METHODOLOGY FOR DETERMINATION OF THE PARAMETERS OF HYDRAULIC STOKE MECHANISMS

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ABSTRACT. When processing the oscillograms of the operating processes the well-known methodology of B. V. Sudnishnikov is usually used. This requires a large volume of computing work and due to this, only one cycle that is typical for the machine operation, is processed. Thus, the accuracy of the results obtained is reduced. The proposed methodology, based on hydraulic mechanisms of strikes, is designed in order to rationalise this activity and to increase the accuracy.

Keywords: mechanism, hydraulic, oscollogram

МЕТОДИКА ЗА ОПРЕДЕЛЯНЕ НА ОСНОВНИТЕ ПАРАМЕТРИ НА ХИДРАВЛИЧНИТЕ УДАРНИ МЕХАНИЗМИ

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РЕЗЮМЕ. При обработване на осцилограмите на работните процеси обикновено се използва известна методика на Суднишников Б. В. Тази методика изисква извършването на твърде голям обем изчислителна работа, поради което се обработва само един, характерен за работата на машината, цикъл. Това намалява точността на получените резултати. За рационализиране на тази дейност и повишаване точността, на примера на хидравличните ударни механизми, е разработена предложената методика.

Ключови думи: механизъм, хидравличен, осцилограма

Introduction

Over the last decades, the hydraulic drilling and the hammer machines had found an increasingly widespread use, as they have gradually replaced the pneumatic ones. This is due to the exhaustion of the possibilities for further improvement of the performance of pneumatic drilling machines. In the 150-year history of the use of pneumatic drilling machines, they have gone a long way towards their perfection. By the end of the 60s of the last century, it was no longer possible to expect better results from the newly created machines. Some progress has been made only in the period 1955-1965 in a relation with the development of methodologies for recording the internal processes and hence for the optimisation of their structural elements.

The only possibility to increase the power and productivity of pneumatic machines was to increase the diameter of the cylinder, the mass of the machine and the supplied pressure. All this, however, is related to higher operational costs and major reconstruction of the mining pneumatic chattels. The transition to higher pressure (up to 2 - 3MPa) is only appropriate for drilling machines that work together with a mobile compressor.

In both society and technology, when the capabilities of a system, a technology, or a machine are exhausted, a qualitatively new solution to the problem appears. The creation of hydraulic drilling machines is a typical example of such a development of the technique. With the introduction of hydraulic drilling machines due to the much higher operating fluid pressure (up to 25 MPa and even more), the power of the drilling machine has increased many times.

The first hydraulic hammer was developed in 1968 and was introduced in 1970 by the French company MONTAGER. In the next years, other companies began to produce such machines. By the end of the 90s, around 150 models were being produced by 20 companies, and their number has been continuously growing.

The principle of operation of these machines is similar to that of the pneumatic drilling machines. They consist of the same basic parts. Due to the practical non-shrinking mode of the oil, two hydro-accumulators are added – one to the pressure pipe and one to the merging one. The machine is supplied by high pressure oil into the high-pressure pipeline from the oil station. The energy of the oil is transformed into mechanical work in the stroke and the rotation mechanisms. After that the oil, with a reduced pressure in the merging pipeline, returns to the oil station.

The advantages of the hydraulic drilling and the breaking machines are quite important in comparison to the pneumatic ones. The most important of these are:

- Higher power transmitted to the instrument (4 to 5 times)
- Greater drilling speed (2 to 2.5 times);
- Higher efficiency (up to 0.4-0.5);
- Less noise, lack of aerodynamic noise;
- Less air pollution, missing oil aerosols;
- Better shape of the stroke impulse and longer pistons;
- More durability of the drilling tool;

- Better control of the working mode;
- Use of cheaper electricity.

Their disadvantages are of small importance. However, there could be noted:

- Heating of the oil – it is overcome by a cooler of the oil station;
- More complex construction and considerably higher costs;
- Greater requirements for their production;
- Better qualification of the service staff.

