Method of evaluation of the useful life of dump trucks BelAZ

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ABSTRACT: Article deals with the methods of the evaluation the useful life of mining dump trucks. The fleet of dump trucks Belaz consists of more then 7000 units on Russian open pit mines. 70% of all fleet of mining dump trucks has the real time of operation more then fixed in norms. Working lifetime of the machine depends of the construction (design), the quality of the machine producer manufacturing , operation conditions in the mines, qualification of the trucks operators, level of the technical service and the expenditures for the materials and spare parts. There was no the reasonable method of the calculation the lifetime of Belaz dump trucks in Russian mining industry in now days. The developed method is based on the evaluation of the minimum of accumulated specific costs of technical service and owing costs during the period from the date of putting machine in operation till estimated date**.**

1. Introduction

The share of truck haulage in the total world mining transport operations has currently reached 75%.

Each truck during its lifetime runs an estimated particular work measured in tons per kilometer i.e. is profit-gaining. With all this each truck model has its own design features and specifications as well as its typical assemblage character influencing the dynamics of the truck running factors during the lifetime.

Technical condition of a particular truck is a factor characterizing its performance and that of the whole truck fleet, governing the amount of the transport company's income. Being a car the truck is getting run out, so, its performance is changing with time.

ANV Group together with the Russian mining companies has, over the recent seven years, been carrying out a number of investigations in developing the methodic for proving the efficient configuration of the haulage equipment, i.e. the dump trucks.

While establishing this truck fleet configuration at the mining operations it is necessary to determine the truck maximal efficient lifetime, beyond which it’s further running, is no more economically reasonable.

Within the framework of this article being the first in a series dedicated to the methodic for rationalizing the truck fleet configuration, the results have been given of investigating the principles of changing the trucks performance during their lifetime at the Russian mining operations.

Therefore, in this paper a number of terms - technical, industrial and economical indicators describing the trucks performance have been considered.

2. Indicators of the equipment potential performance

Technical readiness of a truck is determined as the downtimes during maintenance and repair work to avoid failures and shutdowns for the organizational reasons affecting the truck preparedness (no spare parts, service men, rooms etc.). The indicator characterizing the technical readiness is the truck running time until its breakdown.

Technical readiness - total running time before the breakdown determined as the total time of all time intervals, during which a truck is ready for operation irrespective of its potential actual use.

To assess the level of the Russian mining dump truck fleet readiness applied is the ratio of technical readiness (**Kt**) calculated as the relationship of the number of currently operable trucks versus their total quantity. This approach can not, however, determine the real potential of the trucks technical readiness because the calculation methods and assumed indicators differ. And the calculations of Kt are different on the different mining enterprises.

While studying the **Kt** there is always a question: "What is the denominator?"

So, in terms of the authors' practice in the dump trucks maintenance the following indicator is recommended: ***the truck running time in technical readiness over the time period (month, year).***

The truck running time of technical readiness is the truck total number of hours in technical readiness over a particular period of time.

Annual calendar time is 8760 hours. Annual working time (350 days, 305 days etc.) - differs from the calendar time in the number of day offs, when the company has no activities.The value of enables to correctly define the ratio of technical readiness, which can be derived as Kt versus the working time.

The method for determining the period of technical readiness was tested and implemented at Zhairemsky GOK (Kazakhstan), Pechenganickel works, UK Prokopyevsk-ugol, JSC Mezhdurechye, JSC SUEC and JSC Gaisky GOK.

The coefficient of technical readiness is determined as the ratio of technical readiness time versus calendar or working time assumed at a particular enterprise.

The truck technical readiness is, in its turn, crucial for the trucks availability time.

The trucks availability time - is total number of the operation hours during some period of time (day, month, quarter, year), during which the equipment potential is used in mine. This is a natural exponent of the trucks operation during some time period. The modern methods of the leading haulage truck companies to determine the trucks productivity, fleet configuration and its dynamics apply this factor - the truck availability time during its lifetime.

