Shortening Unscheduled Downtime for More Efficient Use of Haul Trucks

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Abstract. Unscheduled downtime is one of the factors behind less efficient use of haul trucks in open-pit coal mines. This paper discusses how unscheduled downtime affects fleet utilization, a metric of fleet use efficiency. It analyzes the duration and causes of unscheduled downtime of haul trucks at a coal mining facility. The analysis concludes that 70% of cases of such downtime are caused by natural and climatic phenomena, mainly heavy rainfall. The authors analyze the natural conditions and climate of the area where haul trucks are operated; the paper presents the results of such analysis. It further proposes adjusting the maintenance and repair schedule for weather in order to reduce unscheduled downtime and thus use the fleet more efficiently.

1. Introduction

More efficient use of haul trucks, which are mainly used to transport rocks in mining, is an important objective in the coal mining industry [1]. Efficiency here is defined as completing the project within the deadline in the most cost-effective manner [2].

Unscheduled downtime is one of the factors that make the use of fleets less efficient and thus cause financial losses for the facility. To reduce unscheduled downtime at open-pit coal mines, the fleet operations must be adjusted for weather forecasts, which improves fleet efficiency in general.

This paper discusses the case of more efficient use of haul trucks at Luchegorsk Open-Pit Coal Mine (JSC LUR) in Pozharsky Municipality, Primorsky Krai, Russia.

2. Fleet efficiency metrics in literature

Fleet efficiency is of great economic importance for fleet operators.

Natural phenomena and climate hinder the performance of vehicles at open-pit coal mines and cause unscheduled downtime, which compromises fleet efficiency.

More efficient use of trucks is covered in papers by several Russian authors. N.Yu. Kozhevnikova discusses the concept of fleet efficiency and its economic significance for companies in [1].

In a broader sense, efficiency is measured by energy intensity, performance, and cost of transportation [3-6].

In turn, these metrics are affected by multiple fleet parameters such as fleet utilization, fleet readiness, capacity and mileage utilization, average distance of transport, downtime due to handling, time on duty, operating and technical speeds, number of trips, total traveled distance and ‘loaded’ mileage, total transported amount and amount of transport work [7, 8].
In [2], T.K. Balgabekov and A.S. Kosmaganbetova group the efficiency-affecting metrics as follows: fleet capacity metrics (units in the fleet and their total capacity), fleet capacity utilization (fleet utilization, uptime, technical travel speed, downtime due to handling, and cargo transport distance), and capacity utilization (vehicle capacity and mileage utilization factors).

K.E. Gerl and V.D. Shepelyov [9] propose using mileage utilization as an efficiency metric and analyze how it affects the truck fleet utilization.

N.V. Lobov, A.S. Khrulyov, Ye.M. Genson [10] propose specific fuel consumption as a metric of efficiency of specialized fleets, as fuel costs constitute the bulk of transportation costs.

N.A. Varavin and I.M. Shuvayeva [11] as well as Velikanov [12] focus on natural conditions, climate, and the road conditions as factors of fleet efficiency.

G.V. Abakumov, A.V. Buzayev, and I.V. Kolodyazhny note the importance of maintenance and preventive action for road transport [13].

Fleet utilization is used herein as the efficiency metric, as it suits the objectives of the study well, and the authors’ analysis concludes it is the recommendable metric.

3. Why haul trucks have unscheduled downtime
Luchegorsk Open-Pit Coal Mine (JSC LUR) is the largest coal mining company in Primorsky Krai [14, 15]. The problem facing it is that haul trucks are underutilized. Analysis shows that inefficiency mainly stems from unscheduled downtime. Excessive unscheduled downtime means reduced fleet utilization, which in turn means inefficiency.

Analysis revealed the following causes of unscheduled downtime at LUR [16, 17]:
- 70% attributable to climate and natural conditions;
- 20% attributable to faults;
- 10% attributable to other causes (roadworks, another vehicle broken, etc.).

Thus, natural phenomena and climate caused 70% of haul truck downtime cases; they are measurable by the following indicators:
- air temperature. Temperature difference causes more frequent failures to start and faster depreciation;
- wind. Wind cools hot vehicle parts down, which complicates maintenance [11];
- precipitation. Heavy rainfall washes out quarries and roads, which effectively prevents vehicle operations.

4. Natural conditions and climate in the haul truck operation area
LUR operates in Pozharsky Municipality, where the climate is moderately cold. Average winter temperature ranges from -13 to -19°C, average summer temperature ranges from +20 to +25°C. Precipitation is 20 mm/month in winter, 300-400 mm/month in summer. Average winter speed is 2 m/s [18, 19].

Since the effects of climate and nature on transportation cannot be scheduled, they have to be mitigated. Rainfall causes the majority of cases of unscheduled downtime at LUR. Thus, its effects on fleet utilization need to be addressed. We propose using weather forecasts so as to schedule maintenance and repairs on days of heavy rainfall.

