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Mining Equipment Analysis to Reach Target Production on Overburden in Kutai Kertanegara East Borneo

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ABSTRACT
Mining equipment operations is one of the vital means to support target production determined. Early activities of mining is clearing land plants (overburden). Data have been obtained and analyzed based on literature related to the issue: there are geometry road calculate, time circulation, efficiency, productivity, equipment needs, compatibility and alternative combinations. Based on research results, value work efficiency of wheel loading and dump truck are 74.63% and 58.37%; productivity of 10 units of wheel loading 5.05BCM/hour and 25 units of dump truck 5.189 BCM/hour; 0.65 congeniality mining equipment with waiting time 6.61 minutes for wheel loading; Efforts to reached target production are: barriers improvements that occur and perform additional work time, so work efficiency wheel loading increased 76.97% with productivity 5.213 BCM/ hour and efficiency of dump truck increased 61.11% and productivity 5.432 BCM/hour; addition 2 units wheel loading increase productivity 5,867 BCM/hour; the other alternative combination tobe optimal productivity and obtain 4 (four) alternative combination mining equipment. Alternative combination of most optimal productivity is adding dump truck without changing wheel loading being 41 unit, productivity dump truck increased 8.909 BCM/hour and compatibility factor wheel loading and dump truck approaching 1.
Keywords: Work efficiency, Productivity and Target Production.

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I. INTRODUCTION

1.1 Background

Mining equipment in mining operation is one of vital to support target production by management. Mining was land cleanup plants/shrubs and stripping overburden, main purpose of overburden is removal layers of soil cover that covers the minerals (coal, gold and others) which consists of sandstones and clays. Overburden has been peeled and then moved to a place called landfill disposal. Disposal is an open mine operation used for disposing of the material.

PT. XYZ mining activities have been doing with open mine system (sufface mining). PT. XYZ has been conducting since coal production in 2009 with total production 12,307,021 MT on 2009–2013 and have backup the rest 16,547.443 MT, during 2009 – 2013 exploration activities, found new backup rest again 1,424,668 MT. So backup rest of PT. XYZ on January 2014 is 17,972, 111 MT.

Based on estimated budget of purchasing equipment cost PT. XYZ coal mine in East Borneo, with production 2,670,000 tons–3,500,000 tons amount Rp. 512.999.050.000,-. Based estimated value, then neeads a proper and thorough analysis in selection of combination use heavy equipment, especially overburden, in hopes selection will get the right combination, both in terms of heavy equipment types, capacity and quantity.

1.2 Problem of the Study

According to the background, it can be formulated as follow:

1. How many work efficiency, productivity and compatibility mining equipment on overburden?
2. How many productivity and congeniality used mining equipment in each alternative as combinations to reached targets production on overburden?
3. Which alternatives are best in combination of optimal productivity mining equipment on overburden?

1.3 Research Purpose

We can conclude the purpose of this research base on the problem above, it can be formulated as follow:

1. To analyze work efficiency, productivity and compatibility mining equipment on overburden.
2. To analyze productivity and congeniality used mining equipment in each alternative as combinations to reached targets production on overburden.

3. To determine alternative combination of optimal productivity mining equipment on overburden.

II. REVIEW OF RELATED LITERARURE

Equipment are excavator, wheel loader and dump trucks, used in work of overburden. One type of equipment can also serve more than one activity, such as an excavator, besides functioning as an excavate, can also be used as an equipment of fit or even as a dump trucks for a certain distance. (Asiyanto, 2008).

According Nuryanto (2000) some key points as ingredients of thought in terms of use heavy equipment are as follows; 1) Decision in terms of use heavy equipment based on scenario: the equipment must provide an income greater than expenses incurred (including costs of operation/ownership) if not, then no need purchase; Knowledge of heavy equipment should be controlled by an engineer, both latest information regarding development of latest equipment as well as ability to vote with right heavy equipment which suitable for a particular method of execution are appropriate; 2) The relationship of costs by having informed that heavy equipment field, should be able to increase capacity of work and minimize costs incurred; 3) Problems that may arise and should be planned: the expenditure for purchase or maintenance of equipment, the cost of surveillance (periodic), skilled operators and training need for workers and effectively

2.1 Affect Production Factors of Mining Equipment

Cost of jobs, m^3, m^2, m, tons and so on, heavily influenced by a productivity equipment. The higher quantity of work produced per unit of time (hour), then equipment cost per unit of work is getting low. Otherwise when low productivity, cost per unit of work equipment are increasingly high. Therefore productivity is very important role in management of the mining equipment. (Asiyanto, 2008).

