Optimization of the Need for Support Grader Units for Coal Mining Hauling Road Maintenance Activities

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Abstract

The implementation of production in a mine is supported by the existence of good mine road maintenance, because this activity is an important component in supporting the achievement of production targets. Accidents at the mine, especially on the mine road, which are experienced by most of the company's production units, serve as a guide that the mining support unit has an important role in addition to supporting the achievement of production targets, namely in terms of safety. The purpose of this study was to ensure that the number and specifications of grader units already in the mine meet the road maintenance needs of the mine roads. The research method used is off-site and on-site analysis. Off-site analysis was used by analyzing the Physical Availability of the Grader unit against production achievements, while on-site analysis was used by surveying and observing the activity of the Grader unit at the mine. The lack of a grader unit causes the road maintenance needs of mining roads to be not fulfilled, which can lead to a lot of road damage which can also accelerate equipment breakdown so that it has an impact on increasing company costs. It is therefore, necessary to study the need for a grader unit on the mine road in the production area.

Keywords: road maintenance, grader, supporting, physical availability, equipment

1. Introduction

Open coal mining system is influenced by climatic and weather conditions. In the rainy season, mining activities experience obstacles in the form of muddy roads and blast holes filled with water. These climatic factors affect the efficiency of mining production in the form of time and costs. Costs that are affected by road conditions are the amount of fuel consumption [1, 17-20] and lifetime tire [9,29]. Increased production at coal mines usually follows an increase in hauler unit operating routines to achieve targets [2]. Due to an increase in hauler units operating in the mining road area, sometimes mining roads often experience damage due to the condition of the hauler unit overload which results in a large amount of overburden and coal material being scattered on the road, as is the case with underground mines [3-4]. Aspects of haul road maintenance cannot be considered separately from structural and functional aspects of design because they are interrelated [5]. Errors in determining road components cause road accidents so that the process of identifying the effectiveness of road component maintenance can reduce traffic accidents. The road geometry is the main point in maintaining road conditions by considering the interrelationships between various maintenance components and sub components. [27]

Maintenance of haul roads on roads with limited widths results in congestion and this can be managed properly using the python module [28]. In surface mining operations, ultra-heavy trucks operate on a haul road network typically 10-40 km. This road network is often not optimally designed and maintained and as a result, the identification and repair of functional road defects becomes a problem. Most surface mine operators agree that good roads are desirable, but it is difficult to translate this into an effective road maintenance system. This paper presents a haul road maintenance management system that utilizes rolling resistance assessment based on evaluation of haul road functional performance, together with a mine haul truck operating cost model to obtain the optimal frequency of road maintenance in the presence of unit graders [6,7,8]. Rolling resistance also affects the lifetime tire [29] based on the type of material [9-10]. Road management in mines is affected by traffic volume, material, construction, quality and speed of damage [12]. A specific application is presented that illustrates the potential of techniques for managing maintenance with the result of reducing total road user costs [30] and improving the services provided to road users.

2. Material and Methods

This research was conducted based on secondary data from Report Equipment Performance. In addition, it is supported by direct observation data on mining road conditions and the activities of grader units operating on mine roads.

Observations were made to obtain information related to the condition of the mine road, the need for a grader unit for mine road maintenance and the characteristics of the soil at that location. Information related to the unit grader which includes unit characteristics, unit operating characteristics and unit activities in the form of working hours or work targets to complete road repairs with the total area of the road being mined. Broadly speaking, this research method includes:

a) Collecting data by drawing Equipment Performance Report consisting of Total Working, Total Delay, Total Idle, Total Loss time, Total Breakdown, PA (Physical Availability) and UA (Utilization Availability).

b) Analyzing PA (Physical Availability) Unit Grader data which is inaccurate where the sum of working time, breakdown and standby is not the same as the number of available hours, then PA data is obtained from the Monthly Report.

c) Comparing the actual PA Unit Grader with the PA Target (Budget) that has been determined according to the KPI (Key Performance Indicator)

d) Request data for the distance and width of the mine road based on survey data where the road distance is calculated from the loading point to the dumping point.