Figure 1 shows the rainfall chart for Pozharsky Municipality for 2018 [18, 19].
As can be seen in the chart, May through August were the rainiest months, January and February were the driest.

5. Shortening unscheduled downtime for more efficient use of haul trucks
LUR has a fleet of 33 haul trucks. The proposed efficiency improvement method was tested on the cast of BelAZ 7555 D, a single vehicle.

In 2018, the unit had 205 hours of unscheduled downtime:
- 144 hours due to weather;
- 55 hours due to faults;
- 6 hours for other reasons.

The company scheduled maintenance and repairs on a quarterly basis. Thus, it made sense to find the quarter that had the longest unscheduled downtime and to make an adjusted M&R schedule for it. Figure 2 shows downtime of BelAZ 7555 D for each month of 2018.
Apparently, April, July, August, and November all had more unscheduled downtime. July and
August were also the rainiest months. On this ground, it was decided to schedule maintenance and
repair for three months (Q3): July, August, and September.

To make the schedule, we had to calculate how often maintenance and repair would be needed and
how long they’d take. Primary maintenance (PM) for BelAZ 7555 D needs to be done ~ once every 14
days, secondary maintenance (SM) needs to be done once every 28 days. However, following the
adjusted schedule, PM would take place once 13-14 days, and SM once 28-29 days. These minor
changes were made to account for the local climate and natural conditions. Maintenance was
scheduled on the days that were most likely to have heavy rainfall. Excessive or insufficient mileage
was compensated by changing each shift’s job for the unit: the vehicle would be sent to either a longer
duty (transport of crushed stones) or a shorter duty (transport of overburden). Thus, the haul truck
would go to maintenance during heavy rainfall that would otherwise cause unscheduled downtime.

This adjusted schedule is now estimated (given the rainfall forecasts) to have reduced unscheduled
downtime by 40.5 hours over three months, see Figure 3.

![Figure 3. Hours of unscheduled downtime in July, August, and September of 2018.](image)

The efficiency of using haul trucks is measured by a set of qualitative and quantitative metrics. One
such metric is fleet utilization, which is what we use herein to test the proposed unscheduled
downtime reduction method.

Fleet utilization value for a specific vehicle is effectively the time it spends on duty on working
days. LUR mines and transports coal all week long; therefore, Q3 2018 had 92 working days.

Since downtime due to poor weather counts in hours rather than whole shifts, vehicle hours is the
more suitable unit of measurement for fleet utilization. LUR works in two shifts, each lasting 11
hours. Thus, each vehicle is supposed to be on duty 22 hours a day.

Vehicle hours in operation [20]

\[
AH_w = \sum_{i=1}^{D_w} T_{li}
\]

where \(D_w\) is the number of days in operation;
\(T_{li}\) is the time on duty, hours.

Over Q3 2018, BelAZ 7555 D was on duty for 1606 hours (\(AH_w=1606\) vehicle hours, v-h),
unscheduled downtime \(AH_{ud}\) totaled 62.5 hours.

Vehicle-hours of the unit per its schedule

\[
AH_n = T_p \cdot D_n
\]
where $T_p$ is the scheduled operating hours per day on a two-shift day, h; $D_n$ is the scheduled number of operating days.

Vehicle-hours of the unit per its schedule

$$AH_n = 22 \cdot 92 = 2024 \text{ v-h.}$$

Fleet utilization

$$K_r = \frac{AH_w}{AH_n}.$$  \hspace{1cm} (3)

Fleet utilization for BelAZ 7555 D over 3 months, no adjustment for unscheduled downtime

$$K_r = \frac{1606}{2024} = 0.79.$$  

Fleet utilization adjusted for unscheduled downtime

$$K'_r = \frac{AH_w - AH_{ud}}{AH_n}.$$  \hspace{1cm} (4)

Fleet utilization for BelAZ 7555 D over 3 months adjusted for unscheduled downtime

$$K'_r = \frac{1606 - 62.5}{2024} = 0.76.$$  

Thus, unscheduled downtime brought fleet utilization from 0.79 down to 0.76.

Fleet utilization for BelAZ 7555 D after adjusting the maintenance and repair schedule for remaining unscheduled downtime

$$K'_r = \frac{1606 - 22}{2024} = 0.78.$$  

Calculations show that adjusting the M&R schedule and reducing the unscheduled downtime by scheduling M&R on days of likely rainfall can improve fleet utilization for this specific unit by 2.5%. Since fleet utilization effectively quantifies fleet efficiency, adjusting the maintenance and repair schedule for weather forecasts does improve fleet efficiency for the company. Notably, LUR’s facilities can maintain multiple vehicles at a time.

6. Conclusions

The conclusion is that the proposed method can improve the efficiency of haul truck usage at LUR. Therefore, this method is recommendable for coal mining facilities that face the challenge of underutilizing their haul trucks due to weather-caused unscheduled downtime.

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