Perfection of constructive schemes of drive of running equipment of a career motor transport

Yuliya Lagunova[1,2,*], *Igor* Ivanov[2] , and *Sergey* Horoshavin[1,2]

[1] Ural Federal University named after the first President of Russia BN. Yeltsin, 19, Mira St., Yekaterinburg, 620002, Russia
[2] Ural State Mining University, 30, Kuibyshev St., Yekaterinburg, 620144, Russia

Abstract. A comparative analysis of the main types of power equipment and transmissions of drives for running equipment for quarry vehicles was performed. The interrelations of the constructive schemes of drives of running equipment with traction class and carrying capacity of quarry vehicles are shown. Dependence of diesel engine power on air temperature and atmospheric pressure is revealed. An analysis of design schemes of transmissions of running equipment is given. Based on the evaluation of the design schemes, the directions for improving the drives of running equipment for quarry vehicles are given. As a result of the analysis of various types of drives and power equipment, it was revealed that when assembling the base machine, an individual approach should be applied.

1 Introduction

The development of an open method for the development of mineral deposits is accompanied by an increase in the scale of production and volumes of transportation of rock mass, an increase in the depth of quarries, an increase in the share of semi-rocky and rocky rocks, and the complication of mining technical conditions for mining equipment.

The manifestation of negative trends in the mining sectors of the economy causes the growth of material and energy costs in the extraction of minerals, and the specific weight of the costs of transporting the mountain mass increases at an accelerating rate. Currently, the share of "transportation" costs reaches 50-60%, and at a depth of the quarry 250 m and more - 65-70%.

In connection with the current situation, the problem of increasing the efficiency of mining equipment operation due to the creation of new technical level machines with reduced material and energy consumption and environmentally friendly is becoming particularly topical.

2 Purpose and objectives of the study

The purpose of the research is to increase the efficiency of functioning of a career motor transport.

* Corresponding author: yu.lagunova@mail.ru

Objectives of the study:

- Analysis of design schemes and technical solutions for driving equipment for quarry vehicles;
- identification of trends in the development of structural schemes of structural elements of drives;
- justification of directions for improvement of drives for running equipment for quarry vehicles.

3 Solving research problems

The object of the research is the constructive schemes of the drives of running equipment for quarry vehicles.

The subject of the study is the establishment of interrelations between the constructive scheme of drive of running equipment and traction class (load-carrying capacity) of career vehicles.

Methods of research - analysis of the results of scientific research on drives of road vehicles, analysis of inventions and utility models devoted to running equipment for quarry transport (Figure 1).

Illustrations on the same scale

COMPARISON OF THE PARAMETERS OF THE LARGEST DUMPERS OF THE WORLD

	БЕЛАЗ 75710	CATERPILLAR 797F	LIEBHERR 282B	BUCYRUS MT6300AC
Carrying, t	450	363	363	363
Engine	2 x MTU DD 16V4000	Cat C175-20 ACERT	DDC/MTU 20V4000	DDC/MTU 20V4000
Cylinder	2 x 16	20	20	20
Engine power, hp (kW)	2 x 2330 (1715)	4055 (2983)	3650 (2720)	3650 (2720)
Tires	59/80R63	59/80R63	59/80R63	59/80R63
Full weight with load, t	810	623,7	596,9	603,3
Maximum speed, km / h	64	68	64	64
Fuel tank capacity, l	2 x 2800	3785	4732	4920
DIMENSIONS				
Length, mm	20600	15090	15320	15570
Width, mm	9750	9530	9090	9700
Height, mm	8170	6530	7320	7920

Fig. 1. Parameters of BelAZ 75710 and its closest analogues [1-5].

In modern quarry dump trucks, primary diesel engines are mainly diesel engines, as well as gas turbine engines [1-5]. In addition, combined power equipment is being developed, for example, diesel-trolleys.

To increase the power of the diesel engine with the same dimensions and number of cylinders, a boost is used, i.e. Air supply to the cylinders under pressure created by a centrifugal compressor. At the same time, the power of the diesel increases by 40-50%, and the specific fuel consumption is reduced by 10-20%.

The power of the diesel depends on the air temperature and atmospheric pressure, since the latter affect the temperature of the coolant, the viscosity of the fuel and lubricating oils. Therefore, the power under given atmospheric conditions [6]

$$N_н = N_н \, pT_0/(p_0 T), \tag{1}$$

where N_H — is the rated power of the diesel engine under standard conditions, kW (standard temperature is T_0 = 288,5 K and barometric pressure p_0 - 101,5 kPa); *p* и *T* – are, respectively, barometric pressure, kPa, and air temperature, K, for specific conditions.

Thus, the power generated by the diesel engine decreases with increasing temperature (due to the increase in the coolant temperature) and with a decrease in pressure (due to insufficient charging of the cylinders with air and deterioration of cooling).

