

Estimation of truck-shovel dispatching in Cao Son Open-Pit coal mine and the ability in applying information technology for increasing its efficiency

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Abstract. With many types of trucks and shovels for hauling large volume of waste rocks to the dump sites and coal to the storages, the truck – shovel dispatching in Cao Son open pit coal mine is the operation which needs to be improved. At present, the combination between trucks and shovel is usually assigned at the beginning of shift and adjusted during the operation at the mine. The GPS tracking system are integrated into each truck to monitor the position in real time, but applying this information to find the best destination to send the truck to satisfy the production requirements and to minimize truck operating costs is still not used. This paper presents the estimation of the information system, data, the remaining problems of truck – shovel dispatching system, from that proposes the application of available information technology for increasing the efficiency of this activities at the mine.

1. Introduction

Cao Son surface coal mine, one of the biggest surface coal mine in northeastern coast of Vietnam, is located in Quang Ninh province (Figure 1). The mine has the mining area of 4.87 km² and the reserve of 48.13 milion tons. At present, the coal production of the mine is from 2.8 to 3.3 milion tons/year and the waste rocks which need to be loaded and hauled is from 26 to 32 milion m³/year. Therefore, the loading and hauling operation plays an important role in the whole mining system of the mine. The waste rock is transported to the outside waste dumps in two types: 1) directly to the waste dump by trucks and 2) combination of trucks and conveyer belt.

The combination between trucks and shovel is usually assigned at the beginning of shift and adjusted during the operation at the mine. Although the GPS tracking system are integrated into each truck to monitor the position in real time, but using this information to find the best destination for sending the truck to satisfy the production requirements and to minimize truck operating costs is still not used. The present choice of the mine is the strategy of fixed assignment of each truck at the beginning of the shift to a specific shovel and a dump point and this trucks works with that shovel for the entire shift. In the case of changing in practical operating conditions, such as breakdown of the shovel, the trucks then are reassigned to another loading position. This strategy usually causes more idle times due

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to the lack of trucks or the queues form near particular shovels. Another strategy is dynamic assignment of trucks and shovel with flexible assignment of truck after dumping to a free or less busy shovel is still not applied due to the weak in technology and the large number of trucks and shovels at the mine. It is clearly that the mine should the way to improve the truck-shovel dispatching system by applying available information technology for increasing the efficiency of this activities at the mine.



Fig. 1. Location of Cao Son surface coal mine [google maps]

2 Real situation of truck-shovel dispatching at the mine

Cao Son surface coal mine is working 3 shifts/day for loading waste rocks, 2 shifts/day for loading coal and 8 hours/shift. With the diversity of 20 rope shovels and 11 excavators with bucket capacity from 3.3 m³ to 12 m³. The rope shovels were invested about 40 years ago and sometimes breakdown due to technical problems and maintainance. The other 11 hydraulic excavators are used for both loading waste rocks and coal at the seam. The waste rock is excavated with the bench height from 10m to 15m by rope shovels or hydraulic excavators. Coal is loaded with the subbench height from 5m to 7.5 m. As reported by Cao Son mine [1], the rope shovels mostly are out of date and usually damages which lead to low efficiency of the shovels. The hydraulic excavators are in good quality and meet the technical requirements of the mine, however, due to the small number, they do not replace the old rope shovels. For hauling the waste rocks and coal at the mine, there are total 148 trucks are used, which include: 121 trucks with weight from 55 tons to 98 tons for hauling waste rock and 18 trucks with weight from 32 tons to 40 tons for hauling coal and auxiliary works. Table 1 shows the types of shovels and excavators used at the mine.

