

ANNOTATION

dissertational work Akhmetova M.I. "Comprehensive assessment and ways to improve the quality of operation of mining dump trucks" submitted for the degree of Doctor of Philosophy in the specialty 6D070700 - "Mining"

Assessment of the current state of the solved scientific or scientific-technical problem

The mining industry is the basis of the industrial potential of many countries and largely determines the economic performance of other industries.

Transportation of the mining mass in quarries is the most important link in a single technological process of mining. The main type of technological transport in the mining of minerals by the open method is road transport.

In modern conditions, one of the main tasks of any enterprise is to increase the efficiency of the transport process with minimal costs.

Improving the efficiency of road transport by optimizing the number of dump trucks, taking into account the influence of many operating factors and design improvements, can be achieved through intensification in various conditions and rational distribution of dump trucks along routes.

The solution of these problems will allow to achieve improvement of technical and operational performance of career vehicles, reduce transport costs, improve the environmental situation in the career.

The basis and initial data for the development of the topic

The basis for the development of the theme is the need and the need to improve the performance of mining dump trucks in difficult conditions Kacharsky career. In modern conditions of production one of the main tasks of any enterprise is to increase the efficiency of the transport process with minimal costs.

In the thesis, on the basis of the analysis of scientific and technical literature and the statistical data obtained at the quarries, initial data were taken for the development of the thesis topic.

Justification of the need for this research work.

The tendency of a constant increase in the carrying capacity of motor vehicles leads to the expansion of its effective use. At the same time, the growth of the depth of quarries complicates the conditions for the exploitation of motor vehicles and imposes increased requirements on its reliability, which is determined, in particular, by the durability of the metal constructions of dump trucks.

The need to perform this research work is dictated by the availability of opportunities and the need to improve the efficiency of mining dump trucks by establishing analytical dependencies of the influence of operating factors on the performance of dump trucks and developing a complex of loading dump trucks to significantly increase the longevity of metal structures of load-carrying dump trucks nodes.

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Information on the planned scientific and technical level of development, on patent research and conclusions from them

The analysis of scientific and technical literature on the effective operation of heavy-duty mining vehicles, conducted research in the conditions of SSGPO Kacharsky open-cast mine and KazMinerals Open Company Aktogay open-cast mine on the use of road transport was conducted.

In carrying out the work, an integrated research method was used, including analysis and scientific synthesis of scientific and technical information, statistical processing of operational data of dump trucks, finite element modeling, solid modeling, use of digitized data of a dump truck state monitoring system.

Based on the analysis of the research, the effectiveness of the use of new technical solutions aimed at improving the performance of career road transport is considered. The thesis presents the results of the scientific analysis of the current state of the scientific and technical problem and the content of the results obtained to improve the performance of excavator-automotive complexes. On the topic of the thesis filed an application for an invention which is under review.

In the dissertation, it is planned to optimize the quality of operation of dump trucks by reducing loading time, waiting for loading and reducing downtime for repairing metal dump trucks.

Information about the metrological support of the thesis.

Studies on the topic of the thesis were carried out using the reporting data of on-board computers of open-pit dump trucks of the ATC of the Kacharsky career of SSGPO JSC and the career of Aktogai KazMinerals LLP. The equipment was equipped with a measuring and fixing complex based on GPS navigation (RacelogicV-boxVB2SX5 S / n 009697). The normal measurement frequency is 5 Hz (5 times per second). Such a complex with great accuracy makes it possible to determine: the speed of movement of dump trucks, time, distance traveled, the height of the position relative to sea level, the trajectory of movement, all types of accelerations, etc. In the career of AktogayKaz Minerals LLP used a Jigsaw program that tracks, keeps records and compiles reports of high-frequency

components through GPS navigation. Voltages in the suspensions were recorded through sensors, records were retrieved using the VIMS software.

Relevance of the topic

The achievement of maximum efficiency of the excavator-automobile complex (EAC) is considered as a unified system related to the mining, climatic and organizational conditions of a particular mining enterprise.

During the operation of dump trucks, the most dangerous, from the point of view of crack formation, are the dynamic loads that occur during the movement of the vehicle on the quarry roads and during its excavator loading.

Consideration of these issues in the complex will improve the performance of career vehicles, reduce transportation costs, and as a result, reduce the cost of transportation of the mining mass and obtain an economic effect with minimum capital investment. Despite the considerable number of papers devoted to the issues at hand, some problems have so far remained unresolved. This is mainly due to the fact that currently used methods for modeling and managing road haulage were created on the basis of describing them as a local object, with preference being given to linear models. An integrated approach to this problem expands the possibilities of finding alternative solutions and ways to improve the efficiency of freight transportation in open pits, which predetermines the relevance of the research topic.

The novelty of the topic is to establish new patterns of influence of technical and operational factors on the performance of mining vehicles and the development of predictive estimates of the stress-strain state of durability and survivability of metal dump trucks.

Scientific novelty of research:

1. The vector of optimal parameters of rational consolidation of the available number of dump trucks of various types to excavators, providing minimal time loss, has been established.

2. A new complex for loading has been developed, containing telescopic hydraulic jacks of a corresponding capacity, which are hinged on the body of the dump truck, which make it possible to increase the efficiency of the excavator-automobile complex with the existing vehicle fleet.

3. The complex dependences of the performance of dump trucks on the distance of transportation, speed of movement and time spent on the operations of loading and unloading the dump truck, the approach for loading, unloading, waiting for loading have been established.

4. On the basis of the research, a rational structure of the fleet of trucks was proposed, which allows to optimize the entire system of transportation of rock mass by road, as well as optimize the parameters of the excavator loading of dump trucks, which allows increasing the life of tires by 1.5-2 times, and supporting metal structures of the dump truck in 1, 5-2.5 times.

Communication work with other research projects

The work was performed as part of Lot No. 2 of the project "Justification of the expediency of switching to a combined road-conveyor-rail mode of transport and approbation of the safe, intensive development of work areas along steep sides

using excavator-car complexes at the Kachar open-cast mine of SSGPO JSC” / 20 dated October 19, 2017, concluded with the Sokolovsk-Sarbai Mining and Processing Production Association Joint-Stock Company within the limits of financing for 2017-2019.

The purpose of the research is to increase the efficiency of the use of open-pit motor transport by improving the performance indicators of open-pit dump trucks.

The object of the study is intra-career road transport.

The subject of the research is the process and operating conditions of the technological park of the open pit mine.