So when the temperature rises from -15 to +45 ° C, power is reduced by 7-9%, and when operating a dumper in a mountainous area, a 6% decrease in power occurs at a difference of 1000 m.

At present, a new family of M-150 and DM-185 engines has been developed by the Zvezda NPK manufacturing enterprise, commissioned by the Ministry of Industry and Trade of the Russian Federation. In terms of their functionality, fuel efficiency and environmental friendliness, they surpass industrial diesel engines of foreign manufacturers, have significant potential, and their life cycle will be more than 25 years [6].

The main features of the new engines are high specific power characteristics, low fuel consumption, compliance with EU requirements for emissions of harmful substances into the atmosphere.

Gas turbine engines (GTE) for heavy-duty trucks have high reliability, four times the resource, smaller size and weight than the corresponding diesel engines, are capable of operating on any type of fuel, have good starting qualities at low temperatures (down to -50 ° C). At the same time, they are more expensive and have a significantly lower efficiency [6].

Development and commissioning of electric transport is becoming an urgent task, especially in connection with the deepening of quarries. The use of diesel-trolley trucks allows to provide high speed of dump truck driving in trolley car mode, to shorten the time of cargo transportation and, ultimately, to reduce the number of dump trucks.

3.1 Analysis of structural schemes of transmissions of running equipment

In the drives of running equipment for quarry vehicles, hydromechanical and electromechanical transmissions are used.

Hydromechanical transmission is used at dump trucks with carrying capacity up to 200-250 tons. The main transmission units are a hydrotransformer and hydromechanical transmission. The torque converter provides automatic torque conversion of the engine depending on road resistance. Automatic hydromechanical transmission (Figure 2) allows you to select the optimal traction-speed mode of the dump truck movement, which facilitates the control of the vehicle and ensures traffic safety. The automatic transmission control system improves the performance characteristics of a career dump truck, increases the life and reliability by maintaining optimal operating conditions.

The transmission also includes a hydrodynamic retarder brake, which ensures the constant speed of the dump truck on descents without the use of wheel brakes, thereby increasing the safety of traffic in a complex road profile.

Electromechanical transmission is used for dump trucks of extra-large payload up to 450-500 tons. It consists of a generator of direct or alternating current and traction electric motors. The use of such a transmission allows individual drive of the wheels and the use of several axles as driving axles.

In dump trucks, the layout of the traction motor, the mechanical transmission (gear) and the brake mechanisms of the working and parking brake systems in the hub of the rear (driving) wheel, called "electric motor-wheel", is common. Sometimes some elements of the electromechanical system are partially removed from the wheel hub to improve cooling conditions, or fans are installed, for cooling in other situations, liquid cooling is done. You

can also use brushless motors, which partly solves the issue of heat removal, but it becomes more complex and expensive management system.

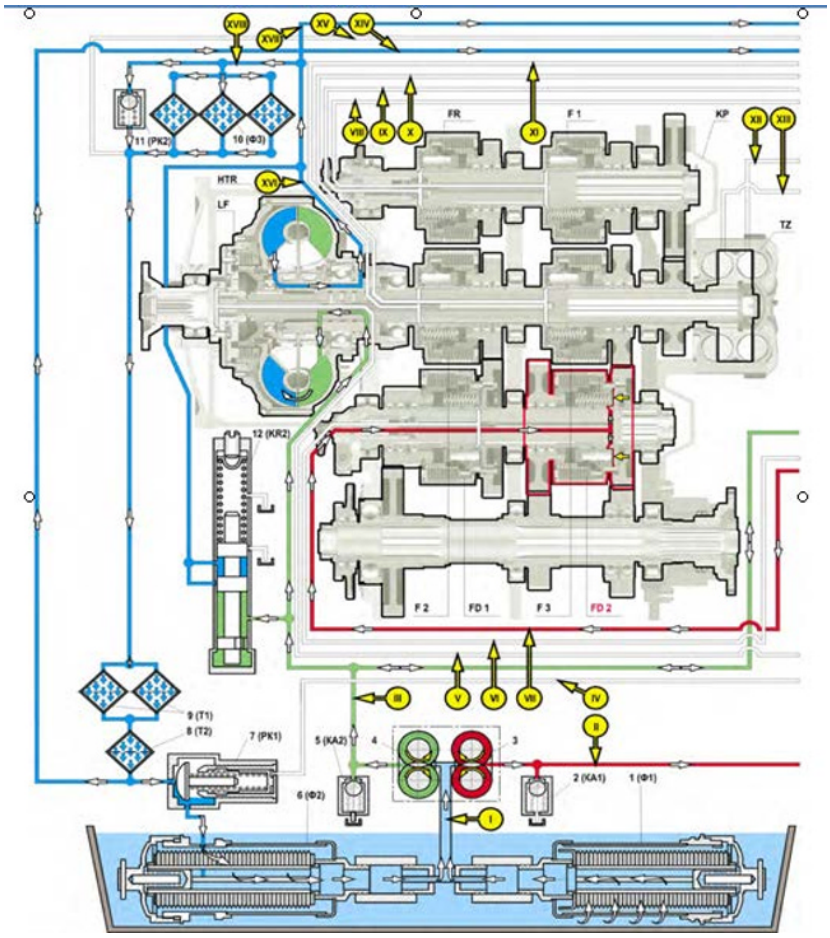

Fig. 2. Hydromechanical transfer of dump trucks of BelAZ 7555 series [7].

