J E M T
Journal of Earth and Marine Technology
homepage URL: ejurnal.itats.ac.id/jemt

STUDY OF PRODUCTIVITY ANALYSIS OF DIGGING LOADING IN GRAVEL MINING IN PT. GALUH CEMPAKA DISTRICTS CEMPAKA CITY BANJARBARU SOUTH KALIMANTAN PROVINCE

Usman[1]*, Yazid Fanani[1], Fajar Rizki Widiatmoko[1]
[1] Department of Mining Engineering, Mineral and Marine Technology, Adhi Tama Institute of Technology Surabaya
*e-mail: usmanhaneman1@gmail.com

Article info
Received:
July 25, 2021
Revised:
August 26, 2021
Accepted:
September 2, 2021
Published:
September 30, 2021

Keywords:
Productivity, Excavator, Dump Truck, Cycle Time, Gravel

Abstract
Galuh Cempaka Ltd. is a Gravel Mining Company with an area of 2,994 Ha. The mining system was surface mine or open pit. There are several things which should move in dig and load activities, such as mechanical soil, productivity, and compatibility of loading and conveying equipment are important factors in gravel mining activities. It influences on how far to know the effective work hour and the productivity. The purpose of this research was to determine work efficiency in Galuh Cempaka Ltd, and calculate the productivity of each equipment and the Match Factor value of the loading and conveying equipment in mining activity. From the observation and data processing, it obtained 1 unit of excavator Komatsu PC 400LC, wasingplan as far as 1.5 km. The effective work time was obtained work efficiency of 0.82 and after it was conducted the efficiency become 0.83 and it was reduced the obstacles from excavator CAT 320D. Before digging toll productivity got optimizing from CAT 320D in gravel excavation, it got 94.2 tons/hour and after it got optimizing from CAT 320D excavator in gravel excavation, it obtained 99.6 tons/hours and the IVECO 380 dump truck for gravel loading was 125.55 tons /hour. It obtained Match Factor Overburden (08) < 1. it means it is less than 1. So, there was waiting time for transportation equipment which had not arrived yet. Match Factor Gravel (1.2) > 1 means more than 1. So, there was a waiting time for transportation because the digging tool was filled.

1. Introduction

PT. Galuh Cempaka is a private company engaged in diamond mining which is located in Cempaka District, Banjarbaru City, South Kalimantan Province. The mining system used is an open pit mining system with the Surface Mine method, where the research and data collection is carried out in the DS12B Pit.

PT. Galuh Cempaka has set production standards, but the company wants optimization and maximizing productivity. Galuh Cempaka Ltd. has planned to optimize and increase production as a form of the company's work effectiveness to be better. The author took the initiative to propose research to increase the effectiveness in the form of optimizing production scheduling.

In the production activities carried out by Galuh Cempaka Ltd. uses a 1-unit excavator, Komatsu PC400 type, for overburden removal, while overburden loading from the pit to disposal uses a 3-unit Iveco 380 Dump Truck. For gravel excavation, 1-unit Catterpillar 320 excavator is used, while gravel loading uses 2-unit excavators. Iveco 380 Dump Truck unit. After doing this research, what needs to be studied is the time required to complete the gravel excavation with the production target set by Galuh Cempaka Ltd.

2. Theory

Cycle Time Excavator

Cycle time is the time required for one cycle of production activities from start to finish [11].

$$CTex = \frac{T1+T2+T3+T4}{60} \quad \text{.....(3.1)}$$

Information :
CTex = Total Excavator Cycle time (minutes)
T1 = Digging time (seconds)
T2 = Charged swing time (seconds)
T3 = Shedding time (seconds)
T4 = Free swing time (seconds)

Cycle Time Dumptruck

Dumptruck is a tool used to transport materials resulting from the burning from the mining site to the landfill site [12].

$$CTd = \frac{T1+T2+T3+T4+T5+T6}{60} \text{.....(3.2)}$$

Information :
Ctd = Total dump truck cycle time (minutes)
T1 = Loading time (seconds)
T2 = hauling time (seconds)
T3 = Time to position the spill (seconds)
T4 = Dumping or shedding time (seconds)
T5 = Empty return time (seconds)
T6 = Positioning time at loading (seconds)

Factors Affecting Productivity

The factors that affect the cycle time of the digging and transport equipment [13], namely the compactness of the material can affect the productivity of the loading and unloading equipment [14] and the loading pattern [15].