Table 1. Types of shovels and excavators at Cao Son surface coal mine [1]

No.	Type	Bucket capacity, m ³	Number
1	Rope shovels EKT – 4,6; EKT – 5A	4.6 to 5.0	11
2	Rope shovels EKT – 8H	8	8
3	Rope shovel EKT – 10	10	1
4	Komatsu PC1800-6	12	1
5	Komatsu PC750-7	3.4	2
6	Komatsu PC1250	6.7	4

7	Hitachi 670	3.5	2
8	Caterpillar CAT – 356 BL	3.2	2

The transportation of waste rock from loading points to dump sites is carried out by a system of haul roads with different length and slope inside and outside the mine. The loading time depends on the bucket capacity, digability, and weight or truck capacity. The queue at the loading points usually happens when the trucks with different capacity are used at each shovel or excavator. Therefore, the positioning of trucks for transporting waste rock from a particular mining area to bring profit for the mine is an important but complex issue. The efficiency of mining operations largely depend on the proper dispatching the position of truck and shovel, respectively, along the haul roads and dump sites. Type and number of trucks and shovels is one of the important factors for determining the optimal parameters of surface mining system. Besides, the running and loading time of trucks at the shovels will define the efficiency of truck-shovel system. The diversity in capacity of trucks and shovels at Cao Son clearly shows the complex in dispatching process at the mine. Any improvement on efficiency of truck-shovel system may save large amount of money in almost mining procedures at mine but with little or no investment on buying or replace the necessary mining equipments. Figure 2-4 show charts getting from statistical data of stopping and running time of shovels and excavator at Cao Son coal mine [2].

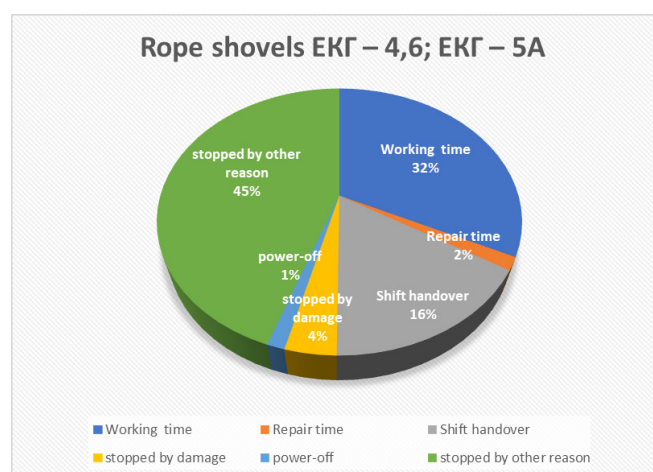


Fig. 2. Working and stopping time of Rope shovels EKT – 4,6; EKT – 5A [2]

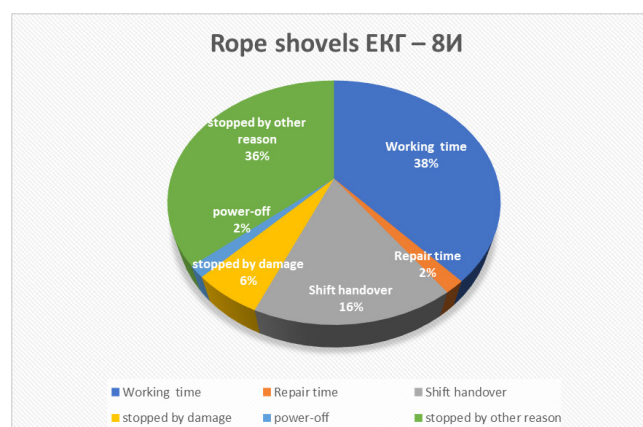


Fig. 3. Working and stopping time of Rope shovels EKT – 8И [2]

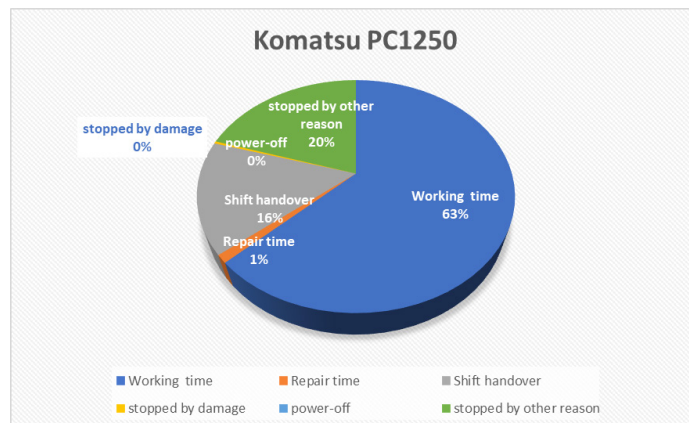


Fig. 4. Working and stopping time of hydraulic excavator PC-1250 [2]