2.2 Harmony of Wheel Loader and Dump Trucks

Supervising is an inspection of the used of implementation of work in order to avoid the diverge. Another definition from supervising is an effort to evaluate project data, alongside with SOP authorities to give a hint to the intervene action (PT3).

2.3 The Definition of Performance

Match factor is compatibility between wheel loader equipment with dump trucks. Price of each set of labor harmony work of equipment used determined based on data path time and amount equipment used in each set of the work. To assess compatibility of working equipment and dump trucks used by using a match factor formulated.

$$MF = \frac{Na \times CtL}{Nm \times CTa}$$

Description:

Na = Number of dump trucks
CtL = Time takes to fill to brim.
NM = Number of load equipment
CTA = Time Dump trucks path outside waiting time

The judge are:

MF < 1, meaning equipment fit working less than 100%, while dump trucks work 100% so there is waiting time for equipment load due to waiting dump trucks yet to come.

MF = 1, meaning equipment load and loading work 100%, sehigga does not occur the waiting time of both types of these equipment.

MF > 1, meaning wheel loader fit works 100%, while dump trucks working less than 100%, so there is a waiting time for loading

III. RESEARCH METHODOLOGY

Types of this research is deksriptif. Diskriptif method according type of problem that investigated research conducted include kind of case study research. Research case study is an depth research about the individual, group, an organization, program of activities and so on in certain time. The purpose of case study was to describe the picture in detail about the background, nature and character that is typical of cases, later than typical traits would be a thing which is common.

Location of coal mine (overburden) in the Kutai Kartanegara, East Borneo. Geographically located at coordinates 0 116° 55' 18" East Longitude (EL) and 0° 31' 44" South latitude (LS). To reach area of exploration by motor cycle or car, via Tenggarong-Loa Kulu-Site Pangkor-Road Hauling-PT.XYZ-location. It takes about 1 hour.

Data has been retrieved then tobe analyzed based on related literatures to these issues, there are; 1) Calculate geometry streets of wheel loader and dump trucks; 2) Calculate that cycle time wheel loader and dump trucks; 3) Improve efficiency of wheel loader and dump trucks either teoretically which was later done repair efficiency wheel loader and dump trucks to obtained that productivity theoretically better; 4) calculate productivity wheel loader and dump trucks either theoretically or improvements of productivity equipment fit in dump trucks and theoretical to obtained that productivity theoretically better; 5) Calculate theoretical equipment as well as needs; 6) Count

number of dump trucks between harmony with equipment excavate fit by looking at the number of dump trucks and equipment excavate fit in the field.

IV. ANALYSIS AND DISCUSSION

Production of equipment in addition being influenced by physical condition and lift, also influenced by State of workplace equipment used. To achieve specified production targets, assessment of existence of required production capacity and load equipment transport is used. Such assessment is done by means of observation and research on the circumstances on the ground and that factors affect of equipment. By knowing these things is expected to give best efforts in achieving objectives of production.

4.1 Condition of Mining Front

$$R = \frac{Wb}{\sin \alpha}$$

Based on the specifications of the largest truck dump trucks (Komatsu HD 465)

Wb = (wheelbase front and back) = 4.3 meter
α = (angle of deviation of front wheel) = 30 °

$$R = \frac{4.3}{\sin \alpha} = 8.6 \text{ meters}$$

So bend fingers at least capable of traversed by truck is 8.6 meters. The width of the truck 4.75 m. Then area of the loading point required is = 2 x 8.6 + 4.75= 21.95 m.