The objectives of the study, their place in the performance of research work in general:

- a theoretical study and substantiation of the influence of the operational and organizational conditions of the mine on the performance of dump trucks;
- experimental determination of the main characteristics of the quarry cargo flows, estimation of the theoretical and actual time of the voyage, identification of the downtime of dump trucks in the Kachar open-pit mines;
- development of technologies for determining the parameters of static and dynamic loading of metal structures of mining dump trucks in the process of loading the shipped exploded rock mass using modeling;
- development of a technique for optimizing the transportation of the mining mass and the composition of the fleet of dump trucks, taking into account the technological parameters of the quarry, durability and survivability of the metal structures of dump trucks when loading the rock mass.

The tasks assigned are consistent and logical, they determine the internal unity of the research work as a whole.

Methodological base of scientific research

The main methods of research and analysis used in the performance of the thesis are:

- method of regression and correlation analysis;
- statistical analysis of operational data;
- construction of graphical dependencies in Microsoft Excel;
- modeling the stress-strain state of a dump truck using the Autodesk Inventor Professional 2018 software;
- studies of the dynamics of the dump truck loading process in the Universal Mechanism program.

Provisions for the defense:

- increasing the efficiency of the excavator-car complex of the open pit is possible by comprehensively taking into account the influence of various technical and operational factors and the durability of load-carrying structures of dump trucks;

- it was established for the first time that it is possible to increase productivity of an excavator-automobile complex by 15-20% with lump-load cargo from 0.6 to 0.8 m optimizing loading processes of low-capacity dump trucks with

retractable supports when working together with excavators with a large bucket capacity;

- regularities of changes in dynamic and static loads negatively affecting the durability of metal structures of dump trucks, it is advisable to install based on the results of modeling the loading of rock mass in dump trucks with excavators with different bucket capacity using the Universal Mechanism software;

- in real conditions of existing quarries, the voltage of metal structures in the process of loading dump trucks exceeds the allowable by 30-40%, and their span is 2-2.5 times higher than the fatigue limit.

Publications and approbation of work

According to the results of the dissertation, 11 published works were published, including:

- 2 articles in journals included in the Scopus database (Transport Problems Poland, Gliwice 2016, ISSN 1896-0596 IF 0.265; International Journal of Engineering and Technology; United Arab Emirates, 2017, ISSN 2227-524X IF 0.08);

- 4 articles in journals recommended by the Committee on the Control of Education and Science of the Ministry of Education of the Republic of Kazakhstan;

The main provisions and the results of research on the thesis were reported and received approval at international scientific conferences:

- International scientific-practical conference "Exploration oil and gas business in the twenty-first century: technology, science, education," KazNRTU named after KI Satpayev Almaty 2016;

- International scientific-practical conference "Mining and Petroleum Electromechanics" -2016 ", Russia, Perm, 2016;

- International scientific-practical conference "Theory and practice of mining, processing and use of natural stone" -2017, Russia, Magnitogorsk;

- "VII International symposium of younger searchers" Transport problems Katowice, Poland 2017;

- "IX International conference" Transport problems Katowice, Poland 2017

According to the research results, an application for the invention of the Republic of Kazakhstan was submitted on the topic "Method of loading rock mass into dump trucks and a complex of devices for loading" No. 2018 / 0090.1 of February 8, 2018, confirmed by a positive result of formal expertise.

The scope and structure of the work. The thesis work consists of introduction, four sections, conclusion, list of references and applications. The volume of the thesis is 131 typewritten pages, 10 tables, 60 figures, references including 104 titles and 5 appendices.

The main content of the work

For the study of ways to improve the efficiency of the EAC, the conditions of the Kachar career have been adopted. The study of the influence of operational factors on the performance of the automotive transport fleet of KazMinerals Aktogai and Kacharsky, through the processing of statistical data, made it possible to identify the main factors affecting the operation of vehicles:

- distance of transportation of the rock mass;
- truck load capacity;
- movement speed;
- execution time of loading and unloading operations.

To study the dependence of productivity on the above factors, we used the methods of correlation and regression analyzes.

As a result of the research, dependencies of the performance of dump trucks on the distance of transportation, speed of movement and time spent on carrying out the operations of loading and unloading a truck, approaching for loading, unloading, waiting for loading (time of operation) were established.

As a result of the processing of statistical data obtained directly from the places of operation of road-haulage vehicles, graphical dependencies of changes in shift performance on loading-unloading operations for various types of dump trucks were constructed. Graphic images of dependencies were built using Microsoft Excel and are presented in Figure 1.

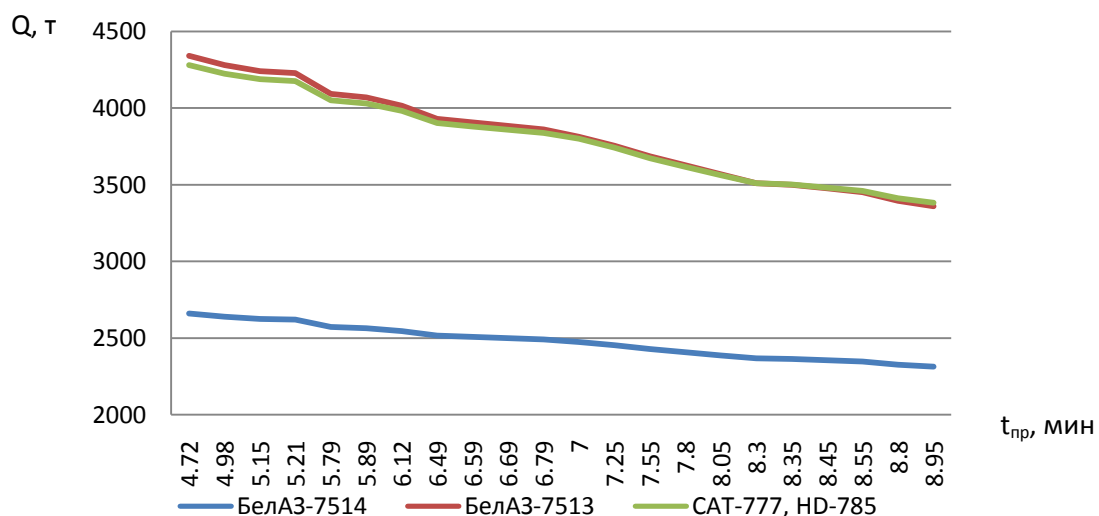


Figure 1. Graph of performance dump trucks from the time of loading and unloading operations

The analysis of graphical dependences showed the linearity of the correlation dependence of the performance of the dump truck on the time of loading and unloading operations.