The availability time ratio Kat is determined as the truck operation time vs the working time assumed at the enterprise. Kat reflects the level of organizing the transport company's operational service as well as the operational conditions of the haulage equipment.

An interesting fact: if, over the recent decades, the world level of the truck annual runtime was 5,000 hours with Kat = 0.57, the producers of mining equipment are nowadays ready to secure more than 7500 h of runtime per year for each truck (the calendar time being equal to 8760 h) [2, 3].

3. Dump trucks performance indicators

The indicators characterize the actual results of a particular truck operation and of the whole fleet in a pit (mining operations) as well as the average indicators with regard to trucks types and models, and of the whole haulage fleet.

The truck productivity - is the tonnage of particular truck, average truck or a particular truck model over a particular time period (shift, day, month, year). The productivity is measured in tons, m3 and in tons per kilometer.

The truck run is the number of kilometers run over some period (clay, month, and year) for the whole fleet and for truck types - average or particular truck.

The truck productivity in tons-km and tons per operation hour (in tons-km/h for trucks) is the factor describing real exploitation of the equipment potential in the pit and the truck productivity. (Monthly or yearly truck productivity in tons-km can easily be calculated by multiplying the truck productivity and the sum of operating hours.

3. Economical indicators of dump truck fleet performance

To evaluate the truck performance the mining companies apply per unit costs per volume of fulfilled or scheduled work.

Per unit costs of truck rock mass haulage (as per **whole fleet** and per particular truck model) per ton of rock mass, rbl/t.

Per unit costs of maintenance per volume of haulage (rbl /t-km).

Maintenance cost include the costs of spare parts, service materials, salary of service staff, rent and service of maintenance and repair shops, as well as the costs of contracted service organizations.

Per unit costs of rock mass haulage per hour of technical readiness is determined as a relationship of total haulage costs versus total runtime of the fleet or particular truck in hours of technical readiness.

Per unit costs of the trucks maintenance per hour of technical readiness is the ratio between the trucks total maintenance costs of haulage fleet or particular truck model total runtime in technical readiness.

This-factor characterizes changing technical conditions (runout) of a particular vehicle in time and, also, aver-agely of vehicle groups or the whole equipment fleet.

All the above factors describing the trucks performance depend on the truck model specifications as well as on the dynamics of its changing technical conditions during its lifetime (particular mining and climate setting).

During the truck operation the breakdowns, naturally, become more frequent due to wearing out of the load-bearing elements, main units and aggregates, electrical networks and hydraulics. Therefore, the enhanced efforts to eliminate all these effects result in higher costs of the spare parts and materials to maintain the required technical readiness of the equipment. (Fig. 1)

