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RESEARCH ARTICLE

MATCH FACTOR DETERMINATION OF EXCAVATOR-TRUCK COMBINATION IN SURFACE MINING: CASE STUDY OF MERIT PILA COALFIELD, SARAWAK

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ABSTRACT

Effective fleet management in surface mining is crucial to optimize the cost of surface mining. A complete method to determine the match factor for heterogeneous excavator-truck combination at Merit Pila Coalfield, Sarawak will be presented in this paper. This application is a fast and easy way to quantify the effectiveness of the fleet in mining. The match factor of 1.09 was obtained and proven by observation with the queuing length of one truck at one of the excavators. This result is crucial for the mining engineers to quantify and evaluate the existing performance and plan for more effective excavator-truck combination and scheduling in the near future.

KEYWORDS

Match factor, coal mining, surface mining, excavator-truck combination.

1. INTRODUCTION

The major capital investment in surface mining of Merit Pila Coalfield are the excavation and transportation equipment. It is important to utilize the machineries being invested by maximizing the productivity as the machineries are cost up to millions of dollars. Two typical scenarios that show the inefficiency of machineries included the excavator waiting for the trucks or the trucks waiting to be loaded. The ideal match is to maximize utilization of the loading tool (excavator) and minimize the waiting time for the trucks.

This study will focus on the match factor determination of excavator-truck combination for surface coal mining in Merit Pila Coalfield, Kapit, Sarawak. Figure 1 shows that the Merit Pila Coalfield is located at the central Sarawak of Malaysia. The coal in Merit Pila Coalfield is contained within Upper Oligocene to Miocene Nyalau Formation which consist of conglomerate, sandstones and mudstones [1].

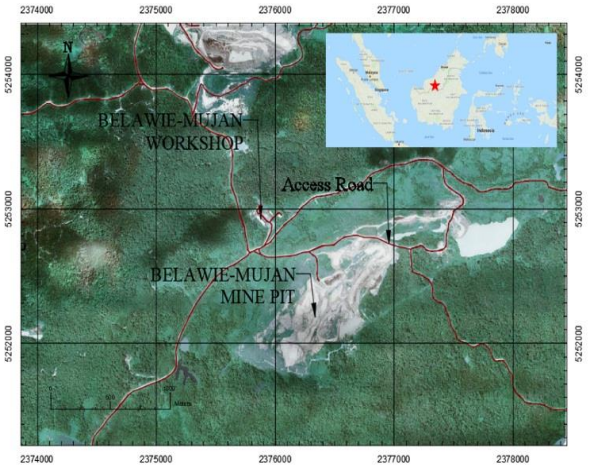

Figure 1: Geographic position of Merit Pila Coalfield, showing the position of Belawie Mujan Mine

2. METHODOLOGY

Match factor which was introduced by a researcher has been used as an indicator of productivity performance in mining and construction industries for decades. Match factor proposed by a researcher assumes that all the trucks and loaders are of the same type or homogenous [2].

However, in mining industry different types of excavators and trucks may work at the same pit including Merit Pila Coalfield. A previous researcher proposed a method of defining match factor for heterogeneous fleets. Therefore, the match factor in this study will be calculated based on the formula proposed by another researcher [3].

3. GENERAL INFORMATION OF BELAWIE MUJAN MINE PIT OPERATION

The study was conducted at one of the mine pits at Merit Pila Coalfield which is known as Belawie Mujan mine pit. The mine operates at 24-7 basic nonstop excluding 5 days of field break per month. About 4 excavators and 7 dump trucks are assigned to this operation (Table 1). The number of trucks, type of equipment and capacity are shown as below:

Table 1: Capacity of each equipment

No. of trucks.	Machine	Model	Capacity (m3)
4	Dumper	KOM HD465 (T1)	43.2
3	Dumper	HIT EH1100 (T2)	41.5
1	Hydraulic Excavator	KOM PC1250 (L1)	6.7
3	Hydraulic Excavator	HIT EX1200 (L2)	6.7

It can be observed that the excavator is positioned at a reasonable height (Figure 2) above the truck by creating an elevated bench which is about the same height as the truck. This is one of the good common practices for excavator operator due to visibility reason.The removed overburden consists of moderately weathered and fragmented sedimentary rock which is blasted by using ANFO and Nonel system. The total hauling distance from the excavation area to the dump site is about 122m at a maximum slope gradient of 1:1.6.

