE value of 0.43 or 43 and the actual productivity value was 38,836 bcm/month. So the actual productivity of the two digging tools in February 2023 is 89,483 bcm/month, which value has not yet reached the production target set by the company.

In March, the OEE value of the Dossan SL 500 Excavator loading digging equipment was 0.40 or 40%. The actual productivity value is 49,908 bcm/month. Meanwhile, for the Komatsu 300 Excavator, the OEE value is 0.41 or 41%. And the actual productivity is 38,800 bcm/month. So the total productivity of the two tools in March 2023 is 88,708 bcm/month, which value has not yet reached the production target.

In February, overburden removal equipment productivity was reassessed using the Overall Equipment Effectiveness (OEE) technique after making changes to reduce the amount of lost time. On the Dossan SL 500 excavator, the OEE was found to be 0.67 or 67%. Meanwhile, for the Komatsu 300 Excavator, the OEE value is 0.80 or 80%.

Meanwhile, in March, after repairs were carried out, the OEE value for the Dossan SL 500 Excavator was obtained, namely 0.75 or 75%. Meanwhile for the Komatsu 300 Excavator, it is 0.73 or 73%.

In February, the production value of the Dossan SL 500 Excavator after optimization was found to be 111,805 bcm/month, while the Komatsu 300 Excavator was 117,411 bcm/month. Then total production after repaired, it has reached the target of 229,216 bcm/month, even exceeding the company's planned target of 100,000 bcm/month.

Meanwhile, in March, after repairs were carried out, the production value of the Dossan SL 500 Excavator was 154,761 bcm/month and the Komatsu 300 Excavator was 109,522 bcm/month. Then total production after repaired, it has reached the target of 264,283 bcm/month, even exceeding the company's planned target of 100,000 bcm/month.

8. Conclusion

8.1 actual productivity value of the Dossan SL 500 Excavator and Komatsu 300 Excavator in February was 89,483 bcm/month in March and 88,708 bcm/month in February, this still did not reach the production target of 100,000 bcm/month. Meanwhile, the loss caused by not achieving the production target in February was 1,935,105,000 rupiah, while in March it was 2,077,705,000 rupiah.

8.2 The Overall Equipment Effectiveness (OEE) value for the Dossan SL 500 Excavator and Komatsu 300 Excavator in February 2023 is very low, respectively 41% and 43%, while in March the OEE value for each piece of equipment was 40% and 41%.

8.3 In February, the highest value of Six Big Losses was on the Dossan SL 500 Excavator, namely equipment failure losses, namely 42.15%. On the Komatsu 300 Excavator loading digging equipment, the highest Six Big Losses value was Equipment failure losses, namely 43.24%. Meanwhile, in March, the highest value of Six Big Losses was on the Dossan SL 500 excavator, namely equipment failure losses, namely 47.66%. On the Komatsu 300 Excavator loading digging equipment, the highest Six Big Losses value is Equipment failure losses, which is 46.50.

8.4 After implementing measures to improve performance by adjusting the delay time value to match the ideal loss time, production estimates using the Overall Equipment Effectiveness (OEE) technique show that the amount of overburden removed in February was 229,216 bcm, while in February March was 253,657 bcm. This indicates that the company has not only achieved, but also exceeded its projected target of 100,000 bcm/month. In February, the OEE value for each dig-loading equipment and transportation equipment was 67% and 8080%, while in March it was 75% and 73%.

9. Suggestion

9.1 To increase efficiency in overburden stripping, downtime must be minimized by allocating sufficient standby reference time for each delay.

9.2 To achieve the company's expected output goals for overburden stripping, it is very important to extend the working hours of the excavation equipment.

9.3 Strict supervision is needed to increase operator compliance, so as to increase the efficiency of tool use.

9.4 To overcome the significant time lost due to internal company problems and allocation of units to unrelated tasks, the authors propose two potential solutions to meet overburden stripping production targets. The first option is to add additional units, while the second option is to optimize equipment performance during Shift 2 by using a reference for maximum standby hours in a one month period.

Bibliography

[1] Alam, M., Mahanta, B. K., & Nawghade, N. (2018). Comparative Performance Study Of Mining Trucks by Overall Equipment Effectiveness. *Engineering and Technology*, *5*, 448-453.

[2] Darman, H., & Hasan, F. (2000). *An Outline Of The Geology Of Indonesia.* Indonesian Geologists Association.

[3] Hasan, MI 2002. "Main Materials of Research Methodology and Applications Completed with Research Proposals and Thesis/Thesis Research Reports.

[4] Hastary, S. 2021. "Optimizing the Production Process Using the Overall Equipment Effectiveness Method." Journal of National Development Economics 14: 119– 30.

[5] Hutmi R. (2022). Evaluation of the Productivity of Loading Digging Tools to Achieve Overburden Stripping Production Targets Using the Overal Equipment Effectiveness (OEE) Method in Block 55 PT. Take Care of Sandai Business - Sandai Site, Sandai Kiri, Sandai District, Ketapang Regency, Kalim.

[6] Indonesianto, Y. (2014). *Mechanical Earthmoving.* Yogyakarta: Mining Engineering, UPN Veteran.

[7] Nakajima, S. (1988). *Total Productive Maintenance*

[8] Projosumarto, P. (1995). *Mechanical Earthmoving.* Bandung: Department of Mining Engineering ITB.

[9] Putri, NA, & Gusman, M. (2018). Optimizing Komatsu 300E-6 Shovel Production Using the Overall Equipment Effectiveness (OEE) Method for Stripping Overburden Layers in Pit 2 of the West Banko Mine PT. Bukut Asam (Persero) Tbk. *Journal of Mining Engineering*, *3*, 1300-1309.

[10] Prabowo, H., Hutmi, R., & Dewata, I. (2023). Optimizing Digging Equipment Productivity Using Overall Equipment Effectiveness (OEE) Method in Coal Overburden Mining Activities. INVOTEK: Journal of Vocational and Technological Innovation, 23(2), 99-108.

[11] Nugraha, MF (2023). Optimization of Loading Digging Equipment and Transport Equipment for Overburben Stripping Activities in February 2023 at Pit 4 SBE PT. Asia Multi Investama, Muaro Kilis Site, Tengah Ilir, Tebo, Jambi (Doctoral dissertation, Padang State University).

[12] Prabowo, H., & Marcelino, UZD (2023). Technical Study of Productivity and Compatibility of Excavators with Dump Trucks in PT Coal Getting Seam 18 Activities. Kurnia Alam Investama, Batanghari Regency, Jambi Province. CIVED, 10(2), 398-408.

[13] Prabowo, H., Premana, H., & Amrina, E. (2023). WORKING COMPATIBILITY OF VOLVO EC330 BLC EXCAVATOR LOADING EQUIPMENT AND MERCEDES BENZ AXOR 2528 C DUMP TRUCK TRANSPORTATION EQUIPMENT IN COAL GETTING SEAM B ACTIVITIES. Journal of Science and Technology: Journal of Science and Industrial Technology Applications, 23(1), 86-98.

[13] Ananda, AD, Rahman, HA, & Prabowo, H. (2023). Analysis of the Compatibility of Coal Loading and Transporting Digging Tools in Overburden Production in Pit Alam 1-3 at PT. Muara Alam Sejahtera, Lahat Regency, South Sumatra. Mining Development, 8(3), 33-41.