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RESEARCH OF THE MINE SHUTTLE CAR VS-30 DRIVE MODE

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ABSTRACT

The article presents the results of experimental investigations of the magnitude and nature of change loads drive of mine shuttle car VS-30 used to deliver ore to extraction chambers in potash mines. The design of program-recording complex "VATUR" developed by employees of the department "Mining Electrical Engineering" Perm National Research Polytechnic University. In the investigation of operating modes of the drive of self-propelled mine wagons were carried out measurements and recording the instantaneous values of voltage and current of electric motors, calculated values of active and apparent power consumed by the motor pump stations and bottom conveyors of mine shuttle car. Carried out investigations modes of operation and changing loads on the units and details of the tram drive. It is proved that the operation of electric motors of the mine shuttle cars increased characterized by a systematic overload. Outdated system controlling the rotational speed of shafts drive motor gives rise to considerable dynamic loads on components of mechanical transmissions for shuttle cars. Significant loss of time causing the reduction in technical performance longwall set of equipment of potash mines arises during the maneuvering operations and unloading ore from shuttle cars. Based on the analysis of the change of loading drives and statistics of dangerous failures were justified the technical solutions to improve the reliability of mine shuttle car. The recommendations to increase the efficiency of transporting potash in the longwall set of equipment, improving maneuverability of self-propelled cars and reduce downtime for unloading are given.

Keywords: potash ore, mine shuttle car, recording complex, loading drives, parameters operating mode.

INTRODUCTION

For companies engaged in the extraction of potash ore by underground methods, remain relevant task efficiency excavation and transporting machines, increasing the productivity and operational reliability; reduce material costs for the maintenance of efficiency of mining equipment. The solution of these problems is possible on the basis of studies of regime parameters of the process equipment; determine the amount and nature of changes in load acting on the engine and transmission components of mining machines, data analysis, according to statistics of emergency failures.

THE MAIN PART

Currently, the potash mines of the Russian Federation adopted a camera system mining seams using mechanized of combine complexes, which include heading-and-winning machines, transfer bunker and mine shuttle cars (MSC). The most widely used two-axle shuttle cars 5VS-15M (upgraded model 10VS-15) and three-axle wagons VS-30, manufactured by JSC "UGMK-Rudgormash" (Voronezh) carrying capacity 15 and 30 tons respectively. Shuttle cars are equipped with three-phase asynchronous motors AVT 15-4/6/12 (drive speed) and AVK 30/15 (drives pipeline and oil station) with a stepped variable speed rotor.

Highly maneuverable biaxial MSC have proved themselves when working with combines PC-8M and Ural-10A, but productivity is 2-3 times lower technical performance of modern heading-and-winning machines [1].

The high load capacity and power available shuttle cars VS-30, according to the JSC "Uralkaliy", cause an increase in the efficiency of the transportation of ore extraction chambers by 20-25% [2]. However, during the operation of the car VS-30 identified shortcomings, determine the need for further improving the design and technological schemes of work MSC: triaxial layout of the car causes an increase in the time of maneuvering operations; there are delays in unloading; characterized by low levels of reliability motors (up to 30% failure rate), electric equipment (up to 35% failure rate) and chassis components (up to 30% failure rate) shuttle cars. A significant number of idle shuttle cars VS-30 are caused by failure of the tires of the wheels, which is not formally an emergency waiver.

Today the effectiveness of the use of mechanized complexes is limited by capabilities haul machines, carrying out transportation of potash stope (Table-1) [3].

Table-1. Performance of delivery MSC, t per min.

Carrying capacity of wagon, t	Haullength, m			
	35	100	150	200
15	4,15	3,18	2,75	2,38
18	4,98	3,82	3,30	2,86
22	5,62	4,38	3,80	3,30
30	7,12	5,64	4,93	4,32

Studies of loading drive self-propelled carriages VS-30 in various modes of operation carried out in the mines JSK "Uralkaliy" by staff of the department "Mining Electrical Engineering" Perm National Research Polytechnic University jointly with the specialists of JSC "The regional climbing center" (Perm). Methodology of research involved the use of software and recording

complex VATUR (Figure-1), carries out measurement, recording and storage of instantaneous values of current and voltage consumed by motor MSC [4-6].

The complex VATUR includes processing unit, and switching power supplies, current and voltage sensors. By current clamp the input current is converted into an output voltage in proportion 1 A: 1 mV. Accelerometer tilt sensor is installed along the longitudinal axis of the MSC and records longitudinal dynamic loads (acceleration, deceleration), and also shows the angle of the wagon, the corresponding profile of the track.

Visualization and processing of data is carried out using a specially developed program VATUR-off. According to the average values of the instantaneous values of currents and voltages build schedules changes in active power consumed by the drive MSC.