4.2 Width of Road Transport

Determination of width of road transport minimum for straight:

$$L = (n \times Wt) + (n + 1)(0.5 \times Wt); \text{ meter}$$

Description:
L = width of minimum transport road straight, meters
n = number of lines
Wt = total dump trucks Width, meters

$$L = (2 \times 4.65) + (2 + 1)(0.5 \times 4.65)$$
$$= 9.3 + (3 \times 2.325)$$
$$= 16,275\text{m} \sim 17 \text{ metres}$$

Determination of the width of the road transports to a minimum on turn:

$$W = n(U + Fa + Fb + Z) + C$$
$$C = Z = \frac{(U + Fa + Fb)}{2}$$

Description:
W = width of road transports to a minimum on the bend, meters
n = number of lines
U = wheel distance vehicles trail, meters
Fa = juntai width front, meter
Fb = juntai width, meters
Ad = distance of front axle with front of the truck, meters
AB = distance of rear axle with back of a truck, meters
C = distance between two will intersect, truck meters
Z = distance of outer side of truck to edge of the road, meters
Fa = Ad X sin α
Fb = Ab X sin α
α = Angle of deviation (turn) front wheel
Wb = distance of front axle with rear wheels, meters

Based on specification of dump trucks and equipment performance observations carried out in the field, then retrieved the following data, to Komatsu HD 465-7:

- Distance between front axle with rear axle: 4.3m
- distance of axis of front wheels with front part: 1, 985m
- distance of rear axle with rear: 3.070 m
- distance between wheel trail (u): 3.515 m
- turning radius: 8.5 m

Angle of the front wheels storage (α)

$$\sin \alpha = \frac{Wb}{\text{turning radius}}$$
$$\alpha = \sin^{-1} \frac{4.3 \text{ m}}{8.5 \text{ m}}$$
$$\alpha = \sin^{-1} 0.51$$
$$\alpha = 30.7^{0}$$

Diversion front wheel when turning around corners forming 30.7^{o} then width of road transports to a minimum on corner to two ways:

FA = 1.985 x 30.7 $\sin^{o}$ = 1.01 m
Fb = sin x 30.7 3.070^{o} = 1.57 m
C = Z = ½ (U + Fa + Fb)
= ½ (3,515 + 1,01 + 1,57)
= 3.05 m

Then width of road transport on a turn is:

$$W = n(U + Fa + Fb + Z) + C$$
$$= 2(3.515 + 1.01 + 3.05 + 1.57) + 3.05$$
$$= 21.34 \text{ meters}$$

4.3 Grade

Based on technical specification data dump trucks Komatsu HD 465-7:

- Heavily laden: 98, 800 Kg ~ 98.8 tons
- Empty weight: 42,800 Kg
- Horsepower: 715 HP

To find out the capabilities of climb dump trucks Komatsu HD 465-7 can be calculated as:

a. Rimpull necessary:
Rimpull to tackle incline (e.g. grade = a%)
98.8 ton x 20 lb/ton x a% = grade (1,976 x a% grade) lb
Rimpull to resolve prisoner scroll
Prisoners scroll (Rolling Resistance) 65 lb/ton
98.8 ton x 65 lb/ton = 6,422 lb
Total rimpull needed = (a x%) 1,976 lb + 6,422 lb

b. Rimpull necessary:
Rimpull magnitude available on trucks can be calculated using the following formula:

$$\text{Rimpull} = \frac{\text{HP x 375 x Mechanical Efficiency}}{\text{Speed (mph)}}$$

Note that maximum speed possible on gear 1 with 85% mechanical efficiency was 6.375 mph, then:

$$\text{Rimpull on gear 1} = \frac{375 \times 715 \times 85\%}{6.375}$$

Table 1: Rimpull available on Each Truck Gear

Gear	Speed (mph)	Eff. Mechanical (%)	HP	Rimpull (lb)
1	6.375	85	715	35,750
2	9.9424	85	715	22,922.7
3	13.6708	85	715	16,671.03
4	18.0206	85	715	12,646.98
5	24.856	85	715	9,169.06
6	33.556	85	715	6,791.82

In order to be able to move the truck, the amount of the required rimpull must equal the rimpull is available. These circumstances will occur when the incline (a%) of transport paths:

(1,976 x a%) lb = lb 6,422 35,750 + lb
1,976 x a% = 35,750 lb – 6,422 lb
1,976 x a% = 29,328 lb
a% = 14.9%

