Determinaton of indicators for assessing mining vehicles quality in modern conditions

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Abstract. In Russia, mineral resources are located mainly in Siberia, Yakutia, the Arctic and the Far East that predetermines the development of mining industries in those regions. Mining and transport equipment operates mostly in harsh weather conditions characterized by sharp continental climate for most of the territories. Under the influence of these factors, the efficiency of using the equipment of various types is significantly different, and it normally decreases while operating costs increase by 2-5 times comparing to similar expenditures in Central Russia. In modern economic conditions, when there is a wide choice of mining and transport equipment of local and foreign production, mining companies face the problem of choosing machines that are suitable to operate in certain mining, geological, climatic, geographic, and economic conditions. To assess the quality of mining equipment, there is a need for a special technique that will allow selecting a machine of certain type, size, and manufacturer taking into account its working effectiveness and the cost of its acquisition and operating in specific conditions.

1. Introduction.

As mineral resources are located throughout Russia mainly in Siberia, Yakutia, the Arctic and the Far East, in the short term it means that mining industries are being developed in those territories. Mining operations here are mainly carried out by open-mining, which is currently characterized by mining depth increasing as well as stripping ratio increasing and thus, using mining and transport equipment of large unit capacity.

For most of these territories, climate conditions under which the equipment is usually operated are characterized by sharp continental parameters. They are low air temperatures in winter (up to -60 -65°C); long winter period (up to 9-10 months); large annual (up to 80 - 90°C) and daily (up to 25 - 35°C) amplitudes of changes in air temperatures; high speeds of wind; snowstorms and frost fogs (up to 20-25 days a month in winter); in addition, seasonal and permafrost soils. So, most of the North and North-Eastern regions of Russia are located under specific geographic and, consequently, economic conditions. On the one hand, it is a large distance from the economically developed regions of Central Russia, and on the other hand, there is neither developed transport infrastructure nor large sources of energy supply. Under these factors, the efficiency of using mining and transport equipment of various types differs significantly and generally decreases [1, 2, 3] (time-outs can count from 40 to 50% of calendar time) with an increase of operating costs 2-5 times compared to similar expenditures in
Central Russia. Under current economic conditions, with a wide choice of mining and transport equipment of local and foreign production, mining companies face the problem of choosing high quality machines to operate in certain mining, geological, weather, geographic, and economic conditions [4].

2. Materials and methods
The quality of mining and transport equipment is basically assessed according to the following characteristics: the expediency of purchasing and using and operating efficiency. For this purpose, one needs a special technique that allows choosing a machine of a certain type (type, size, and manufacturer) from the proposed list of machines [5, 6]. In this case, the machine is to be functionally most effective in very specific conditions for a set of technical, technological and economic indicators. Such technique will also allow one not only to evaluate the quality of operating machines but also to identify the reasons for their low operating efficiency and, respectively, to develop organizational and technical measures to improve it.

Currently, the most frequent methods are increasing the efficiency of mining machines by improving their reliability with the help of cold-resistant materials that leads to increasing the durability of parts and assemblies. On the whole, it helps adapt the design of machinery to maintenance and repair as well as improve actual maintenance and repair system.

Under operating conditions of mining enterprises, the method of improving the maintenance and repair system is the most acceptable as it makes possible to increase the level of repairing and technical capability of mining vehicles and optimize labor, time and money for their maintenance and repair along with working quality and volume.

The major part of labor and time costs to maintain and repair mining machines is labor intensity which is defined as the number of repair influences by maintenance and repair types to the operating equipment set of an enterprise.

Total labor intensity of repairing (in terms of person-shift) can be calculated by the following formula:

\[ T_{aw} = T_{m.w} + T_{mech} + T_{e.r} + T_{e.g.w} + T_{f.t} + T_{p} + T_{a.c} + T_{ot} \]

where:
- \( T_{m.w} \) - total labor intensity of assembly works (person – shift);
- \( T_{mech} \) - labor intensity of mechanical work by metal working (person -shift);
- \( T_{e.r} \) - labor intensity of electrical repair works (person- shifts);
- \( T_{e.g.w} \) - labor intensity of electric gas welding and metal cutting (person -shift);
- \( T_{f.t} \) - labor intensity of forging and thermal riveting (person -shift);
- \( T_{p} \) - labor intensity of painting works (person -shift);
- \( T_{a.c} \) - labor intensity of adjustment and control (person -shift);
- \( T_{ot} \) - labor intensity of other types of work (transportation, loading, washing, cleaning, preparation of the repair site, etc. (person -shift).

To reduce the amount of computational work or when the data on the complexity of repairs and maintenance of a machine is not enough, one can apply the following formula:

\[ T_{det} = T_{th} \times \left( \frac{P_{det}}{P_{th}} \right)^{2/3} \]

where:
- \( T_{det} \) - the complexity of repairs and maintenance which should be determined in person-hour;
- \( P_{det} \) - the mass of the machine which requires maintenance;
- \( P_{th}, P_{th} \) - labor intensity and mass of the machine, for which there are normative data on the complexity of repairs and maintenance, person-hour, t.