Work Efficiency

The time actually used by workers in doing production [16]. The following is the formula for calculating work efficiency [17]:

Mechanical Availability

In this condition, if there is damage or there is interference with the mechanical device, the tool must be repaired immediately and has been in the workshop.

$$MA = \left(\frac{w}{w+R}\right) \text{ x } 100\% \text{ ....(3.3)}$$

Physical Availability

In this condition, if there is damage or disturbance to the mechanical device, the tool is immediately repaired but the tool is still in the workplace.

$$PA = \left(\frac{w+S}{w+R+S}\right) \text{ x } 100\% \text{ ....(3.4)}$$

Used of Availability

To know the actual time of the tool that has been working.

$$UA = \left(\frac{w+S}{w+S}\right) \text{ x } 100\% \text{ ....(3.5)}$$

Effective Utilization

To find out what percentage of tools are effective at work.

$$UA = \left(\frac{w}{w+S+R}\right) \text{ x } 100\% \text{..... .....(3.6)}$$

Information :
W = Tool working hours

R = Tool repair time
S = Time the tool is idle or inactive

Swell Factor
Changes in the volume of the material to be taken by changing the original shape but the weight of the material remains the same [18].

Fill Factor
The percentage of the comparison of the actual volume that can be filled with its theoretical capacity [19].

Productivity of Digging – Loading Equipment (Excavator)

$$\boldsymbol{Pex = \frac{60}{CTex}\ x\ KB\ x\ FF\ x\ SF\ x\ FK} \quad \text{.....(3.7)}$$

Information :
Pex = Excavator Productivity (BCM/hour)
Ctex = Excavator Cycle Time (minutes)
Kb = Bucket Capacity (m3)
FF = Fill Factor (%)
FK = Correction factor (Work efficiency, Availability; %)
SF = Conversion Factor (Swell factor; %)

Productivity of Transport Equipment (Dump Truck)

$$\boldsymbol{C = n\ x\ Kb\ x\ FF}$$

$$\boldsymbol{Pdt = C\ x \frac{60}{CTdt}\ x\ FK} \quad \text{.....(3.8)}$$

Information :
Pdt = Dumptruck Productivity (BCM/hour)
CTdt = Cycle Time Dumptruck (minutes)
Kb = Bucket truck capacity (m3)
FK = Correction Factor (Work efficiency; %)
n = Amount of filling
FF = Fill Factor (%)

3. Methodology

In obtaining the results of the data required research analysis aimed at obtaining information used to answer research problems, the following research methods:

- Conducting literature studies in the form of references, journals related research reports.
- Primary and secondary data collection.
- Conduct field orientation by making direct observations.
- statistical processing of cycle time data, as well as analyzing the cycle time of mechanical devices.
- Calculation of work efficiency
- Calculation of productivity, as well as analyzing the productivity of mechanical equipment can achieve or not from the specified target.
- Provide recommendations from the problems obtained in order to achieve production targets.

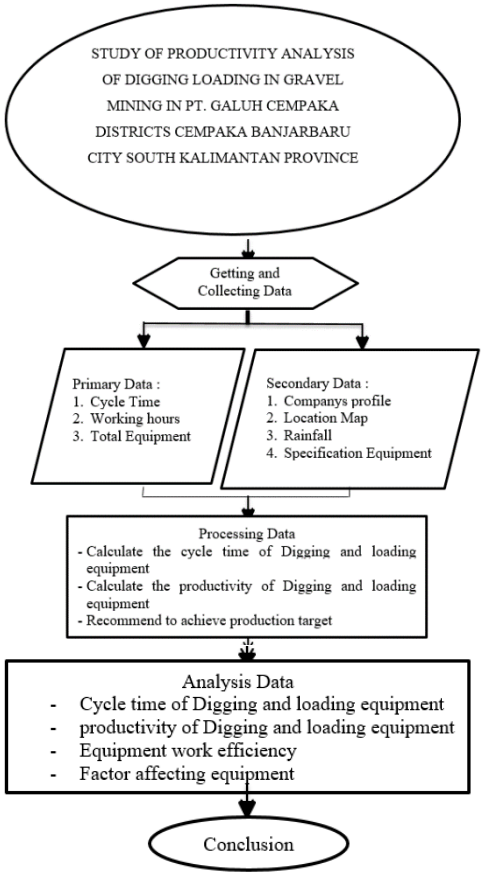

Figure 1. Research Flowchart

4. Results

Effective Working Hours

Effective working hours of loading and unloading equipment at Galuh Cempaka Ltd. was obtained after conducting research on mining sites.