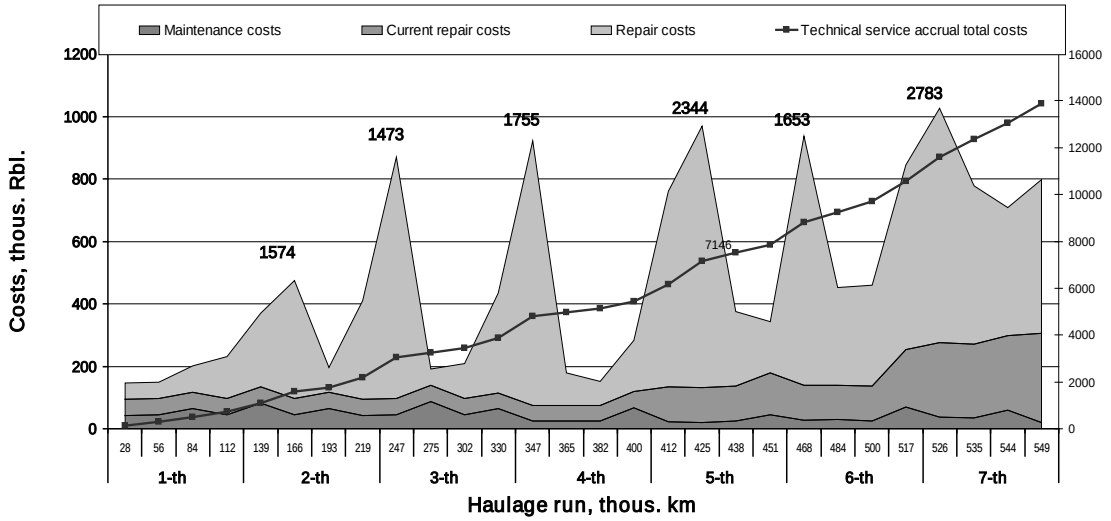

Fig. 1. Diagram of maintenance cost during BelAZ-7548 lifetime

Along with that the dynamics of changing the runtime hours in technical readiness are different for particular trucks, primarily, resulting from the trucks design specifics, quality of MTR, maintenance organization and the service staff skills.So, for each truck model there is an own curve of changing the runtime in technical readiness and of productivity variations, respectively, during the whole lifetime under specific mining and engineering conditions (Fig.2).

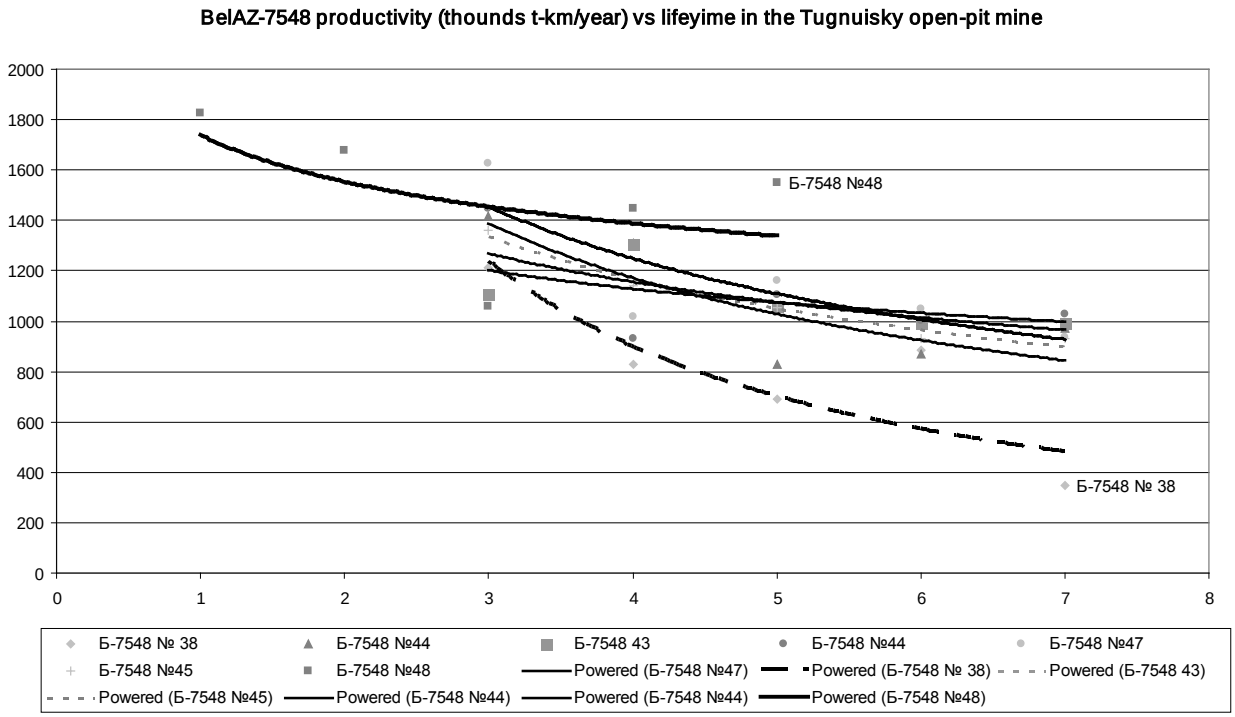

Fig. 2. BelAZ-7548 productivity versus lifetime (Tugnuisky open-pit

4. The study the principles of changing the productivity of dump trucks

In the course of developing the methodic for determining the dump trucks optimal lifetimes a task was, therefore, to study the principles of changing the productivity of various trucks models at the existing mining operations.

