VOL. 11, NO. 9, MAY 2016 ISSN 1819-6608
ARPN Journal of Engineering and Applied Sciences

www.arpnjournals.com

ASSESSMENT OF URAL-20R MACHINE USE EFFICIENCY WHILE DEVELOPING POTASH SALT FIELDS

G. D. Trifanov[1], D. I. Shishlyannikov[1] and S. A. Lavrenko[2]
[1]Perm National Research Polytechnic University, Komsomolsky Ave., Perm, Russia
[2]National Mineral Resources University (Mining University), 21st line, St. Petersburg, Russia
E-Mail: sergey18.09.89@mail.ru

ABSTRACT

The paper has offered the control procedure of working conditions and proved the concept of the machine program recording set of the «URAL-20R» heading-and-winning machine. The paper has also presented the results of experimental works of load intensity and load variation conditions of the URAL-20R actuators obtained with the use of the VATUR portable measuring complex. In the course of experimental works the measuring and recording instantaneous current and instantaneous value of voltage of the working machine electric motors were taken, the actual and full power level, energy intensity of the process of potash massif deterioration were determined. Having used a mechanical-motion transducer there were travel speed of the machine to the bottomhole and the travel rate were registered. The paper has proved that existing means of the objective control procedure of working conditions of the URAL-20R machines do not provide best performance operation of the winning machines. The motor loading indicators that the newest models of the "URAL" machines have are adjusted to peak current and start alarming about the overload at 60-70 % of the load to the driving motors. On the basis of data analysis the paper has proved efficient operating conditions of the URAL-20R combine operation. It is proved that during the combine operation with its nominal performance of 7 t/min. as compared to usual performance of 4 t/min., energy intensity on the potash ore output recedes by 1, 5 times, and the extraction of the crude ore (-0,25 mm) decreases by 30%. The paper has recommended the stationary complex development registering load intensity and load conditions of the actuators monitoring technical condition of the combine transmission system performance predicting gas-dynamic phenomena in the potash massif.

Keywords: potash ore, heading-and-winning machine, registering complex, conditions, efficiency, reliability.

INTRODUCTION

The decreasing energy intensity of the process of potash massif deterioration, the reducing labor costs to operation, improvement of the ore grain-size classification are the key conditions for the increasing use efficiency of the heading-and-winning machines. As the results of use tests of the machines showed, these problems can be solved.

The typical methods for operational efficiency determination of the winning machines provide an analysis of load intensity and load variation conditions on separate actuators and capacity that the machine consumes in, winning machine efficiency determination, energy intensity of the process of massif deterioration and the crude ore grain-size classification [1-6].

The determination of the key indicators of the URAL-20R combine operation used in mines of the JSC "Uralkali" was conducted by the Assistances at the Department of Mining Electrical Engineering of the Perm National Research Polytechnic University in cooperation with the specialists of the JSC «Regional Rope Center» (Perm). The method of experimental works provided the use of the special developed VATUR portable complex (Figure-1) which takes the measuring and recording instantaneous current and instantaneous value of voltage of the working machine electric motors [7-9].

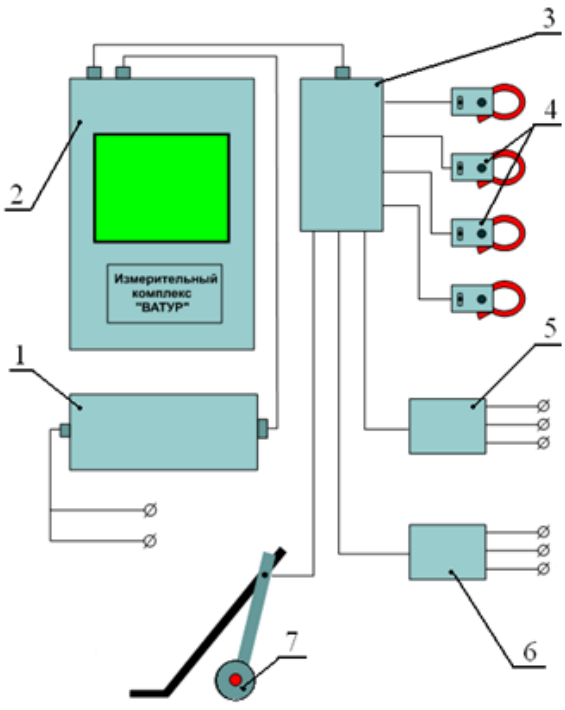

Figure-1. The structural diagram of the measuring VATUR complex:
1 - a power unit; 2 - a processor module; 3 - a switching unit; 4 - the current-sensing devices (the clamp meters); 5, 6 - the voltage-sensing devices; 7 - a travel sensor