e) Retrieve the Display Measurement Selection data to determine the lifetime (age) of the unit as data on the effect of achieving PA (Physical Availability) unit grader.

f) Observing road conditions, especially damaged roads (perforated and flooded), bumpy (undulating) as well as road locations where spoilers and borders are found.

g) Performing Raw Data Record Workhour data retrieval to ascertain whether the grader unit is in a breakdown or standby condition as well as ensuring conformity between Record Workhours and working hours of the grader unit.

h) Observing the entire available grader work area and ensuring that the grader unit work area is in accordance with the data that has been inputted into the information system available through the SAP application.

i) Observing the operation of the grader unit in the form of blade slope when the grader is doing fireplace or road scrap and the gear used is in accordance with its designation.

j) Analyzing the need for grader units by comparing the results of the calculation of grader requirements with the actual current grader availability. If the results of the calculation of grader requirements are greater than the actual current grader availability, it means that there is a shortage of grader needs In that case carry out an analysis of this grader deficiency by referring to the annual grader requirement fulfillment plan in the Yearly Budget Engineering.

The flow chart of the research method can be seen in Fig. 1.

2.1 Grader

Grader is one of the supporting tools in the mine that functions in scrapping the mine road from material that falls from the conveyance (spoil), undulating roads, and potholes. The grader unit works on the mine road area which is often traversed by production operational units in the mine. The grader unit plays an important role, especially in the productivity of conveyances related to the number of transportation equipment rites achieved in 1 (one) shift. This is because if there are no obstacles on the mining road, the achievement of the transportation equipment cycle time will be shorter and required number of ritations can be achieved [24]. Graders are also referred to as road graders or road patrols that function as finishing activities such as backfill work, road construction and others. In the work of an 'advance' grader, the blade faces the front tires. However, if necessary, it can also move backwards, for example for spreading or smoothing of the material, so in this backward movement, the ridge of the blade that functions as the blade can be moved up and down and can rotate 180° This rotation is possible because the blade is mounted on a circle. The grader's abilities include planning, angles are made at an angle of ± 30° from the wheel axis direction, and the angle is lowered slightly (1-2 in) to level ground.

2.2 Grader Unit Capacity

These are several ways to measure operating capacity, or production. One method expresses motor grader production in relation to the total work area [11].

Formula:

$$A = S \times (Le - Lo) \times 1000 \times E \text{ } \textit{(Metric)} \quad (1)$$

$$A = S \times (Le - Lo) \times 5280 \times E \text{ } \textit{(English)} \quad (2)$$