It can be easily seen from charts in Figure 2 to 4 that the working time of the rope shovels is from 32% to 3%, while the stopping time due to damage, repair, and other reasons is nearly 50%. For hydraulic excavator, the working time is much higher, 63%, and total stopping time by all reasons is much lower, 21%. Stopping time by damage is quite high for rope shovels, from 4% to 6%, while this time in hydraulic excavator is only 0%. It clearly shows the disadvantage in the working ability of old rope shovels in comparison with new hydraulic excavators at the mine. For both types of rope shovel and hydraulic excavator, the stopping time by other reasons, that include the dispatching problems, is still high to very high and this should be strongly reduced to increase the efficiency and reducing cost from loading operation. The diversity of 8 excavator types and bucket capacity at Cao Son coal mine proposes the complex problems for truck – shovel system and it is difficult to solve with practical technical conditions of mine.

For the hauling work, the volume of waste rock is quite stable annually. With the new investment of conveyor belt system in 2017, the combination of trucks and conveyor belt prevails over direct transportation to the waste dump. Table 2 shows the volume of waste rocks transported at Cao Son surface coal mine in recent years.

Table 2. Types of shovels and excavators at Cao Son surface coal mine [2]

Year	Total volume, milion m ³	Transported directly by trucks, milion m ³	Combination trucks and conveyor belt, milion m ³
2014	33 210	33210	
2015	33 200	33 200	
2016	25 800	25 800	
2017	25 700	12 700	13 000 (50.58%)
2018	21 700	4 700	17 000 (78.34%)

At this time, the average hauling distance for direct transportation of waste rock to the dump site is 7.5 km, maximum hauling distance is about 10 km. There are two waste dumps for the trucks directly unloading the waste rocks and the loading lift height is from 300m to 350 m. For the combination between trucks and conveyor belt, the waste rock is transported with average distance of 2.5 km to the crushing machine on the surface and then transports by conveyor belt to the waste dump. Conveyor belt has width of 2 m, velocity from 4.0 to

6.0 m/s, length of 3550 m. Maximum fragment size providing for crusher is smaller than 1 m, maximum output fragment size from crusher to the conveyor belt is smaller than 0.4 m. As can be seen in Table 2, the volume of waste rock transported by the combination of trucks and conveyor belt increases the ratio from 50.58% to 78.34%. This proved that this type of hauling has many advantages on production and cost. According to the plan, the hauling volume by conveyor belt increases to 20 million m³ in year 2019.

Some difficulties with the hauling work by trucks at Cao Son coal mine such as: creating dust in dry season, rainy season makes slippery road, mist hides the vision of drivers, long hauling distance, high road slope... These difficulties reduce the hauling capacity of the trucks. The hauling work by truck-conveyor belt requires smaller fragment size from blasting, if fragment size is large, this will reduce productivity and even causing stuck which leads to reducing of hauling productivity. Table 3 presents the working efficiency of trucks at Cao Son coal mine.

Table 3. Working efficiency of trucks at Cao Son surface coal mine [2]

No.	Truck	Number of truck			Working hours		
		Available trucks	Using number	% using	Total	Efficient time, h	% Efficient time
1	CAT 773E, 58 tons	22	18	82	72683	58883	81
2	CAT 773F, 55 tons	10	9	90	23466	19284	82.2
3	CAT 777D, 96 tons	20	16	80	59350	51945	87,5
4	HD 565-7, 58 tons	42	38	90	126542	107923	85,2
5	HD 565-7R, 58 tons	30	28	93	107074	99746	93
6	HD785, 91 tons	14	12	86	45256	40746	90
7	Volvo A35D, 32.5 tons	10	7	70	26751	24471	91.5
8	Volvo A40E, 38 tons	8	7	88	28782	28494	99
9	HM 400-2R, 36.5 tons	15	13	87	39799	28148	70,7
10	Kamaz 6520, 20 tons	10	7	70	8240		
11	Scania P340, 28 tons	10	9	90	40300		

The data from Table 3 shows that the number of trucks put into working is from 70% to 93%, that means the trucks in the ready or maintenance state but not in use are still high, from 7% to 30%, depending on particular truck type.