The VATUR complex includes a processor module, the power and switching units, the clamp meters, the voltage-sensing devices and a distometer. The processor module consists of the computer of industrial version for the portable systems, a voltage-sensing device (ADC) and a 16-bit reversible counter. The clamp meters provide input current transformation to output voltage by a ratio of 1 A-1 mV. The voltage sensing devices will transform input voltage to 1000 V to output voltage by a ratio of 1 V-3 mV. The signals from the clamp meters and voltage sensing devices are given to the voltage sensing device input which interface circuits are connected to the computer. The dismometer was developed on the basis of the PUF-6 rotational travel incremental encoder with 360 line marks in a single revolution. The dismometer is installed on a side cover of the machine from on the side of a magnetic panel and provides the machine movement registration, the possibility to determine capacity and energy intensity of the process of potash massif deterioration.

Within one period of a supply main of 20 ms there are 100 measurements. The calculation of the effective range of current, voltage and capacity, and their recording to a hard disk is conducted every 0,5 s. Preliminary combine measurements showed that connection voltage and the load have a symmetric character, therefore the method of one idle-current wattmeter is accepted for actual power measurement in a three-phase circuit.

THE VISUALIZATION OF SCHEDULES OF THE VARIATION OPERATING CONDITION

On the basis of the measured values of current and voltage the instant values of active and full power of the studied motors are calculated. The average values of variables which are calculated on wattmetergram zones with the set motor operating condition are used for integrated assessment of the operating condition of the combines. The processing and visualization of the measurement results was executed in the developed «Vatur-of» program (Figure-2).

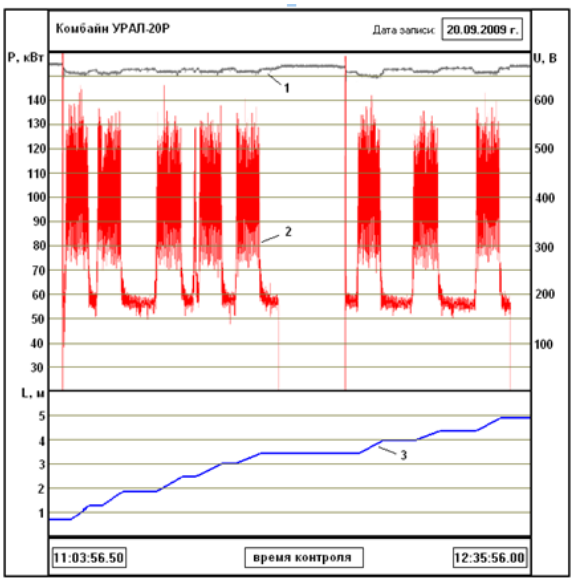

Figure-2. The visualization of schedules of the variation operating condition of the URAL-20R machine in the «Vatur-of» program:
1 - supply main voltage, V; 2 - actual power consumed by the relative rotation motor of the cutter wheels, kW; 3 - movement of the machine, m. Feed velocity of the machine to the bottomhole $V_п \approx 7,3$ m/h

It is known that the formation process of load conditions to actuators' elements of the winning machines is occasional and, generally, non-stationary. The schedule of variation actual power of the electric motor of relative rotation of the cutter wheels (see poses. 2 Figure-2) points out phases of the run, no load operation, notches, set operating regime and disconnection of the machine. The load variation conditions to the actuators causes the variation value of connection voltage (see pos. 1, Figure-2). The travel sensors installed on a side shoe provides the possibility of speed determination of the machine to the bottomhole and the winning machine position at mine roadway.

The measurements taken on the URAL-20R machine that operates at the mine SKRU-3 of the JSC "Uralkali, the minable seam Krasny-II showed that at the normal operating regime (when an engine man, being guided by the motor loading indications, does not allow their overload) all motors of the machine are underloaded (Table-1).

Table-1. Average power consumed by the URAL - 20R machine motors.

Examined motors	Power consumption, kW		Installed capacity of an actuator, kW
	$V_п$ = 7,35 m/h	$V_п$ = 12,0 m/h	
Cutter wheels 1	106,3	167,3	160
Cutter wheels 2	114,6	189,5	160
Berm body	101,6	165,0	2 × 75
Stripping machine	27,4	40,9	45
Transportation motion	29,8	43,1	75

Average power consumed by the machine at feed velocity of $v_п$ = 7, 35 m/h (efficiency of 4, 08 t/min.) is 419,9 kW at installed capacity of 710 kW. The loading of the cutter wheel motors is 106, 3 and 114, 6 kW at nominal power of 160 kW, i.e. 66% and 72%. Other actuators had even smaller load. This is due to the fact that the motor loading indicators installed on the newest developments of the machines are adjusted at the transient (peak) motor load. As the result, an indicator starts alarming about the overload at 60-70% - loading. Feed velocity slow speed is also caused by reduced efficiency of the self-propelled cars which conduct the ore mass transportation from the stope ore to discharge points.