Observations on a map, location of mining transport road sloped ± 12.8% where the ability to climb steeper grades equipment dump trucks Komatsu HD 465-7 is 14.9% (calculation rimpull required), so that dump trucks still able to work well in location of mining area. It's not needed to decreasing the slope of the road because the existence of dump trucks Komatsu HD 465-7 can work well in location of mining.

$$R = \frac{Wb}{\text{Sin } \alpha}$$

Based on specifications of largest truck dump trucks (Komatsu HD 465)

Wb = (distance front and rear wheel axis) = 4.3 meter
A = (the angle of deviation of the front wheel) = 30 °
R = 4.3 = 8.6 metres

$$\frac{}{\text{Sin } 30}$$

Contact area

$$(In^2) = \frac{0.9 \text{ x Weight loading on wheel (lb)}}{\text{Pressure in tons (Psi)}}$$

The accepted load of the road surface

$$(lb/ft2) = \frac{\text{load at each wheel (lb)}}{\text{Contact Area } (In^2)}$$

Based on specifications of equipment, then retrieved data as:

For Komatsu HD 465-7
- Empty weight = 42,800 kg (94,360 lb)
- Heavy Payload = 97,875 kg (215,780 lb)
- Heavy weights for each of the front wheels 32%: 2 = 34,525 lb
- Heavy load for each rear wheel 68%: 4 = 36,682.5 lb
- Tire pressure = 68.15 psi

Based on data, load received each wheel are:

$$\text{Contact area } (In^2) = \frac{0.9 \times 34{,}525 \text{ lb}}{68.15 \text{ psi}}$$

$$= 455.94 \text{ in}^2$$

The accepted load of road surface

$$(lb/ft^2) = \frac{34{,}525 \text{ lb}}{455.94 \text{ in}^2}$$

$$= 75.72 \text{ lb/in}^{2\,c}$$

$$= 10{,}903.7 \text{ lb/ft}^2$$

For rear wheel
Based on that data, load received each wheel are:

$$\text{Wide field contact} = \frac{0.9 \times 36{,}682.5 \text{ lb}}{68.15 \text{ psi}}$$

$$= 484.44 \text{ in}^2$$

$$\text{Load received street level} = \frac{36{,}682.5 \text{ lb}}{484.44 \text{ in}^2}$$

$$= 75.72 \text{ lb/in}^2$$

$$= 10{,}903.7 \text{ lb/ft}^2$$

Power support the way mine based on material used, namely hard dry consolidate clay is 10,000 lb/ft^2 (table 2.2). At this point burdens that are accepted by the road surface of 10,903.7 lb/ft^2 (calculation of load received street level), there is an overload of 903.7 lb/ft^2, so on the surface of the road is often bumpy. To these conditions of use of the motor grader is indispensable, the care of roads routinely and periodically can help optimize the dump trucks work.

4.4 Release Time (Cycle Time)

Power support the way mine based on material used, namely the hard dry consolidate clay is 10,000 lb/ft^2 (table 2.2). At this point burdens that are accepted by road surface of 10,903.7 lb/ft^2

(calculation of load received street level), there is an overload of 903.7 lb/ft^2, so the surface of road is often bumpy. To these conditions of use of motor grader is indispensable, care of roads routinely and periodically can help optimize dump trucks work.

Table 2: Data Path Load Equipment Time

No.	Excavate (tm1)	Swing With The charge (tm2)	Shed The Payload (tm3)	*Swing empty (tm4)*
1	6.86	5.62	4.22	3.44
2	6.34	5.63	4.06	3.21
3	14.44	7.35	3.55	3.19
4	8.63	5.12	4.93	3.9
5	10.65	4.28	3.13	3.35
6	11.25	12.85	3.34	3.44
7	9.28	4.18	4.94	3.97
8	9.12	6.87	3.41	3.85
9	8.45	5.97	3.88	2.63
10	8.23	5.56	2.47	3.81
11	7.32	7.81	3.03	3.58
12	8.36	4.37	3.59	3.32
13	10.12	6.53	4.25	3.13
14	8.23	6.21	4.69	3.03
15	11.12	5.19	3.11	4.62
16	8.25	5.03	3.31	3.52
17	6.65	6.25	3.03	3.31
18	6.5	6.16	3.22	2.58
19	10.29	3.56	3.53	4.12
20	11.25	5.06	4.97	3.52
21	11.14	6.57	4.69	4.09
22	10.53	5.09	4.28	2.18
23	15.28	5.09	4.68	3.54
24	9.09	5.81	3.35	3.56
25	13.25	8.19	4.51	4.72
26	12.53	5.62	5.19	3.12
27	11.56	7.62	3.31	4.18
28	8.12	5.19	4.03	3.25
29	9.62	5.63	4.25	4.18
30	5.44	6.59	3.82	4.31
Avarage	9.6	6.03	3.89	3.56
CT seconds	23.08			
CT seconds	0.38			