To find the relationships between the indicators (the coefficient of technical readiness, running time, tonnage per hour, haulage costs per unit) and the trucks lifetime the data have been collected about the haulage operations of BelAZ-7555, BelAZ-7540, BelAZ-7512 trucks etc. from the companies JSC "Uralasbest", AK "ALROSA", Kolskaya GMK "Pechenganickel", Kovdor GOK, JSC "Karelsky Okatysh", Norilsk GMK, JSC "Mczhdurechye" and from the coal companies owned by JSC "SUEK etc. [1].

The study of the results of regression analysis of correlation between the coefficient of technical readiness and BelAZ trucks lifetime has shown a stable tendency towards depletion of technical readiness runtime hors. The intensity of falling depends on the level of truck maintenance arrangement.

According to "ALROSA" JSC the technical readiness of BelAZ-7548A and BelAZ-75121 trucks during 2nd to 9th years of operation vary from от 0.85 to 0.73 (i.e. 16% with the intensity of 1.8% per year), and from 0.85 to 0.71 for BelAZ-75121 during 7 years (i. e. 20% with the intensity of 3% per year).

In the course of the study the stable tendency towards worsening the trucks technical readiness with longer lifetimes has been vindicated at JSC "SUEK" operations. (Fig. 3).

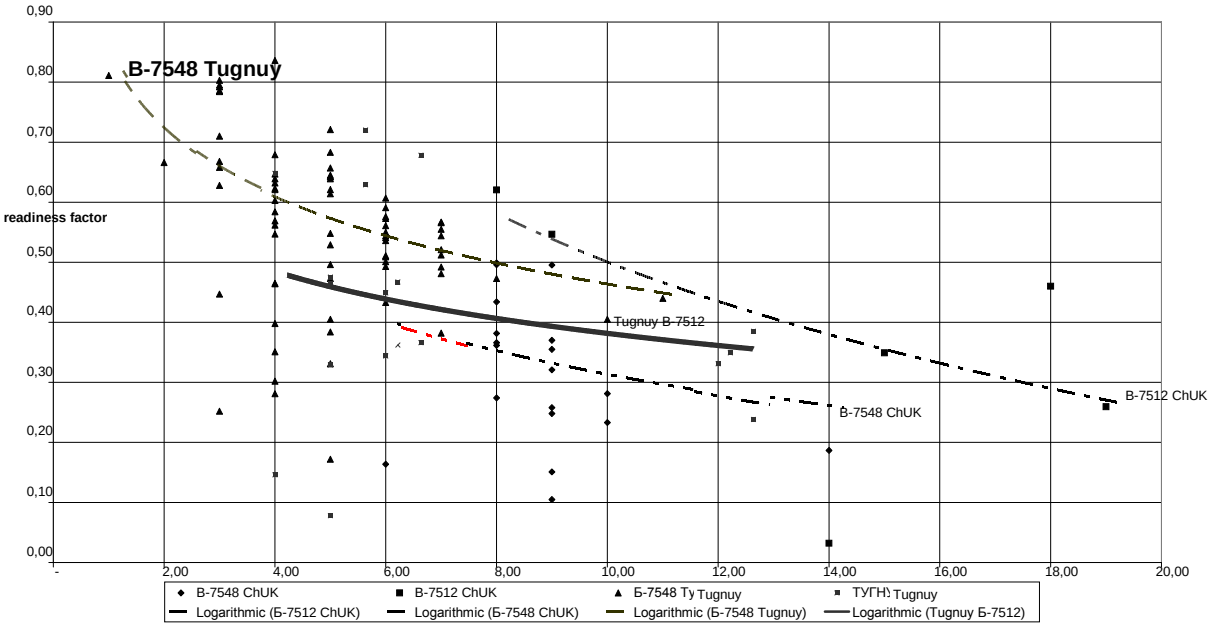

Fig. 3. The availability time ratio (Kat) of truck vs lifetime (Chernogorsky (ChUK) and Tugnuisky (TU) coal mines, JSC «SUEK»)

The maintenance and repair works level as well as the skills and equipment range at the Tugnuisky coal mine contribute, however, to the running time as compared to the Chernogorsky mine. The indicators of the trucks technical readiness (BelAZ-7548) in the Tugnuisky mine are almost 1.5 - 1.8 higher. (Fig. 3).

The studies carried out in order to reveal the correlation between the hourly productivity for various trucks have confirmed the conclusions of many authors [2] that the lifetime influence on specific productivity is negligible. The major factors crucial for the hourly productivity are the shovel bucket capacity, grade and haulage distance.