After an analysis of the obtained results there were repeated measurements on the same machine at feed velocity increased to $v_п$ = 12, 0 m/h taken (efficiency - 7 t/min.). Average power consumed by the cutter wheel machines during the hopper elevator loading is 167, 3 and 189, 5 kW, i.e. these motors had the overload for 5% and 18%. Motor capacity of the top stripping machine is 40, 9 kW (91% from nominal one), of two motors of the berm cutter heads is 165, 0 kW (are overloaded for 10%), the engine of transportation rotation - 43, 1 kW (57, 4% of nominal loading). Thus, the taken measurements showed that at feed velocity of the machine of $v_п$ = 12, 0 m/h the transportation motion actuator motors and the stripping machine are under loaded, while the actuators of the cutter wheels and the berm body work being overloaded.

While fitting the orbital actuators wheels with the non-rotatable cutters, power consumption of the transportation motion motors decreases. There were not revealed a big difference in loading of the relative motion actuators while installating the rotatable and non-rotatable cutters.

RESULTS

The generalized parameters allowing estimating efficiency of the potash massif deterioration by the actuator cutters of the wining cars are energy intensity of the process of cutting and the quantity of fine, crude classes in the ore mass. First of all, energy intensity of the deterioration process is defined by physical properties of the massif, the machine specifications, a physical situation of the cutters, cutting parameters. A value of energy intensity of the process of massif deterioration by the actuator cutters of the URAL-20R machine is calculated according to a formula:

$$H_w = \frac{S}{v_п F_д \gamma}, \quad (1)$$

where H_w – energy intensity of the cutting process, kW × h/t; S - power consumption of the motors of orbital and wheel actuators, kW; $F_д$ - the bottomhole area processed by orbital and wheel actuators, m^2; $v_п$ – feed velocity of the combine, m/h; γ - ore density in the massif, t/m^3.

Energy intensity of the machine mostly depends on feed velocity (Figure-3, a). The conducted researches showed that owing to a variety of reasons the machines work at slow feed velocity of $v_п$ = 6 … 7 m/h. The machine operation with the nominal motor loading and capacity close to nameplate one, at $v_п \approx$ 12 m/h leads to the decreasing power consumption on sand mining by 1, 5 times.

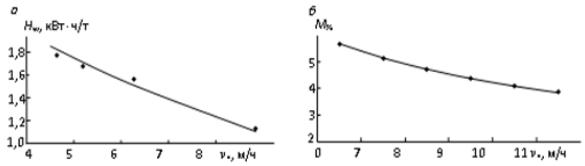

Figure-3. Calculated variation dependence from feed velocity of the URAL-20R machine:
a - energy intensity; б - the quantity of ore fines.

It should be especially noted that an analysis of the executed measurement results showed the possibility for identification to a high precision of the deviations in variation of power capacity of ore deterioration by any cutting body of the machine. The applied method and the equipment allow defining the decreasing power capacity of the process of massif deterioration caused by manifestations of gas-dynamic phenomena, conducting identification of outburst zones [10]. An analysis of the recording of current, voltage and actual power of the actuators provides the possibility for assessment of the remaining lifetime and the control over a physical situation of the heading-and-winning machine transmission system [11].

The increasing feed velocity and capacity of the machine causes the increasing chip thickness that in turn predetermines the crude ore outcrop reduction of less than-0, 25 mm in size. The size of the crude ore outcrop is proportional to a specific cutting way and can be approximated by a formula [12]:

$$M_{\%} = 100 \cdot \frac{L_{\text{уд}}}{L_{\text{уд}} + 32} + 1,2, \quad (2)$$

where M % - the quantity of ore of less than-0,25 mm in size in the muck pile, %; $L_{\text{уд}}$- a specific cutting way, km/m^3.

A specific cutting way of orbital and wheel actuator is inversely proportional to feed velocity of the machine and can be calculated according to a formula [12, 13]:

$$L_{\text{уд}} = \frac{0,06 L_{\text{р}} n_z P_{\text{д}} n_{\text{д}}}{v_{\text{п}} \cdot F_{\text{д}}}, \quad (3)$$

where $R_{\text{д}}$ – a number of the cutter wheels on the actuators; $n_{\text{д}}$ - wheel rotation frequency, rpm; $n_{\text{з}}$ – a number of the cutters on one wheel; $L_{\text{р}}$ – the length of a cutter contact with the bottomhole for one wheel revolution, m.

