CHARACTERISTICS OF THE KALMAKIR QUARRY EXCAVATOR-AUTOMOBILE COMPLEX

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Abstract. *The main task of these studies is to establish an economically feasible mode of operation of quarry vehicles and minimize downtime of excavators and dump trucks involved in the work of the EAC, due to which an increase in the operational productivity of the EAC is achieved.*
Keywords: *quarry, Kalmakir deposit, copper-molybdenum, geological structure.*

The Kalmakir deposit was discovered in the mid-20s and has been mined since 1954 by the quarry method. It has an ellipsoid shape, elongated by 3.95 km with a width of 1.9 km, a depth of 475 m with a depth of mineralization up to 850 meters. The average annual productivity of the quarry is about 33 million tons. The quarry is the largest supplier of copper-molybdenum ore for non-ferrous metallurgy of the Republic of Uzbekistan.

Sedimentary, igneous and metamorphic rocks take part in the geological structure of the deposit. Sedimentary rocks: sandstones, limestones; igneous: quartz porphyry, granodiorite porphyry, syenite-diorites, diorites; metamorphic: secondary quartzites. The ores of the veined deposit are interspersed. Rocks and ores have an intense network of cracks that break the array into small and large blocks. The coefficient of strength on the scale of prof. Protodyakonova M.M. – f=10-16, the density of ores is 2,6-2,8 t/ m^3, rocks are 2,4-2,6 t/ m^3, the loosening coefficient is-1,5. Currently, the development of a career is carried out in a combined way. The lower horizons -are by road, with overloading -to the railway, the upper ones- are by rail. The ore is delivered to the processing plant in railway dump cars at a distance of up to 8 km. The overburden rocks are transported by rail to the dumps. In the quarry, 21 excavators are involved in loading the rock mass, 8 excavators are involved in the dumps. Currently, 33 excavators are in operation in the quarry and on the dumps of the mine, including ЭКГ-8И - 8 units on the dumps, ЭКГ-6,3 - 2 units in the buffer warehouse of the Copper Processing Plant (CPP), ЭКГ-4,6 -1 units on loading ballast for railway tracks. There are 22 units in the quarry, including: ЭКГ-20 - 1 unit, ЭКГ-15 – 4 units, ЭКГ-12.5 – 3 units, ЭКГ-10 - 8 units, ЭКГ-8 - 5 units, ЭКГ-5У - 1 units. On the upper ledges of the quarry, the rock mass is shipped to road transport by 3 excavators, including ЭКГ-12.5 - 1 units, ЭКГ-8И – 2 units. On the lower ledges of the quarry, excavators in the amount of 6 units are shipped to road transport. Of these, ЭКГ-8И - 2 units and ЭКГ-10 - 4 units. The rest of the excavators are shipping rock mass to railway transport, of which 3 units [1,9,19,20].

ЭКГ-10 are located at transshipment points, to which the rock mass is delivered by road. This year, it is planned to put into operation the 4th transshipment point, to which the rock mass will be delivered by road from the northern side of the quarry in the amount of 700 thousand m^3.

The rock mass from the upper ledges is taken out to the external automobile dump. The rock mass from the lower ledges is transported at 3 transshipment points located on the horizon of 565 m. The distance between the points is 500-600 m with separate railway arrivals at each point. The average rolling distance on the upper ledges is 2.5 km, on the lower ones - 4.5 km. In recent years, the pace of mining operations on the upper ledges has noticeably decreased due to the lack of vehicles, which negatively affects the development of the underlying horizons.

25-26 million tons are exported by rail of ore and about 5 million m^3 of overburden into dumps. Motor transport is exported to transshipment nodes – 4-4.5 million m^3 of rock mass, for the contour of the quarry from 1 to 3 million m^3 of overburden. In order to increase the productivity of vehicles transporting rock mass to transshipment nodes and reduce the time spent on their passage from the garage to the quarry and back, a temporary platform has been set up in the quarry on a non-working ledge, where cars are refueled and minor malfunctions are eliminated on them.

Stripping and mining operations at quarries are carried out mainly by excavator-automobile complexes (EAC) of large unit capacity, with a capacity of 20 to 30 million m^3 per year [1].

The characteristics of the EAC of the quarry are given in Table 1. The table shows excavators and dump trucks. The general analysis shows that the EAC quarries are characterized by a large variety of excavator fleets (5 standard sizes) and a small number of standard sizes (3 standard sizes) of dump truck fleets. In accordance with this, the EAC of the Kalmakir quarry can be included – of medium complexity, having about 5 standard sizes of excavators and 2-3 standard sizes of quarry dump trucks.

