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Overall Equipment Effectiveness In Coal Mining Company: A Case Study

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Abstract

An increase in productivity is one of the measures of development in a company. High productivity could increase revenue and profit that can be used to further develop the company. This study was conducted in PT XYZ, one of the biggest coal mining companies in East Kalimantan. The aim of this study was to analyze the productivity of excavators and dump trucks using overall equipment effectiveness (OEE). Based on the calculation, the actual availability and quality of both loading and hauling equipment exceed the targeted values. However, the actual performance is lower than the target. As for the OEE values, all of the equipment have lower actual OEE except Hitachi EX-2500. The lowe OEE values might happen because of bad weather, machine breakdown, and a long queue in the mining area. Based on the analysis results, it is recommended that the company increase the availability, performance, and quality of equipment with the high deviation between actual and targeted values.

Keywords **Productivity; Coal Mining; OEE; Availability; Performance; Quality**

INTRODUCTION

High productivity is one of the goals of the company to survive in the competition and to grow the business. High productivity could increase revenue and profit that could be used to develop and expand the company. An effective and efficient production system is important to increase productivity. It can be achieved by establishing an appropriate measurement (Nachiappan & Anantharam, 2006). Overall equipment effectiveness (OEE) is a quantitative measure to identify indirect and hidden productivity and quality costs, in the form of production losses. These losses are formulated as a function of the mutually exclusive factors availability, performance, and quality (Huang et al. 2003, Nayak, 2013).

PT XYZ is one of the biggest coal mining companies in East Kalimantan. In a coal mining company, heavy equipment is an important factor in the productivity of coal mining overburden. Good management to control heavy equipment is very crucial (Kicki & Dyczko, 2010; Stefaniak et al., 2015). Based on the historical data, the overburden target in one of the coal mining areas handled by one of the contractors did not reach the target of 21,580,000 BCM (billions cubic meter), the overburden could only reach 20,604,452 BCM.

This study aimed to analyze the problem mentioned above by using OEE. The OEE can be used as a tool to measure and evaluate the productivity of the machine. The OEE investigation can improve productivity, reduce cost, raise awareness, increase machine productivity, and lengthen equipment life span (Esmaeel et al., 2018). By identifying the OEE, the company could come up with solutions to increase productivity.

Overall Equipment Effectiveness (OEE) is a combination of metrics or equipment performance measure. The OEE can be used to help the company to figure out how to make the production process more effective and efficient. It is a metric to measure the percentage of time that follows the production plan (Yazdi et al., 2018). The percentage that near to 100% represents high productivity and it follows the targets set by the company (Singh & Narwal, 2017). In manufacturing systems, the OEE is not just limited to the evaluation of time but also arranged a structured process to identify the source of losses in productivity. Thus, companies could apply the OEE approach to improve the performance of machine utilization. The OEE in the mining industry is different from the one in the manufacturing industry. Thus, a framework to classify the losses of equipment

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related to availability, performance, and quality components (Bamber et al., 2003; Dindarloo et al., 2016) is required. Waqas et al. (2013) proposed the OEE parameters by measuring time loss. The parameters are downtime (availability), speed (performance), and quality (loss).

The loss of equipment availability contributes to the production losses, either due to equipment failure, technical damage, or minor stoppage of equipment during the process.

$$AL = \frac{NAT-DTL}{NAT} \times 100\% \quad (1)$$

AL = Availability loss
NAT = Net available time
DTL = Down time losses

Loss in the performance of equipment, including losses in equipment speed during operation as a result of substandard materials, road situation, operator inefficiencies, work situations, and inclined conditions is calculated as follows.

$$PL = \frac{OT-SL}{OT} \times 100\% \quad (2)$$

P = Performance loss
OT = Operating time
SL = Speed losses

Quality defects because of equipment efficiency contribute to production losses. Fill factor is one of the determinants for a digging tool quality such as a shovel, which means that the material is loaded based on its capacity.

$$QL = \frac{LPC}{FPC} \times 100\% \quad (3)$$

QL = Quality loss
LPC = Loaded payload capacity
FPC = Full payload capacity

METHODS

Direct observation was conducted in the SM-D mining area of PT XYZ in East Kalimantan from July to September 2019. This direct observation was done to get a better understanding of the workflow of overburden mining. In addition, historical data were also collected for further analysis.