Figure 2: Mining at Belawie Mujan Mine Pit

4. THE CYCLE TIME OF THE EXCAVATOR AND TRUCK

The cycle time is the fundamental data for calculating the match factor of current operation and finding mismatch. The cycle time of each equipment is measured and recorded at the mining site for 1 hour and the average cycle time (Table 2) is used to determine the match factor.

The truck cycle time as stated in this paper is considered to be the time taken for the truck to be loaded with the material; travel to the dumpsite, dump the load, travel back to the loader and queue for the next load.

The excavator cycle time as stated in this paper is considered to be the time when the bucket opens to unload into the truck; finishes unloading, swings and touch the soil; digs and fills the bucket; swings and takes position to unload.

Table 2: Cycle time of each equipment.

Model	Average Cycle Time (seconds)
KOM HD465 (T1)	198
HIT EH1100 (T2)	198
KOM PC1250 (L1)	24
HIT EX1200 (L2)	25
HIT EX1200 (L3)	25
HIT EX1200 (L4)	25

5. MATCH FACTOR

Based on the observation (Figure 2), it is found that there is an excess of one truck being used at Belawie Mujan mine pit, which has led to queuing at the point of loading. The match factor of 1.09 is obtained with the queuing length of 1 truck at one of the excavators. The calculation is shown as below based on the parameters stated in Table 3:

Calculation:

T1 and L1: 43.2/6.7 = 6 swings; 5 swings (reality), 5 x 24 = 120s
T1 and L2: 43.2/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
T1 and L3: 43.2/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
T1 and L4: 43.2/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
T2 and L1:41.5/6.7 = 6 swings; 5 swings (reality), 5 x 24 = 120s
T2 and L2:41.5/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
T2 and L3:41.5/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
T2 and L4:41.5/6.7 = 6 swings; 5 swings (reality), 5 x 25 = 125s
Truck type 1: 1cm(120,125,125,125) = 3000
Truck type 2: 1cm(120,125,125,125)= 3000

$$MF = \frac{(\text{number of trucks}) \sum_j \left[(\text{number of trucks}) \times \text{lcm}(\text{unique loading times})_j \right]}{\left(\text{loaders}_j \sum_j \left[\frac{\text{lcm}(\text{unique loading times}_{i,j})}{\text{unique loading times}_{i,j}} \right] \right) \sum_i (\text{trucks}_i \times \text{truck cycle time}_i)}$$

MF=[(7x(3000+3000)]/[(3000/120+3000/125+3000/125+3000/125+3000/120+3000/125+3000/125+3000/125)] x198 =1.09

Table 3: Parameters in heterogeneous match factor ratio.

Number of trucks	The total number of trucks in the fleet
Number of loaders	The total number of loaders in the fleet
Trucks_i	The number of trucks of type *i* in the fleet
Loaders_j	The number of loaders of type *j* in the fleet
$\text{Truck loading time}_i$	The cycle time of one loader type when working with a truck type *i*
$\text{Unique loading time}_{i,\,j}$	The cycle time of the loader *j* when working with a truck type *i*
Total loader cycle	The time taken for one loader to serve all trucks in the fleet
$\text{Truck cycle time}_i$	The cycle time of truck type *i*
Truck cycle time	The average cycle time for all trucks in the current period

The match factor of 1.09 indicates the machinery is not fully utilized. Normally, if the value of match factor exceeds 1.0, the scenario where the trucks to queue can be observed due to trucks arriving faster than being loaded with materials. However, if the match factor is below 1.0, it can be observed that the loader is waiting for the trucks to arrive, because in this case the loader serves faster than the arrival of trucks.

6. CONCLUSION & RECOMMENDATION

The analysis result shows that based on existing excavators and trucks combination are over truck. In this scenario, productivity of loader shall be used to budgeting and scheduling. Trucks are recommended to practice 'drive-by' method where the loading position of trucks are parallel to the bench face. This will eliminate the reverse time of the trucks and hence reduces the trucks cycle time.

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