Table 1

Characteristics of the Kalmakir quarry EAC

Dump trucks		Excavators				
		ЭКГ -5у	ЭКГ -10	ЭКГ -12,5	ЭКГ -15	ЭКГ -20
TEREX(90 т)	3	1	14	2	10	1
BelAZ (130 т)	23					
BelAZ (220 т)	2					
CHARACTERISTICS OF EAC: 5 standard sizes of excavators with bucket capacity 5 to 20 m^3; 3 the standard size of dump trucks -BelAZ-75131 (130 t, 23 units.); BelAZ-75306 (220 T, 2 units.) and TEREX. (90 T, 3 units .)						

The efficiency of the EAC is largely determined by the efficiency of the interaction of the elements of this system (quarry excavators and dump trucks), characterized by the amount of equipment downtime during the waiting and work shift. For dump trucks, these downtime reaches up to 32% of the working time.

The overall performance of the EAC is largely determined by the loading time of quarry dump trucks and the characteristics of their movement [2]. In addition, the number and sizes of quarry dump trucks and excavators are two of the most important factors in determining and rational parameters of open–pit mining (OPM). If the number of mining dump trucks and excavators working simultaneously in the EAC is not balanced, this can lead to their downtime and a decrease in their productivity. If there are more dump trucks than required, they will be idle at the excavators waiting and loading; if less – excavators will be idle waiting and working.

The issues of the effectiveness of the joint work of quarry excavators and dump trucks as part of the EAC have not been sufficiently investigated to date, therefore, the task of researching and optimizing the functioning of excavator-automobile complexes of sections by improving the system of distribution of quarry dump trucks at loading points seems relevant.

At the same time, even if the number of quarry excavators and dump trucks in EAC is balanced, downtime may occur if dump trucks are distributed irrationally between excavators, or if dump trucks of different sizes work with specific excavators. This leads to significant losses of working time of machines, a decrease in their productivity, non-fulfillment by the change of production, and, as a result, to a decrease in the overall operational productivity of the EAC. At the same time, even a small increase in the productivity of the EAC will save significant funds by reducing capital investments for the purchase and replacement of equipment. Consequently, the efficiency of the functioning of the EAC and mining operations in general largely depends on how rationally the distribution of quarry dump trucks is carried out at loading points, corresponding routes and unloading points.

The task of reducing costs by more efficient use of both dump trucks and excavators as part of the EAC is the primary task of dispatching quarry vehicles. Dispatching is a dynamic process that requires continuous monitoring of routes, size and location of quarry dump trucks and excavators in order to find a rational distribution. By applying dispatching, you can count either on increasing the productivity of the EAC with the existing fleet of equipment, or on ensuring the desired performance with less equipment. This goal is achieved by reducing downtime and thereby improving the use of technology. Quarry dump trucks are productive only when they transport rock mass, and loading machines – when they load rock mass into a dump truck. It is simple and characterizes the unproductive use of technology and should be optimized, that is, minimized.

At the same time, considering the EAC of the Kalmakir quarry (Table-1), the following can be noted. There is currently no need to deal with dispatching career vehicles of simple EAC, since it will not give the above effect. Fairly well-known methods to optimize the number of quarry dump trucks. In addition, it is also irrational to immediately consider complex EAC. It makes sense to start by considering EAC of medium complexity, which, firstly, are more than others and, secondly, their study is not as time-consuming as complex ones EAC, although the methodology of such a study will obviously be the same as an EAC of medium complexity. Therefore, the loading and transport processes and equipment of the Kalmakir quarry were chosen as the object of research.

Familiarization with the experience of quarries, reflected in the periodical scientific literature of recent years, revealed the lack of noticeable achievements in the field of production organization, in reducing equipment downtime. Moreover, leading experts in this field note that the domestic quarries still use virtually the same methods of organizing OGR as 50 years ago. As a result, the level of use of excavators (including high-performance imported ones) in most quarries has not changed and remains within 50-60% of the calendar time. It is argued that in this matter, practice has lagged far behind the theory of production organization and management [3,4]. In addition, the traditional way of organizing the loading and transport process on a "closed cycle" leads to significant downtime of quarry dump trucks.

The classification of downtime of technological vehicles of the Kalmakir quarry is as follows.

Scheduled downtime is downtime, the duration of which is determined by regulatory documents (for example, [5]). They are regulated values established for specific operating conditions of mining equipment as part of the EAC. Their revision is possible only if the mining conditions change.