Table 1. Effective Working Hours (unit in hours)

Unit	Working Hours Available	Repair	Standby	delay	Effective Working Hours
Komatu PC400LC	480	7.5	37	7.5	428
CAT 320d	480	20.5	60.5	7.5	389.5
DT Overburden	480	5.5	39	7.5	428
DT Gravel	480	5	78	7.5	389.5

Work efficiency

Efficiency is obtained from effective working hours, to be able to determine that the tools operating in mining activities can work effectively. Work efficiency on loading and unloading equipment at Galuh Cempaka Ltd. was obtained with the following results:

Table 2. Tool Efficiency

Unit	MA	PA	UA	EU
Excavator PC 400LC	98%	98%	92%	90%
CAT 320d	94%	95%	86%	82%
DT Overburden	98%	98%	91%	90%
DT Gravel	98%	98%	83%	82%

Cycle Time Excavator

Cycle time excavator namely one work cycle that can be done by the excavator, with that obtained the total time that can be completed in one work cycle by the digging tool.

Table 3. Average Excavator Cycle Time

Unit	*Cycle Time*				Total Cycle Time (minutes)
	Excavation	*Swing* Contents	Spilled	*Swing* Empty	
Komatsu PC400LC	0.22	0.22	0.13	0.21	0.8
CAT320	0.23	0.22	0.13	0.16	0.7

Cycle Time Dumptruck

Cycle time dumptruck namely one work cycle of the loading equipment that transports the excavated material to its storage place.

Table 4 Average Cycle Time Dumptruck

Freight	Cycle Time Dump Truck						Total (minutes)
	loading	hauling	maneuver	dumping	return	spotting	
overburden	0.78	2.05	0.82	1.02	1.5	1.08	7.31
gravel	0.75	3.13	0.82	1.02	2.5	1.08	9.33

Digging Tool Productivity

After obtaining the required data, the next step is to calculate the productivity of the mechanical device. On the excavator, it was found that Komatsu PC 400LC in overburden excavation had a productivity of 139.7 bcm/hour and achieved the set production target, while for CAT 320D in gravel excavation it had a productivity of 94.2 tons/hour and did not reach the specified target, there is a shortage of 1.8 tons of gravel which is still lacking.

Transport Equipment Productivity

After obtaining the required data, the next step is to calculate the productivity of the mechanical device. In the dumptruck, it was found that IVECO 380 for overburden transportation has a productivity of 184.9 bcm/hour and the equipment is capable of carrying the targeted load within one month, while for IVECO 380 for gravel transportation it has a productivity of 125.55 tons/hour and the equipment is capable of transporting the targeted load within one month.

Match Factor

The tool compatibility factor is the suitability between the number of digging and loading equipment and transportation equipment is also one of the factors that affect productivity. Then the compatibility factor of the working tools is as follows:

Table 5 Harmony Factors

Excavation	Tool Type	Number of Tools	*Cycle Time*	MF
Overburden	*Komatsu PC400LC*	1	0.7	0.88
	IVECO 380	3	7.14	
Gravel	*CAT 320*	1	0.7	1.2
	IVECO 380	2	10.2	

From the calculation above, the Match Factor value in overburden excavation < 1, i.e. the loading equipment works less than 100% while the conveyance works 100%, so there is a waiting time for the loading equipment because it is waiting for the conveyance that has not arrived. In gravel excavation > 1, the loading equipment works 100% while the conveyance works less than 100%, so there is a waiting time for the conveyance because the other conveyance is waiting for filling.