With the increasing feed velocity of the machine from 7 to 12 m/h (Figure-3, b) a cutting specific way of $L_{\text{уд}}$ decreases by 1, 7 times that, according to the dependences (2) and (3), will lead to the decreasing crude ore outcrop from 5, 68 to 3, 86%.

The conducted analysis of the capacity measurement results processed on the computer on the URAL-20R machine showed that the load of the main motors is defined by velocity of the machine. With the increasing feed velocity of the machine energy intensity of the process of ore deterioration decreases, the outcrop of ore fractions of -0, 25 mm in size decreases.

Approximate calculations for the given techniques [12,13] showed that during the machine operation with nominal capacity of 7 t/min., as compared to accepted 4 t/min., specific energy consumption on sand mining decreases by 1, 5 times, and the crude ore outcrop (of -0,25 mm in size) decreases by 30%.

CONCLUSIONS

The paper analysis shows that data- diagnostic means of the objective control on the basis of program the VATUR performance registering complex is the perspective innovative development for the mining engineering and allows increasing operational reliability of the mining technique. The use of the measuring complex which is continuously registers load intensity and load variation conditions of the URAL-20R actuators and feed velocity of the heading-and-winning machines will allow conducting assessment of operational efficiency of the heading-and-winning machine, the control over a physical situation of the machine transmission system and motors, to predict gas-dynamic phenomena in the potash massif.

REFERENCES

[1] Shmaryan E.M., Lepikhov A.I. and Gavinsky Yu.A. 1979. The examination and the development of the equipment for continuous recording of mining technique operation regimes. The writings of A.A. Skochinsky Institute of Mining. (172): 48-54

[2] Gabov V. V., Tretyakov N. M. and Modestov, Yu.A. 1984. The INM-1 device for the control over heading-and-winning machine operation regimes. The collection of research papers "Mechanization of mining operations on the coal mines in Tula, TPI. pp. 59-63.

[3] Zagvozdkin I.V., Lesov G.P. and Yanovich D. M. 2013. Safety measures and uninterrupted operation of the heading-and-winning machine complexes on the mines of the JSC Uralkali. Operational safety in the trade. (9): 46-49.

[4] Ivanov S. L., Semenov M. A., Ivanov A.S., Poddubnaya A.A. and Fokin A.S. 2008. Pilot diagnostics of a condition of the heading-and-winning machine transmission system on the parameters of power supply of the actuators. The notes of the Institute of Mining - SPb. Vol. 178: The problems of mining-transport systems and electromechanics. pp. 159-161.

[5] Kolomiytsev M. D. 1988. Operation of the heading-and-winning machines and the automated complexes. L.: Publishing House of the LIM. p. 96.

[6] Krasnikov Yu.D., Solod S.V. and Hazanov Kh.I. 1989. The increasing reliability of the heading-and-winning machines. M.: Subsoil. p. 215.

[7] Chekmasov N. V., Trifanov M. G., Shishlyannikov D. I. and Ivanov S. L. 2014. The methods of assessment of a physical situation and the remaining lifetime of the URAL heading-and-winning machine mechanical transmission systems. Data and analytical bulletin of Mining (Scientific and technical magazine). Vol. 4. pp. 272-278.

[8] Trifanov G. D., Knyazev A.A., Chekmasov N. V. and Shishlyannikov D. I. 2013. The examination of loading and the possibility of the URAL-20R machine actuator forecasting. Mountain technique and electromechanics. Vol. 2. pp. 41-44.

[9] Chekmasov N. V., Shishlyannikov D. I. and Trifanov M. G. 2013. Assessment of the process of potash massif deterioration efficiency by the actuator cutters of the URAL-20R machine. The news of higher education institutions. Mining Magazine. Vol. 6. pp. 103-107.

[10] Laptev B. V. 1994. The prevention of gas-dynamic phenomena on the potash mines. M.: Subsoil riches. pp. 138.

[11] Ivanov S. L. 1999. The increasing life time of the heading-and-winning machine transmission systems on the basis of assessment of power loading of their elements. SPb: St. Petersburg Institute of Mining. p. 92.

[12] Brenner V.A., Zilbert I.S. and Zykov V.A. 1978. The machine operation regimes for the potash ore output. M.: Subsoil riches. p. 216.

[13] Krasnikov Yu. D., Prushak V. Ya. and Shcherba V. Ya. 2003. The heading-and-winning machines. Mon.: Higher education institution. p. 148.