Regression models of the dependence of the performance of dump trucks on the time of loading and unloading operations are represented by formulas 1-4:

$$Q_{\text{БелАЗ-7514}} = -81,97t_{\text{опер}} + 3047,471, \quad (1)$$

$$Q^{\text{БелАЗ-7513}} = -232t_{\text{опер}} + 5435,9, \quad (2)$$

$$Q^{\text{CAT-777}} = -213,64t_{\text{опер}} + 5288,91, \quad (3)$$

$$Q^{\text{НД-785}} = -213,64t_{\text{опер}} + 5288,91, \quad (4)$$

Q – dump truck performance;

$t_{\text{опер}}$ – the time spent on operations loading dump truck unloading, approach for loading, unloading, waiting for loading, min.

An analysis of the regression models obtained showed that with an increase in the time spent on carrying out the operations of loading and unloading a dump truck, approach for loading, unloading, waiting for loading, the performance of dump trucks decreases. Changing the time for loading and unloading operations allows you to determine the performance of the truck at a certain value of this factor.

A graphic view of the dependencies of the joint influence of the transportation distance of the mining mass and time on loading and unloading operations on the performance of the dump truck is shown in Figures 2, 3, 4.

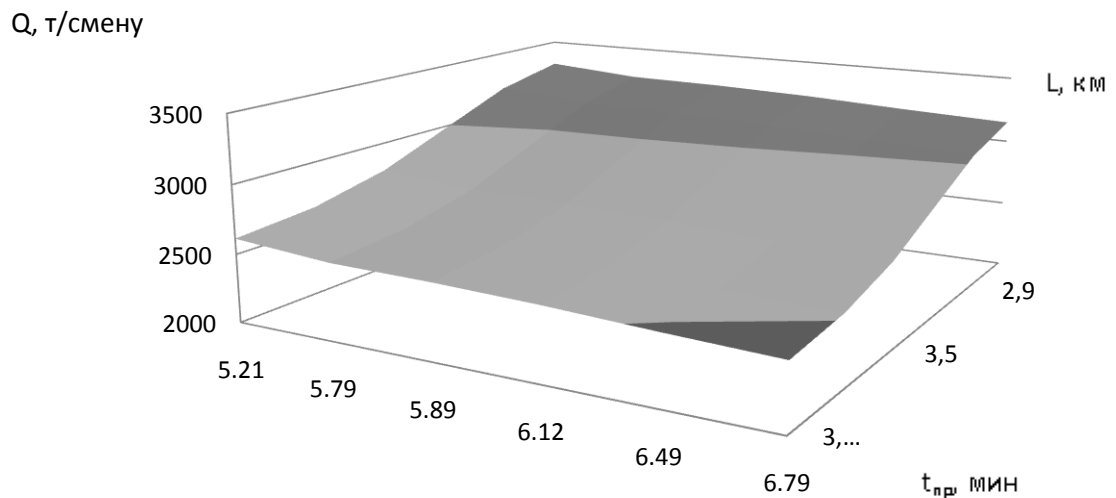


Figure 2 - Graphic view of the dependence of the performance of the dump truck BelAZ – 75145 on the distance of transportation and the time of loading and unloading operations

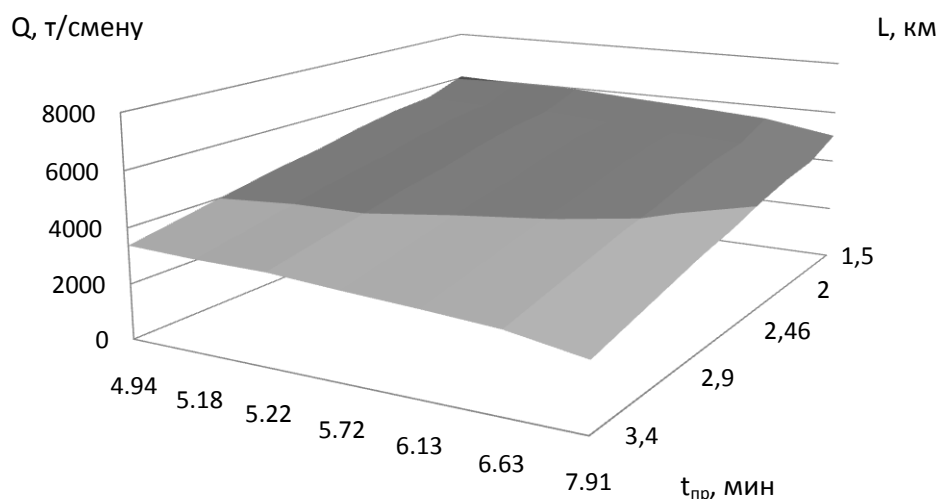


Figure 4 - Graphic view of the dependence of the performance of CAT-777, ND-785 dump trucks on the distance of transportation and time of loading and unloading operations

After determining and substituting the parameters of the regression equation, the mathematical models of the joint influence of the distance of transportation and time on other operations on the performance of the dump truck took the form (5, 6, 7, 8):

$$Q_{\text{БелАз-7514}} = 5676,712 - 682L - 97t_{\text{оп}}, \quad (5)$$

$$Q_{\text{БелАз-7513}} = 9888 - 1415L - 344t_{\text{оп}}, \quad (6)$$

$$Q_{\text{CAT-777}} = 6115,74 - 671L - 136t_{\text{оп}}, \quad (7)$$

$$Q_{\text{НД-785}} = 6115,74 - 671L - 136t_{\text{оп}}. \quad (8)$$

The study of the models obtained showed an inverse dependence of the performance of the dump truck on the distance of transportation and the time spent on loading and unloading operations: with an increase in the factors considered, there is a decrease in the performance of dump trucks.

One of the indicators of the intensity of operation of transport vehicles are vnutrismennyh downtime and downtime during the voyage, caused by a combination of reasons, the main of which are organizational and technical. To reduce downtime and related losses in traffic volumes, that is, more complete use of the calendar fund of time loading and transport vehicles in modern conditions, apply monitoring system of operation of mining equipment.

The full cycle of the movement was 4960 m; Cycle time - 17min 30 s .; The average speed of movement with the load is 15.6 km / h; maximum speed with load - 29.8 km / h; average speed without load - 19.95 km / h; maximum speed without load - 32.6 km / h; average slope of the track - 8.45%.

Passing along the highway, the controllers installed on the dump truck recorded a loss of time while waiting for loading, which can be seen in Figure 5 (in the figure, the green line is a timeline).