The study of the economical factors of the dump trucks in the Russian pits has indicated the tendencies towards higher per unit costs of haulage versus the trucks lifetime.

Less cost efficiency of maintenance through the lifetime is a natural tendency; it's a law of the haulage cost dynamics.

With the longer truck lifetime the maintenance costs and their share in supplying the vehicle viability increase. This share for BelAZ-7548 during five years' operation increases from 8% to 30-35%.

The stable tendencies towards reducing the runtime (Fig. 1) and the productivity, respectively, the maintenance costs per unit sharply increase after 5 years of the trucks operation.

With all that a particular truck has its own dynamics of changing technical conditions, which requires an individual approach to take into account all the above factors to accurately determine the truck lifetime (Fig. 4).

5. Method of evaluation the lifetime of dump trucks

There was no the reasonable method of the calculation the lifetime of Belaz dump trucks in Russian mining industry in now days.

The developed method is based on the evaluation of the minimum of accumulated specific costs of technical service and owing costs during the period from the date of putting machine in operation till estimated date.

$$\tilde{N}_{SP} = \frac{\sum_{t=1}^{Òïð} \tilde{N}_t^{ÒÑf} + \sum_{t=1}^{Òð} \tilde{N}_t^{ÒÑpl} + \sum_{t=1}^{Òð} \tilde{N}_{owing}}{\sum_{t=1}^{Òïð} Q_t^{\hat{e}} + \sum_{t=1}^{Òð} Q_t^{ì}} \Rightarrow \min$$

C sp –specific costs for the period of useful lifetime .

C_t^{Tcf} - real expenditures for the technical service in t-year

C_t^{Tcpl} - planned expenditures for the technical service in t-year

Cowing – owing costs

Q_t^{k} – real volume of transport work of the dump truck in t year, t km

Q_t^{m} – planned volume of transport work of the dump truck in t year, t km

The way of calculation is follow by this method.

$C_{sp_1} = (C_{ts_1} + C_{ow})/Q_1$

$C_{sp2} = (C_{ts_1} + C_{ts_2} + C_{ow})/(Q_1 + Q_2)$

……..