One of the promising areas is a system that allows you to accumulate energy generated by the generator and subsequently give it to power equipment in the required quantities.

Electric transmission makes it possible to significantly simplify the kinematic scheme of a dump truck in comparison with a mechanical and hydromechanical transmission.

BelAZ-7549 dump trucks used the most constructively simple DC electric transmission consisting of a direct current generator (D), traction electric motors (EDT) of direct current and a control system. Regulation of the electric drive is carried out by changing the excitation current of the generator and the traction motors.

BelAZ-75710 dump trucks use a hybrid system with four Siemens electric motors that are powered by two MTU DD 16V4000 diesel generators, each of which produces 2330 horsepower. BelAZ 75710 traction characteristics are presented in figure 3. When moving without load BelAZ 75710 uses one engine, both engines are used under load, which provides fuel economy when driving with an empty body.

Electromechanical transmission provides a mode of electrodynamic braking, in which the output circuit of the rectifier is connected to the excitation windings of traction motors.

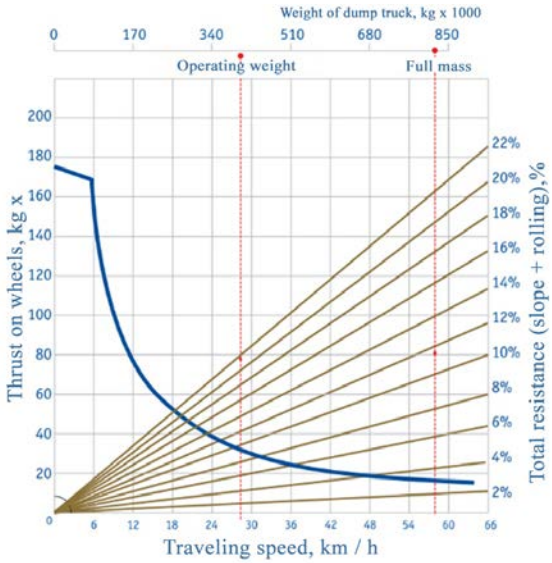

Fig. 3. Thage characteristic of the BelAZ 75710 dump trucks [7]

BelAZ-7521, BelAE-7513 dump trucks are equipped with an alternating-direct-current transmission. In this case, DC traction motors are powered from a synchronous alternator via a common semiconductor rectifier set for them. In principle, it is possible to install individual rectifiers, which allow the machine to be maintained if one of them fails. Dump trucks BelAZ-7550, BelAZ-7560, BelAZ-7570 of heavy load capacity are provided with EMT of alternating current.

As a result of the analysis of different types of drives and power equipment, it is revealed that when assembling the base machine, it is necessary to apply an individual approach and take into account the following parameters: load capacity of the dumper, climatic conditions of operation, road conditions on the quarry (length and magnitude of the elevation, roadway quality) type of fuel under certain conditions.

References

1. Ksenevich V.I., Career trolley transport and environmental issues. Mountain magazine. №**2**. 1998. P. 22-24
2. Stepuk OG, Zuyonok AS, Diesel-trolley transport BELAZ: prospects of use in mining, Mountain Journal, 2013. No. **1**. P. 52-55.
3. Potapov M.G. Quarry transport. Ed. 4 th, revised. and additional., 1980. 225 p.
4. Belaz 75710.https: //traktoramira.ru/stroitelnaya-tehnika/gruzoviki/belaz-75710.html#i-3.
5. Mariev PL, Kuleshov AA, Egorov A.E., Zyryanov I.V. Career motor transport: state and prospects. Science, 2004. 430 pp.
6. I.Yu. Ivanov, A.G. Popov, S.Yu. Brozovsky. Comparative analysis of power equipment and drives of mine dump trucks // Technological equipment for mining and oil and gas industry: Sat. works XVI International. scientific-techn. Conf. "Reading of the memory of VR Kubachek," 12-13 April, 2018, Yekaterinburg. Ekaterinburg: USMU, 2018. S. 45 - 49. (to be published)
7. Technical and operational characteristics of the products: reference book / OJSC BELAZ. Under the general editorship of AN Egorov. - Minsk: "Benstant", 2015, 496 p.