Idle zones are shown in the figure in sections 1, 2 and 3. At the same time, a simple dump truck in the first zone was 258 s, in the second zone - 88 s and in the third zone - 60 s. The presence of a large idle in the first zone is explained by the queue created at the loading point (Figure 5). The loss of time at the unloading point is insignificant, since an unloading platform of optimal width was formed there. Downtime at the download point can be explained by the following reasons. When determining the fleet of dump trucks, quite often the number of cars is not an integer, but a fractional one. At the same time, it is necessary to round off the number of cars in a larger direction, which leads to the formation of a queue and an idle dump truck, or a smaller one, while the excavator is idle.

The results of the analysis of statistical data and conducted studies show that the loss of time of one dump truck in anticipation of loading by an excavator per ride can vary over a wide range and reaches 10 minutes per load, and an average of 498 hours per year. As a result of machine downtime, the total volumes of the exported mining mass are reduced, which, as a result, leads to significant economic losses for the mining enterprise as a whole, or to a lower number of dump trucks, while the excavator is idle.

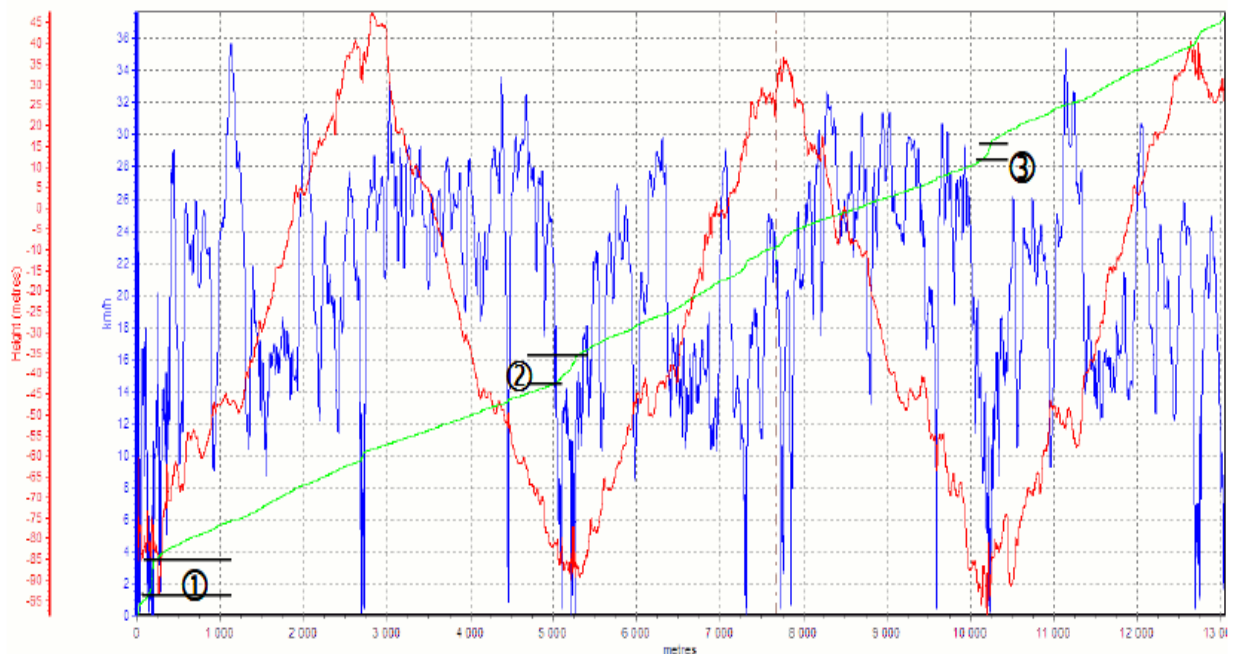


Figure 5 The dependence of speed, elevation and time when driving on Kacharsky open-pit

Based on the results of simulation, a schedule of idle trucks for various types of machines sent to one excavator was constructed, as well as a schedule of total idle times for a diverse type of truck fleet for various values of the proportion of heavy trucks.

Analyzing the data of the graphs in Figure 5, we can draw the following conclusions: first, the loss of dump trucks waiting for loading tend to zero, that is, the same type of park structure; secondly, in the real values of the indicator from 0 to 1 there is a rational ratio of the number of dump trucks of various types, in which their work with a specific type of excavator is characterized by the minimum total loss of all dump trucks in anticipation of loading.

In general, the model of the formation of the optimal fixing of dump trucks of different capacity for an excavator can be represented as follows:

$$s(t_{o\mathcal{H}}^a) = \{A_{\mathcal{M}}, \eta_{\mathcal{M}}\} \longrightarrow Opt, \quad (9)$$

where $s(t_{o\mathcal{H}}^a)$ is the vector of optimal parameters for fixing dump trucks behind an excavator, ensuring minimal time losses $t_{o\mathcal{H}}^a$;

$A_{\mathcal{M}}$ - the number of dump trucks on the route.

However, the optimal solution according to equation (9) is not always achievable in practice, since the required number of each type of dump trucks may not be available for the enterprise. Therefore, this task may have limitations on the fleet structure and boils down to the search for rational fixing of dump trucks to excavators in order to minimize.

The task of rationally fixing the existing number of A_{mij} dump trucks of various types to j and excavators is formulated as follows: it is necessary to find such a vector s^* from the set of ratios of dump truck fleet structure S so that the total loss of time for loading all dump trucks to the excavator $T_{o\mathcal{H}}^{*a} = F(s^*, t_{o\mathcal{H}}^a(s^*))$, was less than $T_{o\mathcal{H}}^a = F(s, t_{o\mathcal{H}}^a(s))$ for any other $s \in S$:

$$T_{o\mathcal{H}}^{*a} = F(s^*, t_{o\mathcal{H}}^a(s^*)) \longrightarrow \min, \quad \sum_{j=1}^m A_{mij} \leq A_{\mathcal{M}}. \quad (10)$$

A redistribution of dump trucks was made for the Kacharsky open-pit mine of Sokolovsko-Sarbayskoye Mining and Processing Production Association JSC: 8 different types of excavators (ECG – 8, SAT – 993K, Hitachi 3600, Hitachi 5500) work in the open pit with motor transport; The fleet of dump trucks consists of 35 vehicles of various types (BelAZ – 7513, BelAZ – 7514, SAT – 777 and Hitachi EN 3500), which carry ore to two transshipment warehouses with different transportation distances. The planned interval of the movement I_{pl} is set according to the value of t_{π} for CAT – 777. All the necessary indicators were calculated and a solution was found to rationally fix the dump trucks to the excavators. The resulting solution is a rational of the permissible, but its implementation is

associated with the possible total outage of dump trucks in the amount of 11.1 minutes for one cycle of turnover of all vehicles. It was also established that the solution obtained with the existing structure of the fleet of samostvals allows periodic occurrence of downtime due to the lack of machines. To eliminate excavator downtime, it was recommended to increase the number of dump trucks in the SAT – 777 open pit by 15 units. According to estimates, the overall economic effect is due to reduction of downtime during loading operations and reduction of economic losses from the unloaded mining mass at the enterprises of Sokolovsko-Sarbayaskoe Mining and Processing Plant Production Association "is 203334 thousand tenge per year.