$C_{sp_t} = (C_{ts_1} + C_{ts_2} + \ldots + C_{ts_t} + C_{ow}) / (Q_1 + Q_2 + Q_3 + \ldots + Q_t)$

$C_{sp}^{Tpc} = (C_{ts_1} + C_{ts_2} + \ldots + C_{ts_t} + \ldots + C_{ts}^{Tpc} + C_{ow}) / (Q_1 + Q_2 + Q_3 + \ldots + Q_t + \ldots + Q^{Tpc})$

$$C_{sp}^{Tpc} = min$$

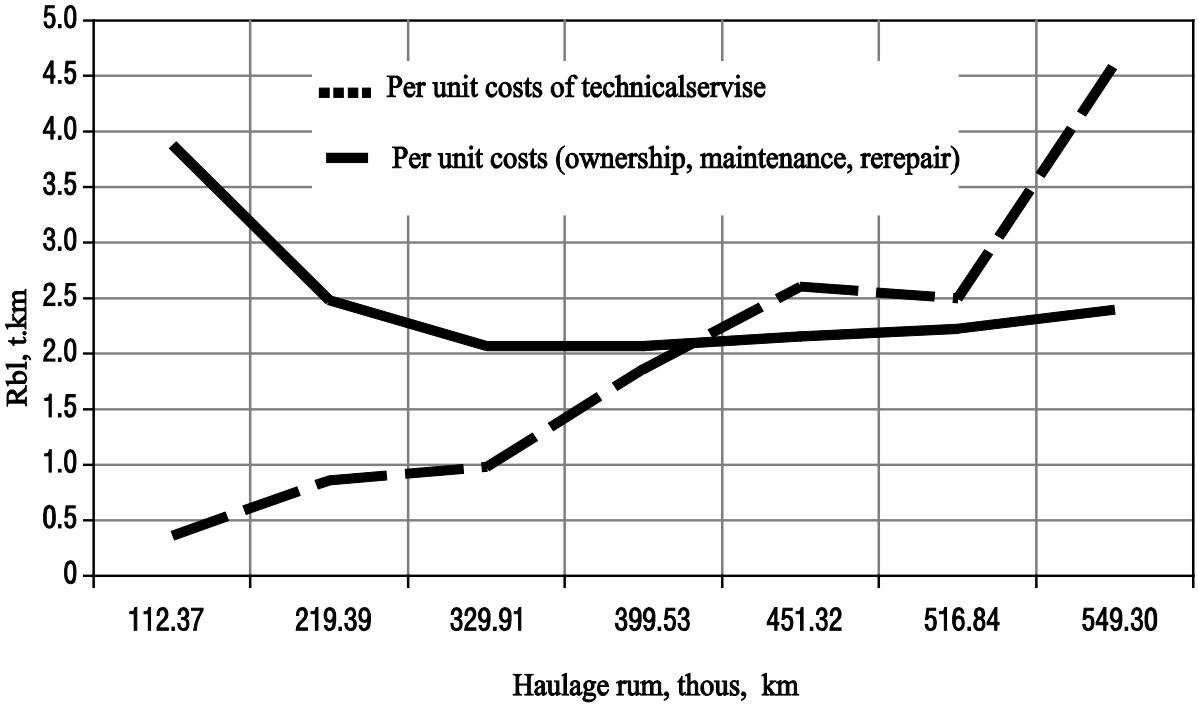

Fig. 4. Changing per unit costs during lifetime of BelAZ7548 truck N38 (Tugnuisky mine)

6. Conclusions

With longer lifetime technical readiness and performance of the dump trucks tend to fatigue.

The intensity of changing the truck running time in technical readiness and haulage routing as well as of its performance depends on design reliability of the haulage equipment, level of operational maintenance and maintenance costs in the total net cost infrastructure.

In the course of investigations in changeless haulage conditions the truck productivity per hour of operation has been revealed to be ' independent from its lifetime.

Changing hourly productivity during the lifetime is determined by the haulage conditions in the pit: haulage route, grade, performance of the loading equipment.

In order to know the track performance during future operation (future productivity) it is necessary to apply the regression models built on actual data about the truck productivity or its actual performance.

Higher maintenance costs is a natural tendency of the haulage costs dynamics during the truck operational lifetime.

A particular truck has its own dynamics of changing technical conditions, which requires an individual approach to take into account all the above factors to accurately determine the truck lifetime.

Reverences

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