Profile trails of chamber in which tests were carried out in the initial section of about 50 m had an angle of ascent 2-3º, and then gradually decreased to zero. In the second half the camera tilt angle varies 2-5º, a wagon was moving downhill. Length of the motorway of 140 m, the average speed 6, 1-6, 5 km/h. The voltage at the terminals of the magnetic station measured at the disconnected wires was 773 V. The following parameters and operation of the drive motor, motor oil station and the scraper conveyor.

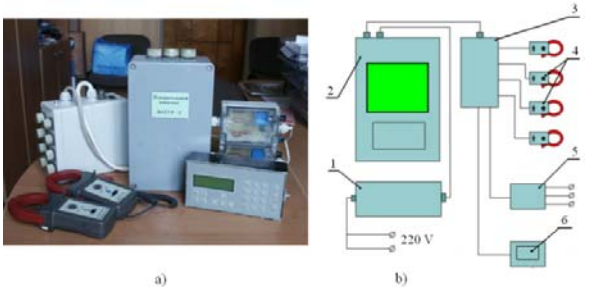

Figure-1. Software and recording complex "VATUR": a) general view; b) block diagram;1 - power supply; 2 - processing unit; 3 - a switching unit; 4 - current sensors (current clamps); 5 - three-phase voltage sensor; 6 - accelerometer tilt sensor

Starting active power consumption for all four engines of loaded wagon VS-30 (Figure-2), when starting at the first speed - 237 kW, a voltage drop in the power circuit - 161 V. At the beginning of an even movements load on the travel drive (the angle of the track 1-2º) is 54 kW. As the angle of the track until 4ºactive power consumed by the travel drive, increased to 126 kW. Thus, for a laden MSC at the first speed drive has an overload of 43%.

Transition from the first to the second speed is accompanied by a short-term increase in active power until 346 kW and a voltage drop to 530 V. When driving downhill, the load on the drive is 142 kW. Transition to the third speed is characterized by prolonged overloads. The size and nature of the change of loading drive motors MSC depends on the trajectory and driving dynamics of the wagon. Gear shifting drive motor is accompanied by the emergence of short-term peak loads.

RESULTS

The movement of wagon fully loaded VS-30 in the presence of even a small slope (2-4º), is characterized by the occurrence of overload on the drive motor and transmission parts, resulting in reduction of life and premature failure of the drive components. Similar conclusions were made by engineering personnel of mines, as well as machinists MSC. In practice, the wagons VS-30 is not loaded more than 22-24 tons of ore, what significantly reduces their productivity.

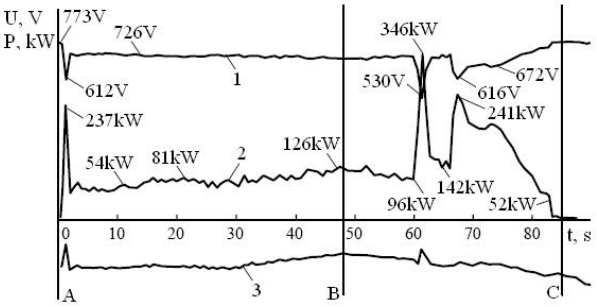

Figure-2. Schedules of change the three-phase voltage and the active power, consumed by the drive motors of loaded wagon VS-30: 1 - line voltage; 2 - active power, consumed by the two drive motors; 3 - accelerometer signal (the path profile); AB - the movement of the wagon up the hill; BC - the movement of the wagon downhill.

Power of pump station and conveyor of the wagon VS-30 from the electric motor AVK 30/15. Start of unloading the wagon VS-30 (Figure-3) is characterized by an increase in the value of active power consumed by the motor of the conveyor up to 41 kW (more than 34% overload, the voltage drop in the main circuit 9 V). When unloading the wagon drive of the conveyor comes into operation 9 times, due to the low capacity of transfer raise. Complete unloading of the wagon is carried out for 4 minutes.

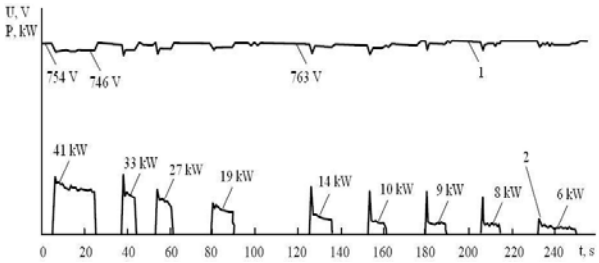

Figure-3. Plots of voltage change and an active three-phase motor power of the conveyor for unloading of fully loaded wagon VS-30: 1 - a graph of change the line voltage; 2 - a graph of change a three-phase active power.

The maximum load on the motors oil stations occurs in a mode for winding the cable on the drum

(Table-2). However, the most unfavorable operating mode oil station occurs when the wagon is stationary and hydraulic drives are not working. In this mode, most of the energy consumed by the electric motor, is spent on heating of the working fluid.

Table-2. Average value active power consumed by the motor oil station MSC VS-30.