Analysis of the structure of the park of open-pit dump trucks operated at a quarry showed that a significant part of the repair time accounted for repairs of the metal structures of the frames and suspensions of dump trucks.

Figure 7 shows the structure of downtime of the fleet of dump trucks, which includes 15 vehicles of the BelAZ-75131 brand and 20 vehicles of various brands of BeLAZ-7555, BelAZ-7514, CAT-777 and Hitachi EN 3500 operated in a quarry for 2017. The structure of the park's downtime was obtained from the results of data processing by a specialized program for recording the operation of mining and transport equipment developed in the section.

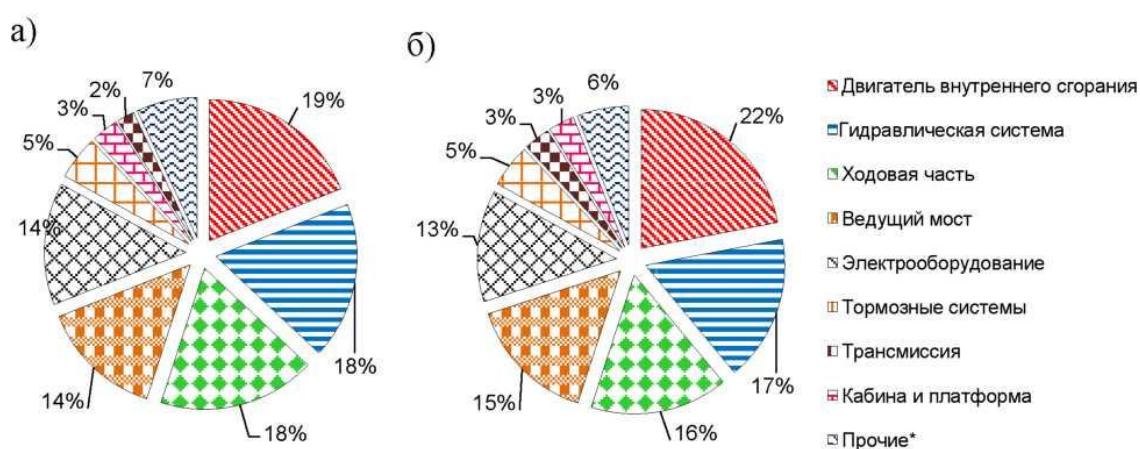


Figure 7 - Structure of downtime of the fleet of dump trucks at Kacharskomer for 2017 a) distribution of failures b) downtime for repairs

As can be seen from the figure, 18% of the time of repairs falls on the undercarriage, moreover, in the structure of other repairs, up to a quarter of the time, welding works take place. In general, the repair of metal accounts for up to 25% of the time from all repairs.

The main reason for failure of metal structures of open pit dumps are cracks formed in the most loaded areas of the supporting structures.

In relation to the designs of BelAZ dump trucks, mathematical models have been developed that describe the oscillations of the elements of a dump truck when it is loaded. For the calculation we will use a simplified model of the dynamics of a car with 4 degrees of freedom in accordance with the article. This scheme is shown in Fig. 8. For this scheme, the following axis arrangement is chosen: let the X axis be directed forward in the vehicle's direction of travel, the Y axis in the transverse direction, and the Z axis in the vertical direction. According to this scheme, the bulk of the car is concentrated in the body m , which can be reloaded by the transported cargo (for example, overburden) and which can fall in parts from different heights, while loading a dump truck can be simulated. The specified mass m can have vertical displacements, as well as the possibility of rotation around the Y axis.

Based on the design scheme (Figure 8), the Universal Mechanism software package was used to study the dynamics problems. The program is designed to automate the process of studying mechanical objects that can be represented by a system of absolutely rigid or elastic bodies, connected by means of kinematic and force elements. One of the possible ways to reduce the dynamic loads on the supporting structures of a dump truck may be the use of hydraulic jacks that take up the load from the rock mass falling from the bucket and transmit it directly to the soil of the ground surface. After unloading the bucket, the jacks are lowered, smoothly transferring the entire load to the supporting structures of the dump truck.

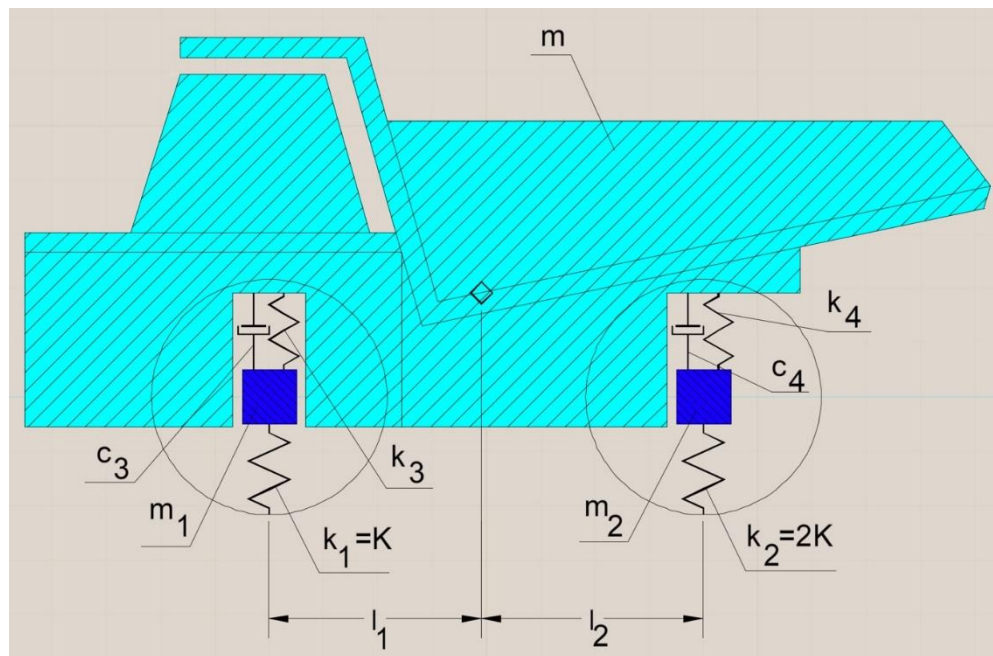


Figure 8 Calculation diagram of the dump truck BelAZ 7555B

The process of creating a model dump truck was built as follows:

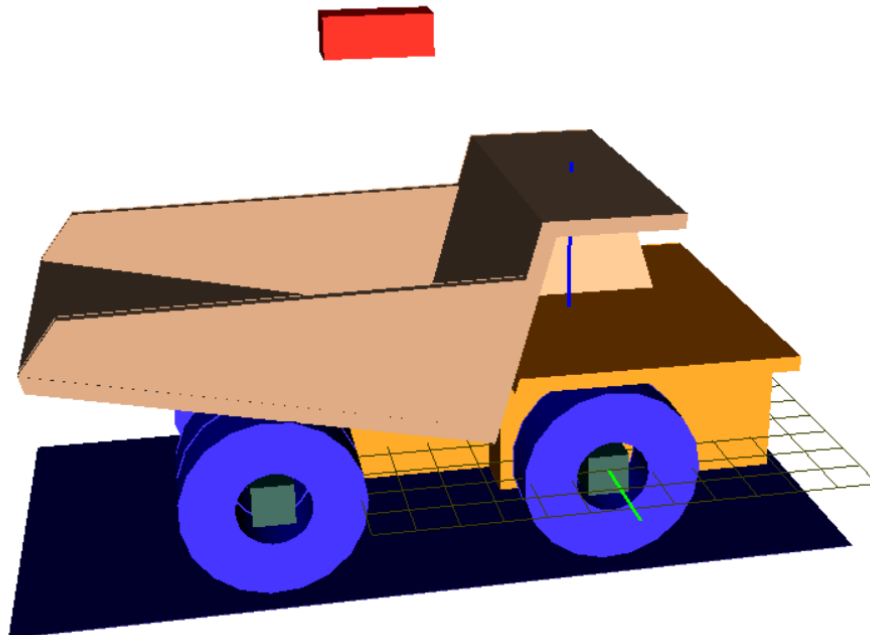
- description of the dump truck model: the graphic images of the model, the body were created, the data were asked as hinges, bipolar forces, contact forces;

- synthesis of the equations of motion of the model: after the model is completely created in the UMSimulation program, the initial conditions of the coordinates are calculated relative to the equilibrium position of the dump truck.

Figure 9 shows the design model with a suspended mass. The design and quantitative parameters of the suspension are one of the most important determining factors in the formation of loads on the supporting frames. The suspension transforms the random process of irregularities of the autolog and the corresponding reactive random process of loading into a random process directly perceived by the frame in the attachment points of the suspension. Dynamic processes are reduced to the description of low-frequency oscillations of the main nodes of the dump truck (Figure 10).

The use of the UM dynamic analysis module for calculating the dynamic loads of the state of the elements of the supporting steel structures of mining dump trucks allowed to theoretically determine the dynamic load value in the process of excavator loading. The analysis of the process of oscillations of bearing metal structures made it possible to determine the number of loading cycles that the stresses obtained experimentally differ from those obtained by the method of finite element and dynamic modeling by 10–15%. This is explained by the fact that when creating the computational and computer model a number of assumptions and omissions were adopted.

a)



b)

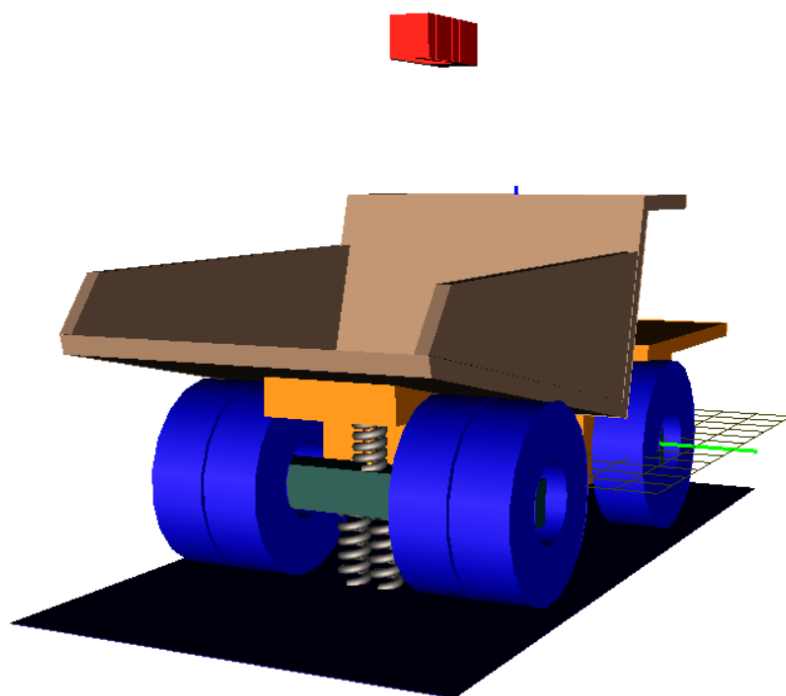
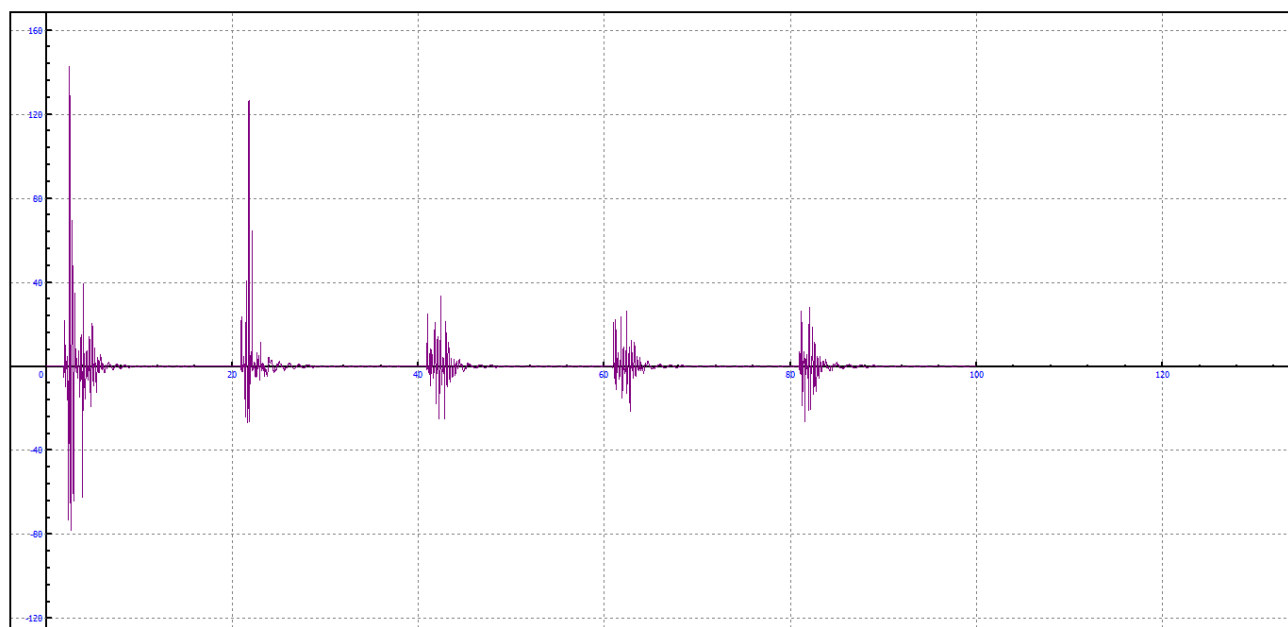