Where, A: *Hourly operating area (m^2/h or ft^2/h)*

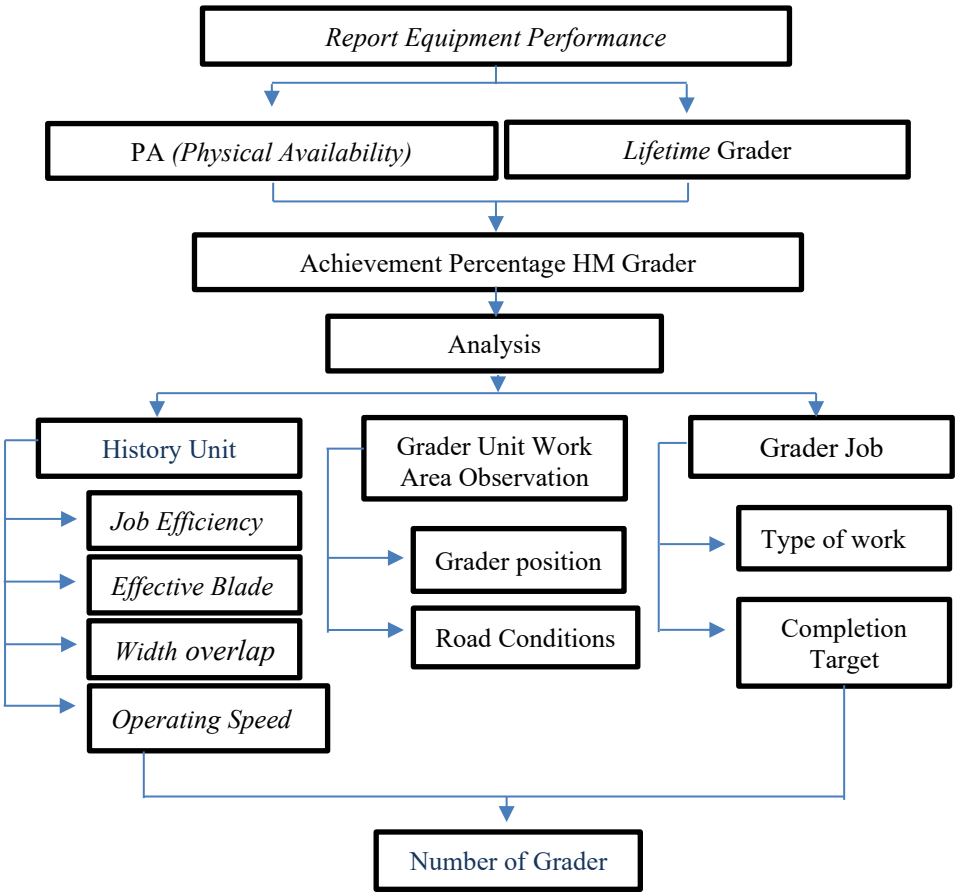

Fig. 1: Research method flowchart

S : *Operating Speed (km/h or mph)*
Le : *Effective Blade Length (m or ft)*
Lo : *Width of overlap (m or ft)*
E : *Job Efficiency*

Operational speed based on usage is divided into several types and can be found in Table 1.

Table 1: Speed of grader according to conditions [21]

No	Operational Type	Speed	
1	Finish Grading	0 – 4 km/h	0 – 2.5 mph
2	Heavy Blading	0 – 9 km/h	0 – 6 mph
3	Ditch Repair	0 – 5 km/h	0 – 3 mph
4	Ripping	0 – 5 km/h	0 – 3 mph
5	Road Maintenance	5 – 16 km/h	3 – 9.5 mph
6	Haul Road Maintenance	5 – 16 km/h	3 – 9.5 mph
7	Snow Plowing	7 – 21 km/h	4 – 13 mph
8	Snow Winging	15 – 28km/h	9 – 17 mph

Usually the slope of the blade and the length of the blade must be effective and adjusted to the angle of the material to be evicted when displacing material or doing scapping activities [26].

Table 2: Effective blade width on grader unit [22]

Moldboard Length m (ft)	Effective Length, m (ft) 30° blade angle	Effective Length, m (ft) 45° blade angle
3.658 (12)	3.17 (10.4)	2.59 (8.5)
4.267 (14)	3.70 (12.1)	3.02 (9.9)
4.877 (16)	4.22 (13.9)	3.45 (11.3)
7.315 (24)	6.33 (20.8)	5.17 (17.0)

The relationship between blade length and effective blade length and blade angle slope which affects the capacity to displace material or flatten material that is scattered on the mine road can be seen in Table.2.

The maintenance of haul roads will greatly affect cycle times, tire components [29], safety and ultimately cost per tonne. To achieve optimal truck productivity, haul roads must be properly maintained [15-16].

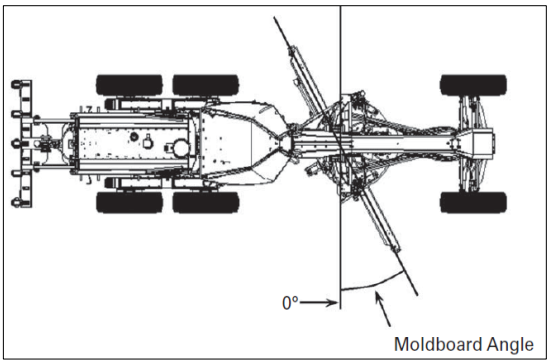

Fig. 2: Use of Blade Angle on Grader unit

2.3 Calculation of Grader Requirement

In calculating the need for support units, especially grader units, the data needed is the total area of the grader unit work area in the form of the total length of the road traversed by the hauler unit to transport overburden material and coal multiplied by the width of the mine road. Here's the equation to get the number of graders needed [2]:

$$\frac{\text{Total Area } (m^2)}{\text{Productivity x Target Completion Time}} \quad \ldots\ldots (3)$$

