MINERAL MINING TECHNOLOGY

ESTIMATION CRITERIA FOR ENERGY CONSUMPTION BY MINING EQUIPMENT IN QUARRIES

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The regularities of fuel consumption by mining equipment during opencast mining are established. The criteria and procedure are proposed for calculating the rates of fuel consumption for mining equipment with diesel drive.

Opencast mining, equipment, fuel, criteria

Payment of basic energy-carriers, such as electric energy and diesel fuel, is one of the most expensive components in cost of opencast mineral mining. As is indicated by a retrospective analysis, this component steadily increases in terms of volume and value [1, 2]. This is for the first turn governed by complicating mining and technical conditions existing in most deposits as well as by constantly rising prices of raw energy resources. Taking into account methods of planning and regulation of the electric energy consumption at mining enterprises [3], the present article considers the points concerning use of diesel fuel representing the main constituent of a liquid energy-carrier.

This fuel type is mainly consumed by manufacturing motor transport, bulldozers, excavators, and drilling rigs.

The first three machine types are widely employed in mining. The diesel-drive excavators and drilling rigs were mostly represented by small-dimension machines (bucket capacity up to 1.5 m³, borehole diameter to 150 m). Some large enterprises run more powerful diesel excavators with a bucket capacity of 10–15 m³, engine power up to 135 kW, and drilling rigs for boreholes up to 250 mm in diameter.

In spite of higher operating costs as compared with electric machines, the use of diesel-drive excavators is proved by their advanced mobility and technological effectiveness in straitened mining and technical conditions. In present-day Russia, the machinery discussed is mainly concentrated in quarries of the “Alrosa” Joint-Stock Company, few excavators of Caterpillar production operate in the Kuznetsk Basin and in Krasnoyarsk Territory.

As mining in the eastern regions of Russia is developing, an increase is predicted in diesel-fuel equipment. Regulation and registration of fuel consumption become of prime importance in such situation. These points are most completely systematized for manufacturing motor transport and, in particular, in researches conducted by the Institute of Mining, Ural Branch, Russian Academy of Sciences and by the Scientific and Research Institute of Motor Transport, Ministry of Transport, Russia [4–6].


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For other mining machine types, such as excavators, bulldozers, loaders, and drilling rigs, there are no fuel-consumption regulation procedures substantiated with respect to the operation conditions and the work fulfilled. Also, fuel consumption is planned by the real data obtained during the past periods of the equipment operation. This approach makes it impossible to optimize standard fuel consumption, which impedes its economic use.

The authors of this article have proposed a procedure for calculation of individual rates of fuel consumption. This procedure takes into account specific features of mining equipment operation. The individual fuel-consumption rate means such a rate that is formed for a concrete machine model with respect to the unit of work fulfilled or with respect to the working time unit relative to definite production conditions.

The following estimation criteria are assumed as the basic ones: the machine-engine utilization factors with respect to time and capacity in carrying out various mining operations (excavation, load, dumping, cultivation, drilling, etc.). As an analogy, the methods of the State Building Department of Russian Federation were used, since they are to the greatest extent allied to the mining industry conditions [7]. In the procedure proposed, the individual rate of fuel consumption:

$$Q_r = q \cdot N \cdot k,$$

where $q$ is the specific nominal diesel fuel consumption, kg/kW·h; $N$ is the nominal engine power, kW; $k$ is the integral coefficient to take into account machine state and working conditions during a shift:

$$k = k_1 \cdot k_2 \cdot k_3 \cdot k_4 \cdot k_5 \cdot k_6 \cdot k_7 \cdot k_8;$$

here, $k_1$ and $k_2$ are the machine engine utilization factors with respect to time and power, respectively; $k_3$, $k_4$, $k_5$, $k_6$, $k_7$, and $k_8$ are the coefficients taking account of fuel consumed for engine actuation and warming, change in fuel consumption depend upon engine power utilization degree, engine wear, increase in fuel consumption when it is cold, machine running-in, as well as straitened and complicated operational conditions, respectively.

Fuel consumption is mostly affected by factors of the machine engine utilization with respect to time and power. Other factors, that depend on technical state of engines and conditions of their operation, are of limited importance. The factor $k_1$ is determined by the real data of machine operation, and $k_2$, by the actual or calculated data on fuel consumption:

$$k_2 = \frac{Q_r}{T_p \cdot q \cdot N},$$

where $T_p$ is the time of machine operation.

To make the calculations of $k_2$ more accurate, the components from (3) should be considered together with downtimes, when the machine engine is switched-off during a shift, and engine power utilization depending on work fulfilled. Then the calculated factor of engine power utilization can be defined:

$$k_2^* = k_0 \cdot k_{i0} \cdot k_{i1},$$

where $k_0$ is the factor of machine utilization with respect to time; $k_{i0}$ and $k_{i1}$ are the coefficients taking into account the downtimes, when the machine engine is switched-off (downtimes due to temporary absence of transport or field of operations, owing to gas contamination, etc.) and the engine power utilization relative to the types of work.

The values of $k_{i0}$ and $k_{i1}$ obtained during timing observations over mining in quarries of the “Alrosa” Joint-Stock Company are presented in Tables 1 and 2.

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