5. Discussion

Based on the results of the study, actual productivity, with an overburden production target of 138.8 bcm/hour and an excavator with a total of 1 unit of 139.7 bcm/hour, the excavator in overburden excavation activities has reached the production target. The gravel production target is 96 tons/hour and the excavator with 1 unit is 94.2 tons/hour. There is a gravel production shortage of 1.8 tons/hour. Meanwhile, the overburden dump truck with a total of 3 units has reached the production target of 184.9 bcm/hour. Dump trucks on gravel with a total of 2 units have reached the production target of 122.65 tons/hour. Based on the problems, to achieve the production target, it is necessary to optimize work efficiency.

Optimization of Cycle Time CAT 320D

The digging conditions in the DS12B pit are solid, so when the excavator is digging gravel, the excavator must first dredge in order to fill a full bucket. Because at Galuh Cempaka Ltd. does not use explosives to destroy gravel. Therefore, the excavator must dig first and take a long time so that it affects the cycle time of the loading equipment. At Galuh Cempaka Ltd. also has improvements to the washing plan which makes the digging and transport equipment have to stop production, because the tools are made by themselves and still have many damage problems that must be repaired. When the loading and unloading equipment on the gravel stops, one of the optimizations that can be done is when repairing the washing plan,

Optimization can be done when repairs occur on the washing plan, the CAT 320D excavator must keep running to prepare gravel so that excavator loading activities can speed up the cycle time of mechanical equipment

Table 6. Optimization of Cycle Time

Information	*Cycle Time*				Total Cycle Time (Minutes)
	Excavation	*Swing* Contents	Spilled	*Swing* Empty	
Before Optimization	0.23	0.22	0.13	0.16	0.7
After Optimization	0.16	0.22	0.13	0.16	0.67

Optimization of Work Efficiency

The work efficiency obtained is a reduction in the time of inhibition, namely during P5M. According to PP 50 of 2012 Article 9, in the safety talk there is a discussion of work risk control and P5M. Therefore, P5M is included in the safety talk section, so P5M time in one month can be eliminated to reduce bottleneck times. After optimizing work efficiency, there was an increase from 82% to 83%, so the productivity of the CAT 320D excavator was 99.6 tons/hour and was able to achieve the production target.

Productivity Comparison Before and After Optimization

After optimizing the cycle time and working hour efficiency, the tools that work can work optimally because the tools work optimally and no time is wasted. From Figure 5.3 it can be seen that the comparison after optimization and before, the excavator which previously had a productivity of 94.2 tons/hour so it did not reach the gravel production target, therefore optimization was carried out so that the excavator could work optimally there was an increase in productivity to 99.6 tons/hour, from these results, the excavator can work optimally and effectively so as to achieve productivity.

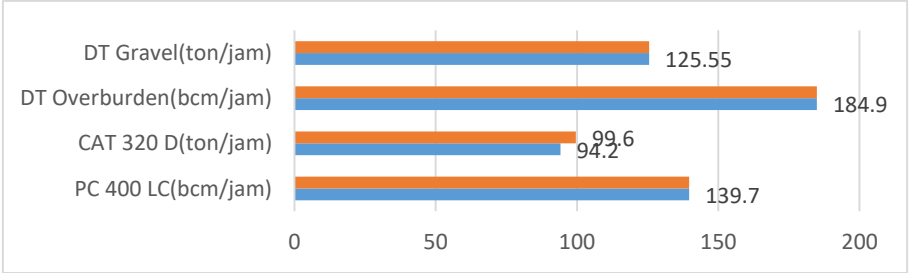

Figure 2. Comparison Graph Before (Blue) and After Optimization (Orange)

6. Conclusion

Based on the results of research at the research site at Galuh Cempaka Ltd. pit DS12B, the conclusions obtained are as follows:

- Productivity of loading and unloading equipment in overburden excavation has reached the production target. Meanwhile, the excavation of gravel on the digging equipment can produce 94.2 tons/hour and has not reached the production target of 96 tons/hour. There is a shortage of gravel production of 4.1 tons/hour.
- Factors affecting not achieving this production target are the cycle time of loading equipment and work efficiency.
- Comparison of excavator productivity in gravel excavation which previously was 94.2 tons/hour so that the production target was not met, so optimization was carried out to get productivity of 99.6 tons/hour so the production target could be achieved.
- The right recommendation to achieve the production target is to optimize the cycle time of loading equipment in gravel excavation and work efficiency. This optimization effort can increase the circulation time of loading equipment so that it can increase effective working hours in order to achieve production targets.