Figure 9 Model dump truck BelAZ 7555V to study the dynamics of the loading process

P (kN)



t(c)

Figure 10 Front axle loads during loading

Table 1 shows the results of the calculation of the force in the dump truck hanger during the loading process with EKG-10 and EKG 12.5 excavators.

Table 1 Dynamic loads in the process of loading a dump truck

	Type of excavator	№	Bucket Dynamic force kN	
			Front suspension	Rear suspension
	EKG- 10	1	135	138
		2	134	125
		3	20	38
		4	28	28
		5	40	26
	EKG -12,5	1	150	145
		2	144	139
		3	60	38

To determine the stress-strain state under the action of constant forces applied to the system and the design of the allowable stresses with supports and without supports, a static calculation of the VAT of the frame of the dump truck BelAZ-7555 was carried out.

Figure 11 shows the most intense areas acting on the frame when loading the rock mass into the dump truck body.

The results of the simulation of the VAT frame with and without supports are given in Table 2. According to the calculated data, it can be said that the use of supports will reduce the stresses in the frame.

Table 2 Voltage in the frame of the dump truck on the order of loading

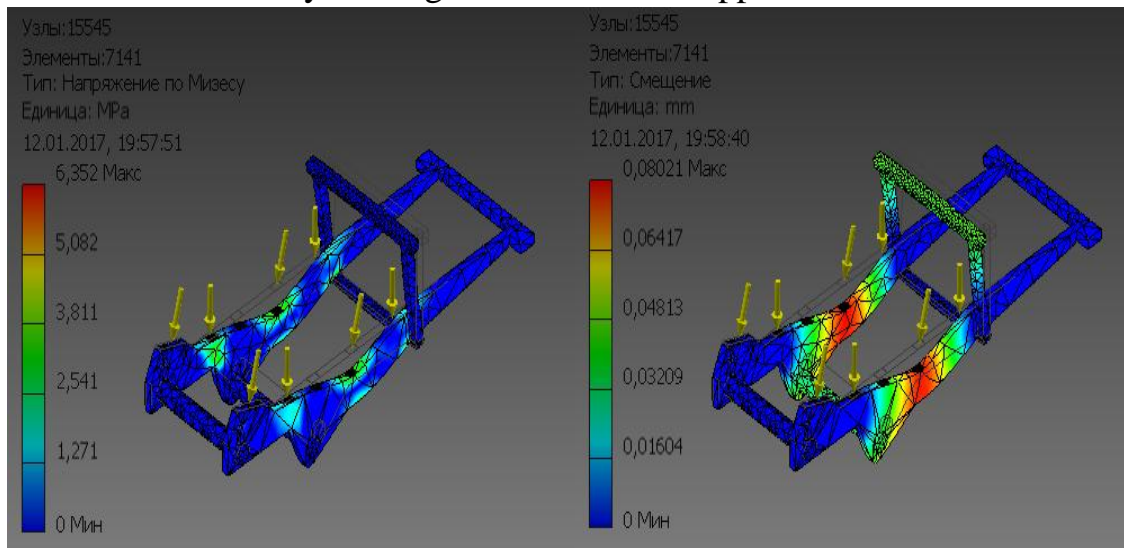
Type of Excavator	№	Stress, MPa		Mixing frame (mm)	
		Without supports	With supports	Without supports	With supports
EKG-12,5	1	1,3	0,8	0,01	0,01
	2	1,5	0,3	0,03	0,008
	3	2,9	0	0,07	0,01
	4	3,5	0	0,08	0,02
	5	7,4	0	0,14	0,02

To eliminate the occurrence of frame defects occurring in the most loaded sections of load-bearing metal structures when loading rocks and reducing dynamic loads when using high-capacity excavators in combination with light-duty dump trucks, it is proposed to install outboard supports on the body of the dump truck that will reduce these dynamic loads thereby increasing the performance of excavator automotive complex.

The main obstacle to the use of high-performance low-capacity mining dump trucks in combination with powerful and efficient excavators are dynamic loads.

From the data of the frame SSS without supports, the most stressed units are determined, the most loaded sections of the supporting metalwork, in the case of their static loading, for the frame are longitudinal spars in the section between the 2nd and 3rd cross member; subframe, 3rd cross.