3 Factors influencing on dispatching strategy at the mine

For monitoring the position of trucks and shovels at mine site, the GPS positioning devices are installed for each truck and shovel or excavator at Cao Son surface coal mine. The mine operating engineers can access the information of trucks and shovels at real time. The 3G signal is covered all mining area, event at the deep bottom of the mine. However, the lack of modern technology leads to the backward in applying efficient dispatching strategy for the mine. The integrated GPS devices only used for tracking and observing mining equipments, the positioning data is not used to make the decision in real time for dispatching the truck-shovel system more effective.

As mention in section 1, the fixed assignment strategy is applying at the mine. The shovels or excavators with bucket capacity from 3 m³ to 5 m³ are usually assigned with trucks of weight from 27 tons to 58 tons. The bigger buckets capacity of more than 5 m³ are assigned with trucks of bigger 58 tons. The mine is working 3 shifts/day for loading waste rocks, 2 shifts/day for loading coal and 8 hours/shift. Due to the lack in compatibility of mining equipment, trucks with different types and capacity run on the same hauling road and unload on the same waste dump, it is difficult for the operating engineers in executive work, especially in effectively assigning truck and shovel, and this leads to the reduction in

productivity of each mining equipments, in particularly, and trucks-shovels system in general.

It can be realized that: some factors influence on reduction of truck-shovel system, such as: bad fragmentation from the muckpiles after blasting leads to the extension of loading time and reduction of loading productivity; the different in combination bucket capacity and truck capacity will lead to the reduction in both loading and hauling productivity of truck and shovel. This problem can be only solved when applying dynamic assignment of truck-shovel in real time. To do this, the available information technology infrastructure of the mine should be effectively used and modern available devices or softwares should be applied for the practical conditions of the mine.

4 Development direction for improving dispatching process at Cao Son surface coal mine

The traditional approach focuses on effectively operating the trucks to improve the use of mining equipments in all procedures in a surface mine. Increasing the use of trucks leads to increase profit, reduce the size of fleet and increase general efficiency. To get this target, the mine can apply some solutions such as: improving the operational efficiency of trucks through increasing productivity and reliable, increasing the truck capacity, combination trucks with conveyor belt system, using truck lifting system to reduce the hauling time. The targets for reducing operational costs of a mine also can be done by effectively use the trucks and shovels with the help of information technology. The truck-shovel system operated by information technology can increase the hauling capacity with existing trucks and shovels or get the production target with less number of mining equipments. The assignment of truck and shovel is carefully considered to increase the use of existing trucks - shovels and reduce the waiting time in hauling system. The waiting time is the main reason that leads to low efficiency of mining equipments and it should be reduced to the smallest.

Many companies have developed mine fleet management system such as “VG Karier” of VistGroup, DISPATCH of Modular Mining or Link of Caterpillar,... with hardware and software system to automatically manage the truck-shovel system through GPS positioning devices [3-5]. In general, the commercial fleet management systems in the world are developed to increase the used time of mining equipments, increase work discipline, the operational engineer can reconsider and improve their efficiency. The available information technology infrastructure at Cao Son coal mine can be used for the integration such system to manage the trucks and shovels. However, the high investment cost of these commercial systems is a problem for the mine to apply. This leads to the requirements to develop a fleet management system with reasonable cost for the mine. With the fast development of GPS positioning devices, especially a smartphone can carry out this function. Therefore, the idea of using smartphone in tracking the position of trucks and shovels for managing and operating works. This device can be programmed to interact with drivers of trucks and shovels to operational center for optimizing calculation.

From above analysis, it can be realized that the application of information technology is the necessary trend for improving truck-shovel dispatching process at Cao Son surface coal mine. Only when the positioning data are managed and then are used for the autonomous assignment of truck and shovel by information technology, the efficiency of truck – shovel then can be increased to its maximum ability.

5 Conclusions

Practical conditions at the mine leads to the application of the fixed assignment strategy for trucks and shovels at Cao Son surface coal mine. Statistical data of working and stopping times of trucks and shovels shows a clear disadvantages of this dispatching strategy to the real conditions. The application of fleet management system with the use of smartphone as tracking devices is the idea that should be encouraged. Due to its reasonable prices and ability to interact with driver, this device can be effectively use to develop a good and reasonable system for dispatching process at the mine.

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