Table 3: Time Data Dump trucks Path

No.	Take A Position Fit (ta1)	Filled (ta2)	The Road To The Charge (ta3)	Take The Position Of Dumping (ta4)	Dumping (ta5)	Back Blank (ta6)
1	15.72	84.43	203.22	21.32	16.24	169.09
2	14.42	81.75	159.91	14.22	14.94	116.53
3	11.73	89.87	176.32	14.62	16.69	146.44
4	11.12	137.06	171.46	13.22	23.12	113.31
5	12.81	114.59	171.41	12.5	11.16	148.78
6	10.09	125.84	163.41	13.78	16.06	100.37
7	10.87	159.62	170.84	19.63	17.13	162.71
8	10.82	106.69	197.19	22.72	12.72	122.66
9	11.15	104.91	167.22	11.75	13.51	126.25
10	12.96	103.25	175.85	14.66	14.74	128.47
11	12.88	97.22	131.06	10.94	13.19	89.19
12	11.72	119.06	145.56	12.37	14.44	104.66
13	11.62	115.22	193.81	12.03	18.18	141.53
14	12.55	105.91	183.31	13.13	15.56	119.41
15	12.78	99.94	232.94	15.81	12.03	132.53
16	10.84	79.41	152.94	14.94	17.79	109.34
17	10.35	113.94	187.72	12.28	14.25	176.75
18	15.06	94.15	184.12	10.91	13.78	130.38
19	20.69	85.97	192.78	16.28	14.19	139.34
20	13.78	113.13	162.97	15.09	12.96	122.81
21	10.65	100.92	153.75	10.68	14.25	102.66
22	12.75	91.66	138.03	10.93	13.34	106.21
23	10.11	114.62	184.21	13.28	13.87	123.81
24	18.22	93.81	193.72	18.56	16.25	152.25
25	12.38	98.66	189.78	12.46	15.53	127.08
26	12.72	94.13	185.62	18.03	13.62	119.25
27	11.76	113.25	158.25	14.59	17.38	131.38
28	14.87	105.25	181.46	11.06	13.62	132.97
29	16.41	93.53	189.35	17.16	10.81	130.16
30	17.62	82.31	187.28	16.63	12.35	128.22
Average	13.05	104	176.18	14.52	14.79	128.48
CT seconds	451.03					
CT seconds	7.52					

4.5 Efficiency Work of Wheel Loader and Dump Trucks

Set schedule work time i.e. schedule of working days from Monday to Sunday, 2 (two) working shifts per day with total work time average 21.3 hours per day.

Table 4: Schedule Work Time

Shift I		
Work Schedule	Description	Time (Hours)
05.30-12.00	Work time	6.5
12.00-13.00	Break Time	1
13.00-17.30	Work time	4.5
	Total	12
Shift II		
Work Schedule	Description	Time (Hours)
17.30-00.00	Work time	6.5
00.00-01.00	Break Time	1
1 am-05.30	Work time	4.5
	Total	12
Total hours of work Shift and Shift II		24

On Friday, rest of the afternoon starting from 11.00 – 13.00 so that hours of work reduced to 23 hours. The average effective working hours to:

Average working hours effectively

$$= \frac{(24 \times 6) \text{ hours/week} + (23 \times 1) \text{ hours/week}}{7 \text{days/week}}$$

= 20.7 hours

= 1,242 seconds

Table 5: Barriers to Work on Wheel Loader and Dump Trucks

The barriers	Wheel Loader (hours/day)	Dump Trucks (hours/day)
The barriers that can be pressed:		
- Late early shift	30	30
- Stopped working earlier	15	17
- The break is too long	19	22
- Purposes of operator	8	10
Total	72	79
Barriers that cannot be suppressed:	201	
- Rain and drying road	24	201
- Damage to the appliance (break down)	10	199
- A daily inspection by the operator	8	10
- Improvements to the front		8
- Fuel injection		20
Total	243	438

4.6 Work Efficiency

Productive wheel loader available in a day reduced the amount of unproductive time.

