Synchronization Conveyance and Loading Equipment for Production Target In Mining Activities On Obi Island

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Abstract. Mining company open pit method, with mining selective system, target production of 3,600,000 tons / year, using the tools excavator sany PC 365 and the tools load ADT dump truck komatsu HM 400 To achieve the predetermined production results, analysis of the factors that affect the production, one of which is the amount of time wasted, due to the influence of time constraints, standby time, and the time of repair of the excavator and dump truck. The effective time of work used by the operator is the time available 12 hours per shift per 1 day, but the reality on the ground of the acquisition of effective time is 6 , 67 hours or 56% for excavator and 6.59 hours or 55% for dump truck, Match factor (The number that shows the comparison between the production of loading equipment and the hauling unit served) is MF <1, which means that the conveyance is always busy, while the loading tools has idle time. Keyword: match factor, conveyance, loading tools

Introduction
Indonesia is a country that is rich in nickel ore mineral resources and is a leading commodity in several regions, including in South Halmahera Regency, North Maluku Province, nickel ore reserves in North Maluku are spread in several regions, Midst Halmahera, East Halmahera and, South Halmahera [1]. One of the private companies operating in the South Halmahera area Obi Island with a production target of 3,600,000 tons / year [2], in production activities in the field there are 2 production operations namely overburden production operations and nickel ore production [2], which are mining activities to produce production using mechanical devices, mechanical devices play an important role in supporting the success of mining activities and production targets [3]. The mining system used is implements a conventional open pit mining system, where there is a combination of excavators and equipment dump truck, the compatibility of the two tools is one of the supporting factors to achieve the production targets planned by the company [2][4] . Problems which generally arises in mining operations is the problem of unachieved productivity targets for loading and unloading equipment which are constrained by technical factors or incompatibility with the tool [5], so that there needs to be an evaluation to examine in more detail what factors are the problem so that the evaluation can be used as a reference for planning and implementing production activities in the next period. Several studies on the synchronization of loading and conveying equipment in mining activities have been carried out before,[3] asphalt production target, [5] which is carried out in coal mining, [6] which was also carried out in coal mining in the East Kutai Regency,[7] Soil Mining In Area 242 With The Application Of Queue Methods To Meet Clay Production Targets at PT Semen Padang,[8] Efficiency Of Tools And Transport Tools Overburden Peeling On Site A In PT. Samantaka Coal Of Riau Province, and [9] with Chart Control Method. Based on some of the above research, this research is focused on the synchronization of loading and transportation equipment in the mining activities of nickel ore on Obi Island.
2. Methods
Methodology in research with direct observation of loading and hauling operations in the field, data obtained by cycle time of loading and hauling equipment, effective working time of loading and hauling equipment, productivity of loading equipment and conveyance and work harmony of tools loading and transportation equipment (match factor) and effective working hours.

A. Tool Productivity

**Truck transport**
In general, the following formula is used to calculate transportation equipment:

\[
P = \frac{K \cdot \delta \cdot m}{h \cdot o} \]

**Tools Load**

\[
P = \frac{K \cdot \delta \cdot m}{h \cdot o} \]

**Information**

- \( P \) = Equipment Production Capability
- \( KB \) = Bucket Capacity (m³)
- \( FP \) = Filling factor (%)
- \( EU \) = Work efficiency (%)
- \( CT \) = Cycle time (minutes)
- \( SF \) = Swell factor (%)
- \( n \) = Amount of filling

**B. Cycle Time**

**a. Backhoe Cycle Time**
The backhoe cycle time depends on four basic movements, namely: Filling the bucket (loading bucket), swing loaded, swinging unloading, and swing empty The backhoe cycle time can be calculated by the equation:

\[
C_{tm} = Am + Bm2 + Cm3 + Dm4
\]

**Information**

- \( Am \) = Digging and charging bucket time (seconds)
- \( Bm \) = Swing time with material load (seconds)
- \( Cm \) = Time to shed loads into the hauling unit vessel (seconds)
- \( Dm \) = Swing time (swing) blank (seconds)
- \( C_{tm} \) = Total load time for loading equipment, (minutes)

b. Dump Truck Cycle Time**
The time of the dump truck cycle depends on six basic movements, namely: Loading dump truck tubs (loading) Material transportation (hauling), load shedding (dumping), Back empty (returns empty), and maneuver blank (empty spot) can be calculated by equation: [11][12][13][14][15]

\[
C_{ta} = Aa + Ba + Cc + Da + Ea + Fa
\]

**Information**

- \( C_{ta} \) = Total cycle time hauling unit (conveyance), (min)
- \( Aa \) = Time adjust the position to be filled vessel material into the tub, (min)
- \( Ba \) = time filled with material load, (minutes)
c. Tool Load Productivity

\[
TP = \frac{K \cdot \delta \cdot m}{\eta \cdot \zeta}
\]

\[FK = MA \times EU \times Sf\]