Mode of operation MSC	Power, kW
The wagon stopped	13,9
The movement of the wagon forward (winding the cable up)	8,3
The movement of the wagon back	14,2

Analyzing the data necessary to note the following. Engines MSC work in intermittent mode. The most adverse conditions are the mode of operation the drive motor of wagons VS-30, what is determined by the presence of systemic overloads. A step change in engine speed, to switch their windings, is obsolete and ineffective technical solution. This measure does not allow for the regulation of effort on the drive shafts basic mechanisms that gives rise to crashes, increasing downtime MSC repair and increase material costs for the maintenance of them of working capacity. Improving the working conditions of electric of wagons is possible through the use of variable frequency drive. Today companies - suppliers of engineering products for potash mines offered new car design with thyristor frequency converters. Currently, being tested and carried out trial operation of the data MSC at the mines of JSC "Uralkaliy" [7-9].

Spectral analysis of records of capacities consumed by the drive motors of the wagon, allows revealing frequency components, characterizing the fluctuations of the kinematic chain "wheel - gear - drive motor". Basic load oscillation frequency drive of wagons varies from 2 to 25 Hz. Defects in the motor and mechanical gears cause the occurrence of variable loads, which causes the appearance of new spectral components. Continuous measurement of the value of the variable components in the power spectra that characterize the specific defects in the drive motor and the mechanical transmission, followed by an analysis of the changes makes it possible to predict the time to reach the limit values of controlled variables. Thus it is possible to implement an automated assessment of technical condition and remaining life of mining machinery units rationally arrange repairs, and monitor the quality of their performance in a simpler way [10-12].

Increased maneuverability three-axle of wagons can be realized by switching the drive on one side at a high speed when cornering. To implement this method of control is necessary to make changes in the electrical equipment of the wagon, and at the stage of designing validate kinematic calculations.

Increased time of discharge the ore and complexity maneuvering operations causes performance degradation of wagons and longwall set of equipment as a whole. The elimination of delays in unloading of wagons VS-30 is possible by increasing the capacity of ore-pass raise winze or installing of the measuring bins.

CONCLUSIONS

The use of modern means of measurement, supervising the magnitude and nature of the change in the load drives MSC allows stage development projects to determine the compliance of electric power stated specifications of the wagons. Additionally, it provides an opportunity to rational choice of operating parameters of wagons and creates effective system of protection against overloads, thus ensuring the highest quality and process reliability in the transportation of potash ore extraction chambers.

REFERENCES

[1] Starkov L.I., Zemskov A.N. and Kondrashov P.I. 2007. Development of machine mining of the potash ore, Publishing House of Perm State Technical University, Perm.

[2] Vedeneev I.A. 2005 New shuttle car for JSC "Uralkaliy", Mining. 3: 48–50.

[3] Lykhin P.A. 2010. About models and problems of the future potash mine, Mine of future. pp. 44-47.

[4] Shishlyannikov D.I., Chekmasov N.V., Trifanov M.G., Ivanov S.L. and Zvonarev I.E. 2015. Substantiation of the rational method to control the operating and technical-condition parameters of a heading-and-winning machine for potash mines. Journal of machinery manufacture and reliability. 3: 283-287.

[5] Shishliannikov D.I., Trifanov M.G., Romanov V.A., Ivanov S.L. and Asonov S.A. 2015. A stand for assessing the technical condition of the transmission in the parameters of the electric power, mining information-analytical bulletin. 4: 227-233.

[6] Shishliannikov D.I., Chekmasov N.V., Trifanov M.G. and Ivanov S.L. 2015. Increasing operational efficiency heading-and-winning machines of potash mines based on the analysis of parameters of registrars records, Mining Machinery and Electromechanics. 4: 3-10.

[7] Barkov A.V., Barkova N.A., Borisov A.A., Fedoseyev V.V. and Grishchenko D.V. 2012. Methods of diagnosing the mechanisms by electric current consumption, NGEI "Sevzapuchtsentr", St. Petersburg.

[8] Izosimov D.B., Shvetsov S.V. and Kim J.O. 1995. Novel technique of optimal digital state observer construction for microprocessor-based electrical drive control, Proceedings of the IECON' 95. 11: 6-10.

[9] Anikin A.S. 2009. Implementation of variable frequency asynchronous electric drive of on mine shuttle car V17K, Vestnik of SUSU: Ser. "Energy". 15: 67-71.

[10] Artemev A.A., Potapenko V.S., Ivanov S.L., Kremcheev E.A., Poddubnaya A.A. and Fokin A.S. 2007. On evaluation of the resource elements of the transmission of mining machines, Mining Machinery and Electromechanics. 9: 31-35.

[11] Ivanov S.L., Semenov M.A., Ivanov A.S., Poddubnaya A.A. and Fokin A.S. Pilot diagnostics of transmissions of mining machines in the parameters of the electric power, Notes of Mining Institute. 178: 159-161.

[12] Sumkanov A.I., Zotov V.V. and Kubrin S.S. 2012. The development of methodology for assessing the condition of the equipment sewage treatment systems of mining enterprises, mining information-analytical bulletin. 10: 260-264.