Wke = Wkt – Wht

= 1,242 seconds – 315 minutes

= 927 seconds

Work efficiency wheel loader can be calculated, that is:

EFF = (productive work time/work time available) x 100%

= (927/1,242) x 100%

= 74.63%

Work Efficiency dump trucks.

Productive working time is the time the work is possible in one day reduced the amount of unproductive time.

Wke = Wkt – Wht
= 1,242 seconds – 517 minutes
= 725 seconds

So the equipment dump trucks can be calculated

EFF = (productive work time/work time available) x 100%
= (725/1,242) x 100%
= 58.37%

4.7 Productivity Wheel Loader and Dump trucks

Ability of productivity can be found by doing a calculation of production capacity of equipment. The larger production results of equipment means that production of such equipment is also getting better.

a. Calculations for the production of wheel loader are:
QM = Nm x (60/CTm) x Cm x F x x E sf (BCM)
Qm = 10 x (60/0.38) x 6.7 x 0.8 x 74.63 x 0.81%
= 5,055 BCM/hour

b. Calculations for the production of dump trucks are:
QM = Na x (60/CTm) x Cm x sf x E (BCM)
QM = 25 x (60/7,5) x 55 x 58.37 x 0.81%
= 5,189 BCM/hour

4.8 Harmony of Wheel Loader and Dump Trucks

Match factor is harmony between wheel loader and dump trucks. Value of each set labor harmony work of wheel loader used is determined based on the data path time and amount of equipment used in each set of the work.

$$MF = \frac{Na \times CtL}{Nm \times CTa}$$

As for combination work between wheel loader and dump trucks in mining are:

Na = 25 units
NM = 10 units
CTM = 0.38 hours
CTL = 1.96 seconds
CTA = 7.52 seconds
MF = (25 x 1.96)/(10 x 7.5) = 0.65

MF < 1, meaning equipment fit working less than 100%, while dump trucks work 100% so there is waiting time for equipment load due to waiting dump trucks yet to come, this is because production of wheel loader greater then dump trucks conditions i.e. busy dump trucks in the process of transporting and unloading equipment while waiting for the arrival of more equipment, so there is a wash time for wheel loader as follows:

$$Wtm = \frac{Nm \times CTa}{Na \times CTa} - (CTm \times n) \text{ (minutes)}$$
= ((10 x 7.52)/25)-(0.38 x 25)
= 6.61 seconds

Based on calculations from the data field, degree of harmony of wheel loader for 10 (ten) unit excavator Komatsu PC1250SP-7 with 25 (twenty five) dump trucks unit dump trucks Komatsu HD465-7 is 0.65 with waiting time by equipment fit for 6.61 minutes.

The increase in work time effectively and work efficiency.

With the reduced time lost due to barriers to effective working time can be on the increase.

Table 6: Barriers Wheel Loader and Dump Trucks

Barriers	Wheel Loader (hours/day)		Dump trucks (hours/day)	
	Before	After	Before	After
Barriers that can be pressed:				
- Late early shift	30	20	30	20
- Stopped working earlier	15	7	17	10
- The break is too long	19	10	22	10
- Purposes of operator	8	6	10	5
Total	72	43	79	45
Barriers that cannot be suppressed:				
- Rain and drying road	201	201	201	201
- Damage to the appliance (break down)	24	24	199	199
- A daily inspection by the operator	10	10	10	10
- Improvements to the front	8	8	8	8
- Fuel injection			20	20
Total	243	243	438	438

4.9 Work Efficiency Equipment Fit

Productive working time is working time available in a day reduced the amount of unproductive time.