Excavators and highway dump trucks are the two types of heavy equipment that were being analyzed using OEE in this study. The OEE is calculated by multiplying availability (A), performance efficiency (P), and rate of quality (Q).

$$OEE = A \times P \times Q \quad (4)$$

where

$$A = \frac{Loading\ time}{Loading\ time-Down\ time}$$

$$P = \frac{Processed\ Amount}{Operating\ time}$$

$$Q = \frac{Processed\ amount-Defects}{Processed\ amount}$$

Availability is influenced by downtime. Utilization is affected by working hours and loss time, while the Productivity index is affected by bucket fill and work efficiency (Waqas et al., 2013).

The hypotheses in this study are:
H_1: The calculated availability is higher than targeted availability
H_2: The calculated performance efficiency is higher than targeted performance efficiency
H_3: The calculated rate of quality is higher than the targeted rate of quality

RESULTS AND DISCUSSION

PT XYZ has 13 excavators and 123 highway dump trucks for loading and hauling processes. There are several types of excavators: Hitachi EX-2500 with the capacity of 15 m^3, Hitachi EX-2600 with the capacity of 17 m^3, Komatsu PC-2000 with the capacity of 15 m^3, and Liebherr EX-9350 with the capacity of 20 m^3. As for the highway dump trucks, there are 3 types: Caterpillar 777D, Caterpillar 777E, and Komatsu 785 with the capacity of 43 m^3.

Targeted OEE Calculation

Based on the targeted availability, performance efficiency, and quality set by the company. The OEE can be calculated as shown in Table 1.

The company did not set a high target for both loading and hauling equipment because of the weather condition in the mining area. All mining activities are halted when it is raining. As a tropical country, rain is very common in Indonesia. From the calculation, the targeted OEE for loading equipment is quite low with only Hitachi EX-2600 has an OEE of 50%. Whereas the targeted OEE for hauling equipment is all set to 56%.

Actual OEE Calculation

Using the historical data, the current OEE can be calculated by multiplying availability, performance efficiency, and quality can be seen in Table 2.

For the loading equipment, the highest availability is Komatsu PC-2000 with an availability of 91%, the highest performance is Liebherr EX-9350 with a performance of 53%, and the highest quality is Hitachi EX-2500 with quality of 95.45%. However, the loading equipment with the highest OEE is Hitachi EX-2600. The equipment with the highest performance is not necessarily to be the one with the highest OEE (Yazdi et al., 2018). This is because the OEE does not only consider the performance of the equipment.

As for the hauling equipment, the highest availability is 98% for Komatsu 785, the highest performance is Caterpillar 777E with a performance of 55%, and the highest quality is Komatsu 785 with the quality of 100%. The hauling equipment with the highest OEE value is Komatsu 785 with an OEE of 53%.

Comparison of Targeted and Actual OEE

Based on the calculation of the targeted and actual OEE, it can be seen that the actual OEE for both loading and hauling equipment generally did not reach the target, except for Hitachi EX-2500 that exceeded the target. Figure 1 shows the OEE deviation of the loading equipment. From figure 1, we can see that although Hitachi EX-2600 has the highest OEE, the deviation between target and actual OEE for Hitachi Ex-2600 is not the lowest. In here, Liebherr EX-9350 has the smallest OEE deviation from the target value.

The deviation between targeted and actual OEE can be seen in Figure 2. Since the targeted value set to be the same for all dump trucks, the Komatsu 785 has the highest actual OEE and the lowest deviation from the targeted value. Using the OEE deviation value, the company could see which equipment needs to be increased in terms of availability, performance, and quality in order to reach the targeted values that have been set by the company. The company should increase the performance of the equipment with a high deviation first.