3. Results and Discussion

Based on the analysis of the Equipment Performance Report on the SAP application, it was found that the Physical Availability (PA) Unit GD825A-2 is below the Physical Availability (PA) target that has been determined by the Yearly Budget, where there are four GD825A-2 unit models that are planned for maintenance mine roads at Pit C and Pit E location.

Due to the routine productivity of haulers that pass through the road with a number of rainy hours, it is necessary to repair roads so as not to hinder the achievement of production targets. Pit C consists of 3 and Pit C consists of 2 lane roads (can be seen in Table 7 and Table 8)

The calculation of Physical Availability (PA) in Table 3. is obtained from the comparison of Machine On Hand Hours (MOHH). The total number of grader units at the location can be seen in Table 4.

From Table 4 it can be one of the causes of the lack of a grader unit, namely the breakdown time is too long and partly due to the need for a transmission change which must wait for the availability of the required components such as the GDKM82034 grader unit. In addition, there are several grader units that often experience breakdown due to the high lifetime of the unit. Based on recorded lifetime and purchase date data for the Grader Unit GDCT14002 and GDCT16003 with a lifetime of more than 2000 HM where the lifetime is recommended to change the status of the grader unit to scarp. The unit can operate, not in the mining road area but on the hauling road so that in the event of damage it does not hamper mining activities and it is easier to move the unit to the workshop area.

Table 3: Comparison of Actual Physical Availability and Budget

Equipment	Total Break down	MOHH (hours)	Actual PA	Budget PA
GDKM82034	571	744	23%	89%
GDKM82041	148	744	80%	89%
GDKM82048	136	744	82%	89%
GDKM82052	53	744	93%	89%
Average Speed			69%	89%

Table 4: Condition of grader unit based on work placement

Equipment	Location	Unit Condition
GDKM82034	-	*Breakdown*
GDKM82041	PIT E	Operate
GDKM82048	PIT C	Operate
GDKM82052	PIT E	Operate
GDKM7004	-	*Breakdown*
GDCT14002	-	*Standby*
GDCT16003	Coal hauling Road	Operate
GDCT14003	Suaran Hauling Road	Operate
GDCT14013	Suaran Hauling Road	Operate

Table 5: Lifetime Unit Grader

Equipment	Model Unit	*Lifetime* Unit (HM)
GDCT14002	14H	25871
GDCT16003	16H	23909
GDKM70004	GDKM705A-4	16145

The characteristics of the soft soil in the location also cause the need for a grader unit to be felt less. The characteristics of the soft soil [13] cause damage to the mining road due to the passage of the Highway Dump Truck unit getting faster so that the frequency of mining road maintenance that must be carried out by the grader unit must be more intensive [14]. In addition, the actual rainfall frequency exceeds the planned budget in the Yearly Budget, which is 124.2 hours or 14% higher than the planning that has been prepared, which is 108.9 hours.

Table 6: Rainfall Conditions

Rain (Hours)		Rain Frequency	Rainfall (mm)
Planning	Actual		
108.9	124.2	36	288.1

From Table 6, it is explained that the frequency of rain that is more frequent and longer, causes the condition of mining roads to be more easily damaged [23]. If there is a rainfall condition like the Table above, the need for a grader unit for slippery activities will increase. Based on the survey data obtained data on the width of the road and the distance between the location of the loading point and the location of the dumping point.