Wke = Wkt – Wht
= 1,242 seconds – 286 minutes
= 956 minutes

Work efficiency can be calculated so that the equipment will fit, that is:

EFF = (productive time/time available) x 100%
= (956/1,242) x 100%
= 76.97%

4.10 Work Efficiency Equipment Transport

Productive working time is the time the work is possible in one day reduced the amount of unproductive time.

Wke = Wkt – Wht
= 1,242 seconds – 483 minutes
= 759 minutes

So the equipment work efficiency can be calculated, i.e.:

EFF = (time productive/time available) x 100%
= (759/1,242) x 100%
= 61.11%

4.11 Production Increased Working Time Effectively and Work Efficiency

The larger production results of equipment means that production of such equipment is also getting better.

1) Calculations for the production of the equipment fit are:
   QM = Nm x (60/CTm) x Cm x F x x E sf (BCM)
   QM = 10 x (60/0.38) x 6.7 x 0.8 x 76.97 x 0.81%
   = 5,213 BCM/hour
2) Calculations for the production of dump trucks are:
   QM = Na x (60/CTm) x Cm x sf x E (BCM)
   QM = 25 x (60/7,5) x 55 x x 61.11 0.81%
   = 5,432 BCM/hour

After increase of work efficiency and increased working time is available, then the production to generated equipment fit also increased from the original 5,055 BCM/hour increased to 5,213 BCM/hour. Similarly, to dump trucks increased from originally 5,189 BCM/hour into 5,432 BCM/hour. Because the desired production target of 8,960 BCM/hour is not reached the next alternative is done with the addition of auxiliary equipment to increase production.

4.12 Addition of Dump Trucks Unit

To meet desired target production then it needs to be done, then dump trucks additions must be known in advance target production and production equipment so that it can be formulated:

$$N = \frac{TVp}{KP}$$

$$N = \frac{8,960}{5,213}$$

N = 1.72 » 2 units

Description:
N = Number of equipment
TVP = Target volume of work, BCM/hour
KP = Equipment, production capacity BCM/hour

Production of dump trucks are:
QM = Na (60/CTm) x Cm x sf x E (BCM)
QM = 27 (60/7,5) x 55 x x 61.11 0.81%
= 5,867 BCM/hour

With the addition of dump trucks unit then there is an increase in productivity of dump trucks 435/BCM, i.e. increased from originally 5,432 BCM/hour increased to 5,867 BCM/hour.

$$MF = \frac{27 \times 1.96}{10 \times 7.52}$$

= 0.71

With the addition of a dump trucks unit 2 or now totaled 27 units then the magnitude of the price factor harmony work equipment load and dump trucks become 0.71. MF < 1, meaning the equipment fit working less than 100% are working 100% dump trucks, this is because the production of equipment load greater than production equipment happens then transport conditions i.e. busy dump trucks in the process of transportation.

4.13 Productivity Alternative Combination of Equipment

Other production enhancement alternative aims to provide alternatives to optimize work of unloading and loading equipment, so that target production can be achieved. This is done so that work of unloading and loading equipment may approach 100% so that waiting time can be pressed as small as possible. Alternatives conducted among which are:

Table 7: An Alternative Combination of Equipment

No.	Types of Activities	Productivity BCM/Hour	Harmony
1.	Replace equipment fit with larger capacity	8,505	0.40
2.	Increase size of the tub from dump trucks and increase number of auxiliary equipment	8,505	1.02
3.	Increase number of equipment fit without changing equipment carrier	8,862	0.38
4.	Increase number of auxiliary equipment without changing equipment fit	8,909	1.07

Alternative 1, replacing the equipment fit with larger capacity. Equipment is Excavator Komatsu PC 1800-6 with a capacity of 12 m^3. Standard equipment path fit time specified by Komatsu is 0.32 minutes. Number of used load equipment as much as 9 units. Production equipment load increased to 8,505 BCM/hour. This alternative was not selected because of the magnitude of the price of labor harmony factors equipment load and dump trucks down to 0.40 and will need a huge cost to buy or rent the equipment with a new type.