Unplanned downtime – downtime of serviceable machines during the shift. These machines have already been put into operation for a specific shift, but for reasons beyond the control of the driver (driver), they cannot participate in the work and, accordingly, perform a shift task.

The structure of downtime of technological vehicles at the Kalmakir quarry is shown in Figure 1.

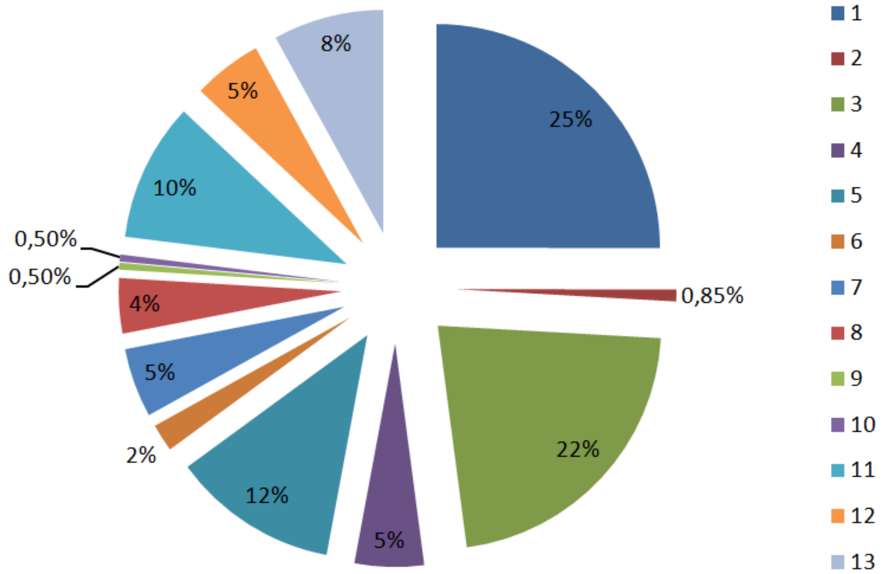

Figure-1. Structure of downtime of technological vehicles at the Kalmakyr quarry:: 1- waiting for loading;; 2- commissioning; 3- dump truck repair; 4- maintenance; 5- excavator repair; 6- drilling and blasting operations; 7- road works; 8- no work front; 9- no electricity; 10- weather conditions; 11- lunch break; 12- control inspection; 13- refill

As can be seen from the diagram shown in Figure 1, downtime waiting for loading accounts for almost a third of all downtime of quarry dump trucks. These are not the downtime that cannot be avoided, and they arise solely because of the unsatisfactory organization of the work of vehicles. If we also take into account the downtime associated with the failure and further restoration of equipment operability (repair of dump trucks and excavators), then the total downtime will amount to 57%. In general, the trends in downtime remain unsatisfactory.

The increase in downtime leads to the need to purchase additional mining dump trucks to fulfill the production program. Reducing downtime gives a real opportunity to reduce capital costs for the purchase of new machines. Of course, it is impossible to get rid of all downtime in real production conditions, but even with a reduction in their part, it is possible to identify hidden reserves and opportunities of open-pit coal mining enterprises. The current situation indicates the weakness of analytical work at enterprises, in particular, in terms of identifying the causes of unplanned downtime of quarry equipment. The existing management systems of mining and transport complexes, for example, of the company Mincom (Australia), although they record the duration and enlarged signs of downtime of each type of mining equipment, they are not able to identify the primary causes of downtime [6,14,15,16,17,18].

Thus, the EAC is a complex system, the properties and relationships of which in most cases are stochastic, since they depend on many specific conditions: the configuration of the quarry, the nature of the transported rock mass (overburden rocks or minerals), the composition of equipment parks and their condition, the organization of work. World practice shows that in recent years, the average productivity of quarry mining equipment has tended to decrease, including for the reasons mentioned above (for example, the productivity of quarry dump trucks in 2016-2020 year decreased by 41%, even despite new technological advances [7,8]).

In this regard, the main task of these studies should be to establish an economically feasible mode of operation of quarry vehicles and minimize downtime of excavators and dump trucks involved in the work of the EAC, due to which an increase in the operational productivity of the EAC is achieved.

The possibility of minimizing downtime can be achieved, in addition to rationalizing the fleets of loading and transport equipment, by creating an algorithm for the optimal distribution of quarry dump trucks at loading points (by improving the quality of the used dispatching system of quarry vehicles as part of the EAC section).

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