Information:
- TP = Production loading equipment (m³ / day)
- KB = Tub capacity (m³)
- SF = Swell factor
- Ff = Full factor / bucket factor (%)
- FK = Correction factor
- MA = Mechanical availability
- Ef = Work efficiency
- CT = Circulation of mechanical devices (minutes)

\[d. \text{ Transport Equipment Productivity}\]

Transport equipment can be calculated using the following equation:

\[P = E \left( K_b \times F_f \right) N \times 60 \text{ minutes / hour} \div CT\]

Information:
- P = Loading equipment (m³ / hour)
- E = Effectiveness of mechanical devices (%)
- KB = Body capacity (m³) = (kb x Ff) N
- Ff = Loader loading factor (%)
- KB = Bucket capacity (m³)
- CT = Circulation of mechanical devices (minutes)
- N = Amount of filling

\[e. \text{ Match Factor}\]

To be able to find out match factors (numbers that show a comparison between production loading tools with hauling units served), we can know the results by doing calculations:

\[MF = \frac{n}{n}\]

Information:
- MF = Match Factor (MF) or harmony factor
- nT = Number of transport equipment
- nL = Number of loading equipment
- CTH = Cycle time transport means (Hauling)
- CTL = Cycle tool load time (loading)

If the results of the calculation are correct:[10][12]
1. In MF = 1, this situation is the most ideal, where the transport and loading equipment are equally busy operating.
2. In MF < 1, the conveyance is always busy while the loading device has time to idle it.
3. In MF > 1, loading tool is always busy while the transport equipment there is idle time. because loading equipment has a waiting time then: [7]
a. Factor of conveyance (Fka) = 100%
b. Factor of loading equipment (Fkm) = MF x 100%

f. Factors Affecting Production

Based on the theory [4] the factors that influence the production of loading and transport equipment are as follows

1. Physical Properties of Materials
   The ability of mechanical devices to work both transport and loading equipment is strongly influenced by the physical properties of materials such as development factors (Swell Factor) or the weight aspect of the contents.

2. Workplace Conditions
   Large workplaces will reduce tool loading cycle time because there is enough space for various positions to be taken, such as rotating, taking positions before loading or shedding and for loading activities. Thus the tool does not need to go back and forth to take a position because the space is quite wide, so the cycle time becomes smaller.

3. Road Transport Conditions
   The selection of mechanical devices for transportation is largely determined by the distance traveled. The function of the road is to support mining operations, especially in transportation activities. If the road conditions are good, then the cycle time will be small.

4. Equipment Condition
   The modeling of mechanical devices for both loading and transport affected the circulation time. The new cycle time of the loading equipment will certainly smaller than the load cycle time that has been used for a long time.

5. Operator Capability
   The ability of the operator is very influential on the time to be used. For operators who are experienced, they will be able to reduce the time needed for the use of loading equipment and transportation equipment.

6. Effect of Weather
   In hot and dusty weather it will reduce the operator's visibility, but this can be overcome by watering the road. Whereas if it rains all activities on the field will be stopped.

7. Maintenance of Tools
   Mechanical equipment must be kept in good condition. Things that must be considered in maintenance of tools include:
   - Regular replacement of lubricants
   - Condition of tool parts bucket, etc.
   - Inventory of spare part that are often needed for the equipment in question.

Result and Discussion

3.1 Mining Activities
   Nickel ore mining activities use an open mining system where mining is carried out in concave form the mining area downwards, Mining activities include land clearing activities (land clearing), stripping and overburden storage at waste dump areas, mining of nickel ore, nickel size separation according to market demand and the shipping production.

3.2 Loading and Transporting Activities
   Loading pattern used is botton loading and unloading patterns where patterns fit between excavator and tools loading parallel, from this angle can affect the turning angle (swing) of the tor excavator, Loading and unloading using the tool PC 365 excavator sany 2 units , in the burnei mining pit.
3.3 Hauling Method
Transportation activities (hauling) is performed to a transported use conveyance ADT dump trucks komatsu HM 400, 5 units for mining area, with transport distance of the front mining (pit burnei) to stock pile (EFO) of approximately 250 -300 meter.