7. Acknowledgement

Thank you to Galuh Cempaka Ltd. to give the writter opportunity to getting and collecting data for this research.

References:

[1] Hall, R., & Nichols, G., 2002. Cenozoic Sedimentation and Tectonics in Borneo: Climatic Influences on Orogenesis. In : Jones, SJ and Frostick, L. (Eds) : Sediment Flux to Basin : Causes, Control and Consequences, Geological Society of London, Special Publications, 191, 5-22.

[2] Bemmelen, Van, RW 1949. The Geology of Indonesia. Martimus Nyhoff, Netherland: The Haque.

[3] Heryanto, R., 2010, Geology of the Barito Basin, Kalimantan, Geological Agency of the Ministry of Energy and Mineral Resources, Bandung.

[4] Kusuma, MI and Nafi, AN 1986: Prospects of Hydrocarbons for the Warukin Formation in the Barito Basin, Kalimantan, Proceedings of the XIV IAG Annual Scientific Meeting, Jakarta, 105 -124.

[5] Heryanto, R., 2000. Pitap Group Sedimentary Rock Deposits in the Southern Part of the Meratus Mountains. Journal of Geology and Mineral Resources, X (109), p. 2-19

[6] Kusuma, E. 2008. Coal of the Warukin Formation in Sampit and Surrounding Areas, Central Kalimantan, Indonesian Journal of Geology, Vol. 3 No. March 1, 2008 : 11-22.

[7] Darman, Herman., Sidi, F. Hasan., 2000, an Outline of The Geology of Indonesia, Published by IAGI.

[8] Indonesian Stratigraphic Code Commission, 1996, Indonesian Stratigraphic Code, Jakarta: IAGI.

[9] Novita, D. 2017. Characteristics and Environment of Coal Deposition of Warukin Formation in Kalumpang Village, Binuang, South Kalimantan. Journal of Geology and Mineral Resources, 17(3), 139-152.

[10] Maryanto, S. and Sihombing, T., 2001. Paleogene Stratigraphy of South Kalimantan Region: Its Relation to Coal Availability. Special Publication No. 26 Pg 29 -51. Bandung Geological Research and Development Center.

[11] Prodjosumarto, Partanto. 1995. Mechanical Soil Displacement, Department of Mining Engineering, Bandung Institute of Technology.

[12] Rochmanhadi. 1992. Heavy Equipment and Their Use. Jakarta : Department of Public Works. Public Works Publishing Agency.

[13] Sudrajat, FR, Purwoko, B., & Syafrianto, MK 2019. Planning the Need for Digging Equipment and Transport Equipment to Achieve Overburden Production Targets in Coal Mining At Pt. Ganda Alam Makmur, Kaubun District, East Kutai Regency, East Kalimantan Province. Journal of Civil Engineering Students, Tanjungpura University, 6(1).

[14] Hartono, W. 2005. Mechanical Land Displacement (Heavy Equipment). Central Java : Educational Development Institute (LPP) UNS UPT. UNS Publishing and Printing (UNS Press).

[15] Indonesianto, Yanto., 2005, Mechanical Soil Displacement, Department of Mining Engineering – FTM, UPN Veteran Yogyakarta.
[16] Hartman, H. L and Mutmansky, JM 1987. Introductory Mining Engineering. New York: A Wiley Interscience Publication.
[17] Tenrisukki Tenriajeng, Andi. 2003. Mechanical Soil Displacement. Jakarta: Gunadarma University.
[18] Peurifoy, R. Etc. 1956. Construction Planning Equipment ana Methods. 7th Edition. New York: McGraw Hill Companies.
[19] Darmansya, N. 1998. Mechanical and Heavy Equipment Displacement. South Sumatra : Civil Engineering Department, Sriwijaya University.
[20] Haryanto, S. E., Budiarto, B., Sari, A. S., & Widiatmoko, F. R. (2019, September). Kajian Teknis Sistem Penyaliran Tambang Dan Rancangan Sumuran Pada Pit Majapahit PT. Prolindo Cipta Nusantara, Kabupaten Tanah Bumbu, Kalimantan Selatan. In Prosiding Seminar Nasional Sains dan Teknologi Terapan (Vol. 1, No. 1, pp. 539-544).