In general, the actual availability and quality are higher than the targeted value. Thus, hypotheses 1 and 3 are true. However, hypothesis 2 is not true because the actual performance is lower than the targeted value. This could happen because of the bad weather, machine breakdown, and the long queue in the mining area. As mentioned earlier, all mining activities are stopped during raining. This is a very difficult situation to control because it is a natural phenomenon. Other than delaying the operation, rain could also affect road access. Bumpy road in mining area influences the performance of the equipment and it could contribute to machine breakdown. When the machine breakdown happens, it usually needs some time to fix the machine. This is the reason why PT XYZ has 13 excavators and 123 highway dump trucks but low availability.

CONCLUSION

This study has presented a productivity evaluation of loading and hauling equipment in overburden mining in PT XYZ. Based on the analysis, it is evident that only hypotheses 1 and 3 are true. From the calculation, the actual availability and quality are higher than the targeted value. However, the actual performance of the equipment is lower than the target. Overall equipment effectiveness (OEE) can help the company to see which equipment has low effective and efficient levels. Thus, the company could take necessary actions to increase the availability, performance, and quality of the equipment to increase the productivity of the process.

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List of Tables

Table 1. Targeted OEE Calculation

Equipment	Unit	Availability	Performance	Quality	OEE
Loading					
Liebherr 9350	5	77%	84%	62%	40%
Hitachi EX-2500	1	61%	73%	57%	25%
Komatsu PC-2000	1	82%	88%	64%	46%
Hitachi EX-2600	6	86%	90%	65%	50%
Hauling					
Caterpillar 777D	72	87%	90%	71%	56%
Caterpillar 777E	8	87%	90%	71%	56%
Komatsu 785	43	87%	90%	71%	56%

Table 2. Actual OEE Calculation

Equipment	Unit	Availability	Performance	Quality	OEE
Loading					
Liebherr 9350	5	78%	53%	90.91%	37%
Hitachi EX-2500	1	80%	46%	95.45%	36%
Komatsu PC-2000	1	91%	44%	90.91%	36%
Hitachi EX-2600	6	87%	50%	91.87%	40%
Hauling					
Caterpillar 777D	72	74%	52%	97%	37%
Caterpillar 777E	8	93%	55%	98%	50%
Komatsu 785	43	98%	54%	100%	53%

Table 2. Actual OEE Calculation

Figure 1. Comparison of Targeted and Actual OEE of Loading Equipment

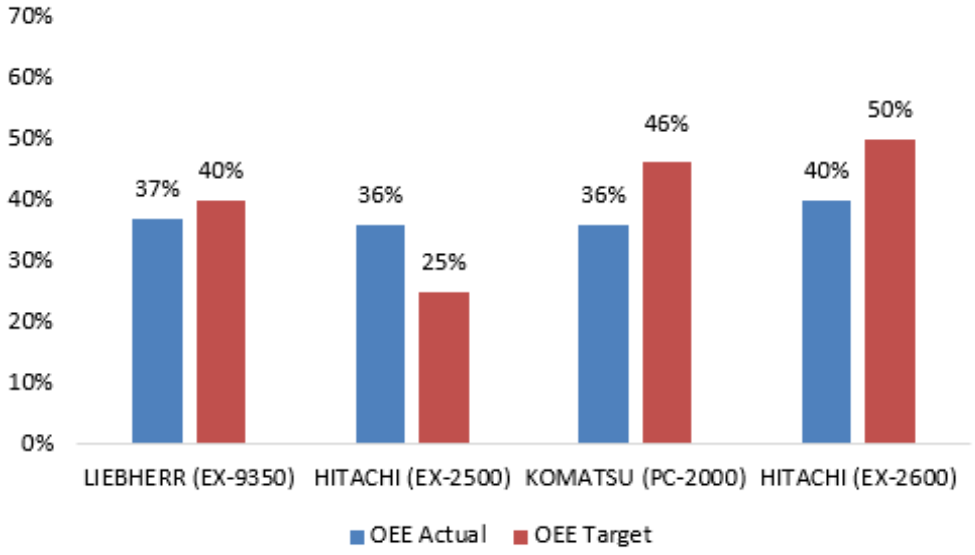

Figure 2. Comparison of Targeted and Actual OEE of Hauling Equipment