3.4 Cycle time of Loading and Transport
The average value of observational data for the load times obtained based on the results of data processing can be statistically described as follows:

| No | Activities         | Time (seconds) |
|----|--------------------|----------------|
| 1  | Time to dig        | 0.72           |
| 2  | Swing fill time    | 0.48           |
| 3  | Time to spill      | 0.46           |
| 4  | Empty swing time   | 0.4            |
|    | Total              | 2.06 (0.034 minute) |

The total circulation time of loading equipment is 2.6 seconds or 0.034 minutes, the opportunity to load in one hour is: 60 minutes / hour / 0.034 minutes / trip =1.764 trip/hour

In its operations there are several factors that influence the production dump trucks, namely cycle time by calculating the movement of the dump truck while the circulation time of the Komatsu HM 400 ADT dump truck is based on field observations as follows:

| No | Activities          | Time (seconds) |
|----|--------------------|----------------|
| 1  | Maneuver time 1    | 4.07           |
| 2  | Load time          | 33.33          |
| 3  | Transport time     | 44.44          |
| 4  | Maneuver time II   | 0.55           |
| 5  | Dumping time       | 0.74           |
| 6  | Time is empty again| 22.22          |
|    | Total              | 101.35 (1,689 minute) |

So the average cycle time for the dump truck needed is 101.35 seconds or 1,689 minutes

3.5 Effective Working Time for Loading and Transport
The effective time of work is the time actually used for operators along with the equipment used for production activities, the amount of time available by the company is 12 hours per one Shift per 1 day, but the reality on the acquisition of effective time is 6.67 hours or 56% for loading equipment and 6.59 hours or 55% for transportation equipment.

3.6 Productivity of Loading and Transport
3.6.1 Productivity of the Sany PC 365 Excavator Load Tools
Production unloading tool excavator sany PC 365 with the time that is available 12 hours, to calculate loading equipment using the following equation

\[ P = \frac{E K \delta m}{C_{ho}} \]
Where the value of each parameter is:

\[
P = \frac{5\% \times 0.9 \times 8 \times 0.7 \times 6 \times m}{0.0 \times m}
\]

\[
P = 778,4 \text{ mjam/hour} \times 12 \text{ hours/day}
\]

\[
P = 9341.3 \text{ m}^3/\text{day}
\]

Based on the data above the results of the calculations that have been done above, the production of affective working time from sany PC 365 excavator loading equipment is 9341.3 m³/day/one unit of equipment.

### 3.6.2 Productivity of Komatsu HM 400 ADT Dump Truck Transport Equipment

To calculate the productivity of the transport using the following equation:

\[
P = \frac{E \times 6 \times m}{C}
\]

Then obtained

\[
P = \frac{5\% \times 2 \times m^3 \times 8 \times 0.7 \times 1.6 \times m}{1.6 \times m}
\]

\[
P = 397,1 \text{ m}^3/\text{hour} \times 5 \text{ units} \times 12 \text{ hours/day}
\]

\[
P = 32,826 \text{ m}^3/\text{day}
\]

Based on the calculation data carried out, the effective working time of the dump truck is obtained by 32,826 m³/day/one unit of dump truck.

### 3.7 Factors - Factors Affecting Tool Productivity

In efforts to achieve production targets as determined by the company, which are 3,600,000 tons/year or 300,000 tons/month or 10,000 tons/day, of course cannot be separated from any problems that affect production activities, based on observations in the field the production target has not reached the predetermined target by the company, this can be caused by several factors as follows:

1. The amount of time is wasted when the road is slippery after rain so it can reduce production.
2. The operator's delay during working hours is quite large at 60 minutes or 1 hour.
3.

### 3.8 Efforts to Increase Tool Production

From the results of observations and calculations it turns out that it has not been able to meet the production targets expected by the company, to increase production targets, the company must increase work time, namely increasing employee discipline, reducing the time of repair and seeking standby time as small as possible, so that work time can be carried out as determined by the company.

### 3.9 Harmonious Factors in the Work of Load Tools and Transport Equipment (Match Factor)

To be able to find out match factors (numbers that show a comparison between production loading tools with hauling units served), we can know the results by doing the following calculations:

\[
MF = \frac{n}{n \times C}
\]

\[
MF = \frac{5 \times 2.0}{2 \times 1.0} = 0.05
\]
From the data above, it is obtained that MF <1 means that the conveyance is always busy, while the loading equipment has idle time.

4. Conclusions and Recommendations
From the results and discussion some conclusions can be drawn as follows:
1. The *sany PC 365 excavator* load production is 9341.3 m³/day
2. The loading tool Komatsu HM 400 ADT is 32,826 m³/day
3. Factors that influence the production of tools are: material, operator work efficiency, haul road conditions and climate
4. Match factor (compatibility factor) between loading equipment and transportation equipment obtained MF <1 means that the conveyance is always busy, while the loading equipment has idle time.
5. In order to achieve productivity to meet production targets, discipline of employees is sought
6. The operator's skills need to be improved because mechanical equipment will produce high production if the tool is operated by a skilled person.

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