Based on the reference from Komatsu Handbook Specification & Application Edition 27 and Caterpilar Performance Handbook Edition 37, the blade tilt when used is 75° and the blade is reused during the next rotation of 0.3 m, so the effective blade length is (sin75° x length blades) – 0.3meters. Here the target completion time is 2 hours where after 2 hours the grader unit should return to its original location because the original road has been tidied up again damaged due to the activities of the Highway Dump Truck unit.

In accordance with the distance and width of the road as well as unit specifications and target completion time, the total area of the road maintenance work is obtained [25].

Fig. 3: Grader unit activity on Mine Road

With the value of the job efficiency coefficient obtained from the Komatsu Handbook Specification & Application Edition 27 reference, where for road repair work and leveling job efficiency it is 0.8 [22]. While the calculation of the productivity value is obtained from the multiplication between the speed of the grader unit and the length of the blade. So based on the above formula the productivity value of Grader GDKM825A-2 is 23,605 m^2/hours. Based on the

Table 7: Grader unit worker load based on the length of the road being maintained

Location	Position	Distance (km)	Unit Grader
Pit E	Jln. Barat - OPD E	2.480	GDKM 82052; 82041
	Jln. Tengah - OPD C2	3.216	
	Jln. Timur - OPD C1	3.448	
Pit C	Seam CX - Westdump	1.157	GDKM 82048
	Seam CX - IPD C3	1.290	

Table 8: Specification of grader unit by manufacture [21-22]

Model Unit	Speed (Km/hours)			Blade Width (m)	
	Gear 2	Gear 3	Average	Spec	Effective
GDKM825 A-2	5.4	8.0	6.7	4.9	4.4
14H	5.7	7.7	6.7	4.3	3.8

Table 9: Work area grader

Location	Road				
	Position	Distance (m)	Width (m)	Large Area (m^2)	Total Large Area (m^2)
Pit E1	Jln. Barat - OPD E	2.480	29	71920	318858
	Jln. Tengah - OPD C2	3.216	31	99696	
	Jln. Timur - OPD C1	3.448	25	86200	
Pit C3	Seam CX - Westdump	1.157	26	30082	
	Seam CX - IPD C3	1.290	24	30960	

productivity value of the GDKM825A-2 Grader above, the number of units needed for a total road area of 318,858 m^2 and the target time for completion of work for 2 hours are:

Number of units needed:

$$= \frac{\text{Total Area } (m^2)}{\text{Productivity x Target Completion Time}}$$

$$= \frac{318858}{23605 \text{ x } 2}$$

= 6.754 unit.

The calculation of the need for the number of units is 6 units of GDKM 825A-2 while the value of 0.754 units of GDKM825A-2 is the same as the area of the road which can be calculated in the following way:

Total Area

= Total unit x Productivity x Completion Time

= 0.754 units x 23605 m^2 / hours x 2 hours

= 35,596 m^2

The area of the road to be repaired is 35,596 m^2 using the Model Unit 14H with specifications for a blade width of 4.3 m, an effective blade width of 3.8 m, job efficiency 0.8, Speed 6.7 km/hours, so the productivity value is 20,518 m^2/hour. Based on the productivity value of Grader 14H required for a total road area of 20,518 m^2 and the target time to complete the work for 2 hours is:

Number of units needed:

$$= \frac{\text{Total Area (m2)}}{\text{Productivity x Target Completion Time}}$$

$$= \frac{35596}{20518 \text{ x } 2}$$

= 0.867 unit = 1 unit

So based on the calculations according to the condition of the mine road, it can be concluded that the need for grader units for PIT C and PIT E mining roads is 6 units of GDKM825A-2 and 1 unit of 14H.

3. Conclusion

Based on the results of this study, it was found that to achieve the target of completing the mining road scrapping process covering an area of 318.858 m^2 within 2 hours requires 6 units of graders with type GDKM825-A and 1 unit 14H. Before carrying out the process of budgeting the supporting unit in the mining area, it is necessary to calculate the area and target completion required because the mine road changes conditions every time due to the road area being traversed every time by the hauler unit operating to transport coal and overburden material.

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