The standards of labor intensity along with the duration and regularity of equipment repairs are usually calculated on the basis of repairs made by an individual (repair with responsibility) method during a 7-hour compact shift when air temperature at the repair site is above zero. For other conditions, modifying factors are used:
$K_{r1} = 0.7-1.3$ - intensity of machine wear in complex mining and geological conditions;

$K_{r2} = 0.75-1$ - worsening of repair conditions on climatic, mainly thermal, reasons;

$K_{r3} = 1-1.3$ - worn-out equipment, determined by the formula:

$$K_{r3} = 1 + (0.05 \div 0.1) \times (i - 1),$$

where:

- $i$ - the serial number of the repair cycle (in the first repair cycle $i = 1$ and in this formula it is not taken into account);
- $K_{r4} = 1-4$ - progressive methods of repair;
- $K_{r5} = 0.7-1.2$ - quality of repair, determined by the formula:

$$K_{r5} = V_{av} / V_n$$

where:

- $V_{av}$ - actual volume of repair works calculated in thousand-rubles or people-shifts;
- $V_n$ - necessary amount of repair according to operating documents in the same measurement units.

In fact, exceeding the actual amount of repairing over the necessary ($K_{r5} > 1$) is possible, when modernizing the machine that is carried out simultaneously with the overhaul, if the nameplate data of the machine are improved or there is a shortage of spare parts of the required nomenclature. Other difficulties that may influence negatively are the absence of qualified repair personnel and necessary manufacturing at the repair base. Using modifying factors, it is also possible to obtain the corrected standards:

repair labor intensity

$$N'_{l.i} = N_{l.i} / K_{r2};$$

overhauls

$$N'_{ov} = N_{ov} \times K_{r4} \times K_{r1} / K_{r3};$$

stock of materials and spare parts

$$N'_{zmz} = N_{zmz} \times K_{r4} \times K_{r3};$$

consumption of materials and spare parts

$$N'_{cm} = N_{cm} \times K_{r5};$$

duration of repair

$$N'_{d} = N_{d} / K_{r4}.$$

Therefore, it is necessary to carry out studies to determine the external conditions influence on the efficiency of mining and transport vehicles and then to develop a complex of organizational and technical measures and recommendations that can reduce negative impact of environmental factors. In general, the evaluation of the quality of mining and transport vehicles assumes the following sequence of calculations [7]:

$$E = C_{tot} / V_{tot}$$

where:

- $E$ - specific economic effect of exploitation of mining (mining and transport) machines, rubles/t, rubles/m³, rubles/tcm, rubles/m, rub/m³, etc.;
- $C_{tot}$ - total costs in rubles;
- $V_{tot}$ - the total amount of work made by a machine during an operating period, t, m³, t/km, m, running, m. etc.;

$Total\ Expenses$

$$C_{tot} = 3_a + 3_a$$

where:

- $3_a$ - expenses for acquisition and transportation of the car, rubles;
Зо - operating costs in rubles.

**Expenses for an acquisition and transportation of a machine**

\[ Z_a = Z_p + Z_t + Z_r \]

where:

- \( Z_p \) - expenses for purchasing a machine in rubles;
- \( Z_t \) - expenses for transportation of the car in rubles;
- \( Z_r \) - customs costs (for foreign cars) in rubles.

**Operating Expenses**

\[ Z_o = Z_{te} + Z_{c.m} + Z_{TOuR} + Z_{sp} + Z_{pr} + Z_{t.c} \]

where:

- \( Z_{te} \) - expenses for fuel (electric power) in rubles;
- \( Z_{c.m} \) - expenses for technical fluids in rubles;
- \( Z_{TOuR} \) - expenses for technical maintenance and repairs (taking into account the costs for training maintenance and repair personnel) in rubles;
- \( Z_{sp} \) - expenses for spare parts in rubles;
- \( Z_{t.c} \) - expenses for construction and maintenance of transport communications in rubles.

**Total amount of work performed by machine during the operation period**

\[ V_{tot} = \Pi_{o.c.m} \times n \]

where:

- \( \Pi_{o.c.m} \) - annual operating capacity of machine, thousand m³ per year;
- \( n \) is the number of years of machine operating.

In each case, the annual operating capacity is to be adopted to the data of enterprises of the region or determined by calculating the index marks that take into account foremost climate conditions of the region, geological and mining conditions of the deposit as well as the specifics of work at the enterprise.

\[ \Pi_{o.c.m} = \Pi_{w.c} \times t_h \times n \times N \]

where:

- \( \Pi_{w.c} \) - working capacity of machine, m³ / hour;
- \( t_h \) - shift duration in hours;
- \( n \) is the number of shifts per day;
- \( N \) - number of working days per year.

### 3. Conclusion

The use of this technique will make it possible to select from a wide list of proposed equipment, with the help of which the unit cost of production will be minimal and, consequently, the profit of the enterprises will be greatest with the least expenses.

### References

[1] Drygin M Y, Kuryshkin N P 2018 *Journal of Physics Conference Series* **944**

[2] Brodny Ja, Tutak M 2017 *IOP Conference Series-Earth and Environmental Science* **95**

[3] Roy S K, Bhattacharyya M M, Naikan V N A 2001 *Transactions of the Institution of Mining and Metallurgy Section A-Mining Technology* **110** A163–A171

[4] Kvaginidze V S, Koretsky V B, Koretskaya N A 2009 *Mining Information Analytical Bulletin* **10** 206–212

[5] Hall R A, Daneshmend L K, Lipsett M G, Wong, J 2000 *CIM Bulletin* **1044** 78–82

[6] Ivanov S L, Shishkin P V 2017 *Innovations and Prospects of Development of Mining Machinery and Electrical Engineering* **87**
[7] Kvaginidze V S, Antonov Y A, Koretsky V B and Chupeykina N N 2010 *Advances in Modern Natural Science* 9 66–67