QM = 8 x (60/0.38) x 12 x 0.8 x 76.97 x 0.81%
= 8,505 BCM/hour

$$MF = \frac{25 \times 1.083}{9 \times 7.52}$$

= 0.40

Alternative 2, increase the size of the tub from dump trucks and increased the number of equipment carried into 32 units. The size of the tub is enlarged 8 m^3 so that capacity be 42.2 m^3. Dump trucks production increased to 8,850 BCM/hour. This alternative was not selected because it would require a large fee to increase the size of the tub from dump trucks and increased the number of equipment carried into 32 units, production dump trucks 8,505

BCM/hour was nearing production target is desirable, namely of 8,960 BCM/hour.

QM = 32 x (60/7,52) x 70 x x 61.11 0.81%
= 8,505 BCM/hour

MF = $\frac{32 \times 2.393}{10 \times 7.52}$
= 1.02

Alternative 3, increased the number of equipment fit without changing the dump trucks. The number of the used load equipment being 17 units. Production equipment load increased to 8,862 BCM/hour. This alternative was not selected because of the magnitude of the price of labor harmony factors equipment load and dump trucks decreased to dump trucks production walupun 0.38 sebsesar 8,862 BCM/hour was nearing production target is desirable, namely of 8,960 BCM/hour.

QM = 17 x (60/7,52) x 6, 7 x 0.8 x x 79.97 0.81%
= 8,862 BCM/hour

MF = $\frac{25 \times 1.963}{10 \times 7.52}$
= 0.38

Alternative 4, increase the number of auxiliary equipment without changing the instrument fit. The number of dump trucks used to be 41unit. Dump trucks production increased to 8,909 BCM/hour. This alternative was chosen because the production of dump trucks have approached the desired production target of 8,960 BCM/hour and the magnitude of the price of labor harmony factors equipment and equipment unloading transports approaching 1.

QM = 41 x (60/7,52) x 55 x x 61.11 0.81%
= 8,909 BCM/hour

MF = $\frac{41 \times 1.963}{10 \times 7.52}$
= 1.07

4.14 The selection of best Alternative

With amount of dump trucks then harmony between wheel loader with dump truck carrier undergoes changes, addition of a number dump trucks as much as 31 units equipment fit excavator Komatsu PC 1250 SP-7 and without changing the equipment fit (dump trucks unit 25 dump trucks Komatsu HD 465-7), production increased by dump trucks 3,720 BCM/hour (8.909-5.189 BCM/hour) and the magnitude of value of labor harmony factors equipment and equipment unloading transports approaching 1, meaning that appliance load and loading work 100%, it does not occur waiting time of both types of these equipment.

V. CONCLUSION

From result and discussion of this research that have been described on the previous chapter, we can conclude that:

1. Value of work efficiency, productivity and harmony work of equipment used on overburden; 1) work efficiency for load current is 74.63% and work efficiency for dump trucks currently is 58.37%; 2) productivity equipment for moment with overburden on job 10 units excavator Komatsu PC 1250 SP-7 of 5,055 BCM/hour and dump trucks unit 25 dump trucks Komatsu HD 465-7 of 5,189 BCM/hour; 3) level of compatibility of work (match factor) for excavator Komatsu PC1250SP unit 10-7 dump trucks unit with 25 dump trucks Komatsu HD465-7 is 0.65 with waiting time by equipment fit for 6.61 minutes.
2. Efforts to achieve target production on overburden; 1) improved work efficiency by doing repairs against obstacles that occur and increased working time is available, so work efficiency for equipment increased 76.97% with increased production 5,213 BCM/hour and dump trucks for work efficiency increased 61.11% with increased production 5,432 BCM/hour but dump trucks has not been able to meet production target 8,960 BCM/hour; 3) addition of dump trucks unit 2 dump trucks Komatsu HD 465-7 will increase productivity equipment transport of 435/BCM, increased from originally 5,432 BCM/hour increased 5,867 BCM/hour.
3. Alternative combination for increased productivity optimal weight of equipment on overburden is alternative to 4, increase number of auxiliary equipment without changing the instrument fit. Total of dump trucks used being 41 units excavator Komatsu PC 1250 SP-7 dump trucks unit and 25 dump trucks Komatsu HD 465-7. Dump trucks production increased 3,720 BCM/hour (8.909-5.189 BCM/hour) and magnitude of value of labor harmony factors equipment and equipment unloading transports approaching 1 (equipment load and loading work 100%).

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