Fifth body loading bucket without supports



Fifth body loading bucket with supports

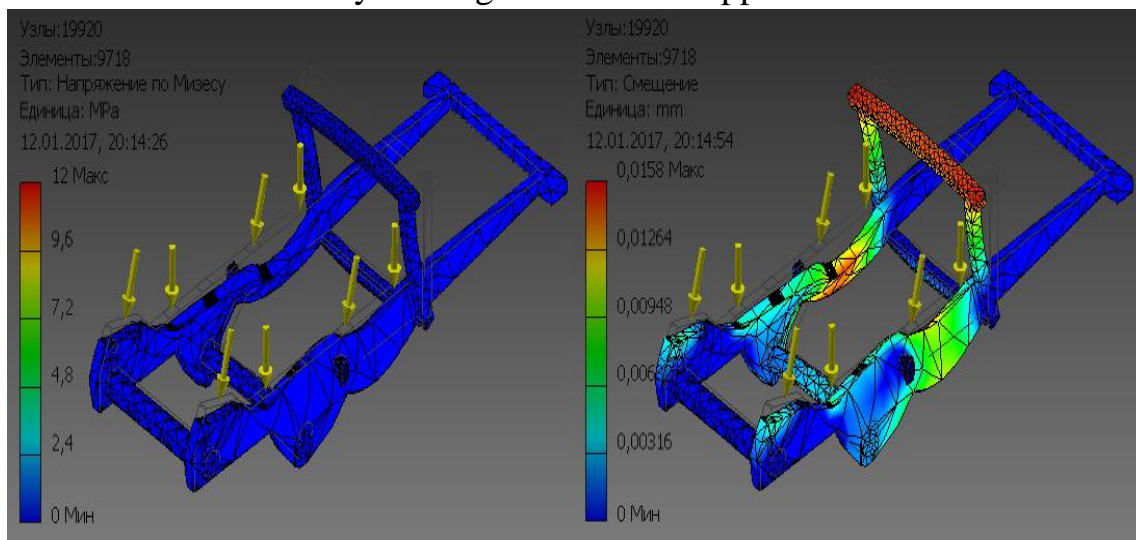


Figure - 11 SSS of a frame when loading mountain weight in a dump truck body without support and with support

The method includes the device supporting the supporting hydraulic telescopic jacks on the body of the dump truck, which in the process of loading

rely directly on the soil of the earthen surface of the loading platform and perceive the load from the mountain mass falling from the excavator bucket. After loading the body of the dump truck, the jacks are turned off, transferring the entire load to the supporting structures of the dump truck. (Figure 12-13)

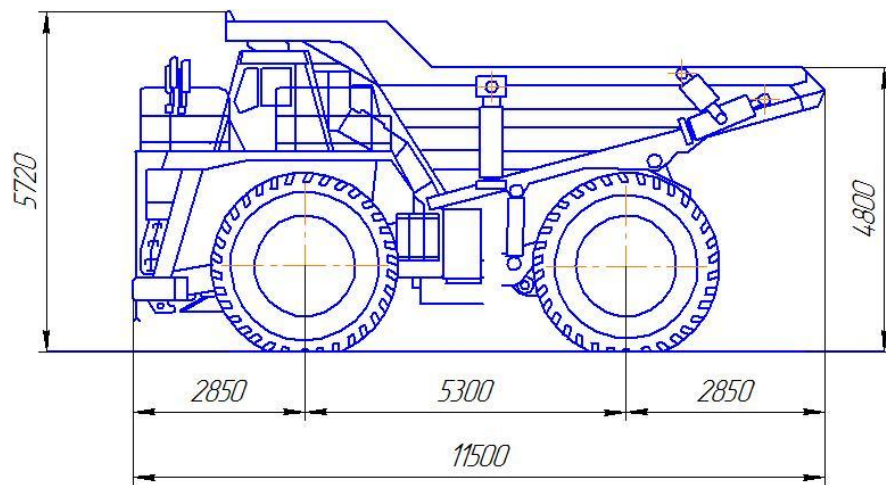


Figure 12 - General view of the complex for the implementation of the loading, where the hydraulic jacks are depicted in the initial (inoperative, transport) position

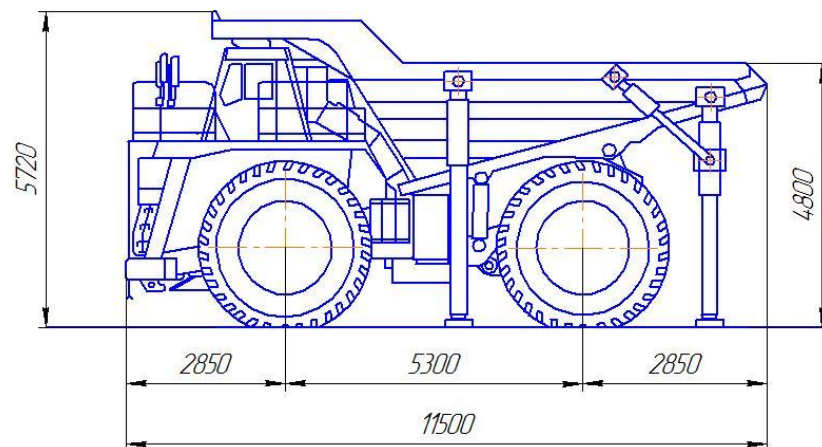


Figure 13 - General view of the device loading trucks in the working position.

Such a constructive solution will reduce the load on the supporting structures of the dump truck to increase the reliability of their work. As a result of reducing the loads, it becomes possible to reduce the cross sections of the support beams, reduce the metal consumption, the tare factor and the cost of the car.

In addition, the use of supporting jacks will allow dump trucks to work in conjunction with high-power excavators. The work of small-capacity dump trucks with high-capacity excavators will reduce the volume of mining preparatory work and the capital costs of creating the entire transport infrastructure of the quarry

Conclusion

The performed studies allowed us to formulate the following main results of the work.

1. Single-factor and multifactor models of the influence of operational factors on productivity for each type of mining dump trucks are proposed, which allow to operate motor transport at the mining enterprise.

2. The dependences of the influence of operating factors on the performance of dump trucks have been established, which allow, with a different-type structure of the fleet of dump trucks, select such a combination of dump trucks with different technical characteristics for which each dump truck will be minimal for each excavator.

3. Recommended computer computational models for the process of loading a dump truck with a blasted rock mass, which make it possible to calculate the elements of the load-bearing metal structures of the BelAZ-7555V dump truck when loaded with an EKG-12.5, EKG-10 excavator. It has been established that the main obstacle to the use of high-performance low-capacity mining dump trucks in combination with powerful excavators are dynamic forces arising during loading of the rock mass, which exceed the allowable by 30-40%, and the magnitude of the stresses arising in this case exceeds the endurance limit of 2-2.5 times.

4. To determine the stress-strain state of the dump truck frame and to evaluate the structure for allowable stresses without supports, a static calculation of the VAT of the BelAZ-7555 dump truck frame was made and the voltage was removed when the additional supports were used and the mixing was reduced.

5. The developed complex for loading, containing articulated telescopic jacks of a corresponding capacity, hinged on the body of the dump truck, allows to increase the efficiency of the EAK, thereby increasing the productivity of the quarry compared to the existing transport vehicle composition by 15-20% and get the estimated annual economic effect, only for Kachar open-pit more than 230 million tenge.