The energy carrier for the hydraulic drilling machines is the high pressure oil. The high oil pressure is created by an oil station. It consists of an oil pump coupled with a driving engine. The pump is placed in a tank filled with oil. The oil from the tank is sucked through a filter by the pump, its pressure increases and is fed to the machine through the high pressure hose. Once the energy is delivered, the oil returns to the oil station tank where the cycle is repeated.

Figure 1 shows the general appearance of the hydraulic hammer drill of the company "TAMROCK" - HL-438. The hammer consists of a bore holder 1, a spindle 2, a washing pipe 3, a protective cuff 4, a seal 5, a piston 6, a cylinder 7, a dispenser corpse 8, a shuttle cylindrical distributor 9, a corpse of the stroke mechanism 10, a cylinder 11, a hydraulic motor 12, bearing 13 and gear 14.

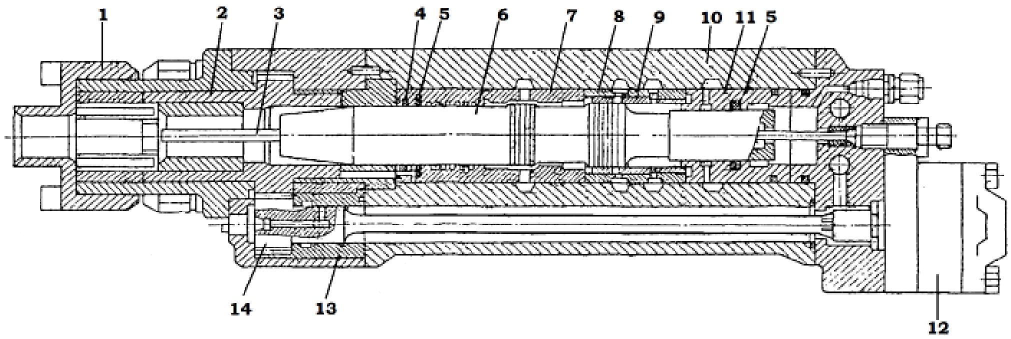

Fig 1. A construction of a hydraulic hammer drill HL-438

Through the shuttle distributor 9, the oil is supplied in series to the two cylindrical chambers. When the piston is moved forward, a strike is applied to the drill. The rotation movement of the tool is accomplished by a hydraulic motor 12 located on the rear cover of the machine. From the engine, because of its high torque, the rotation is transmitted to the instrument by a stage reductor 14. The washing water for the borehole is supplied centrally through a pipe 3.

Exposition

In the laboratory tests of drilling and breaker machines, a significant number of processes are recorded – the displacement, the speed and the acceleration of the piston [Minin I., 2017], the corps and the drilling tool and the compressed air pressure in the machine chamber. These processes are registered in the form of oscillograms or as computer records. The use of the registered records is possible after their preliminary processing. Very often the processing is performed manually by direct measurement and calculation by ordinary means. In such a mode of processing, due to its slow performance, the number of processed cycles is limited and therefore an insufficient accuracy can be achieved.

A methodology for computer registration and processing of recorded oscillograms has been developed in order to rationaliяe this activity. We process a larger number of cycles by determining the parameters we are interested in.

The introduction of the EIT requires changes in the methodology used so far (Sudnishnikov B. V, 1965, Dimitrov D., 1988), along with the introduction of the computer methods (Nedyalkov P., 2010, Stoyanov A., 2016, Ivanov A., 2017). An unlimited number of cycles are processed, the scales of time and power are not set. They are determined by the input parameters. The sequence of processing the oscillograms is as follows:

A section is selected from the oscillogram, where the processes are recorded in quality and the operational mode of the machine is stable. The range of cycles selected for treatment is noted (Fig. 2). The figure shows the operational processes flowchart in a hydraulic stroke mechanism. The methodology will not change significantly for pneumatic stroke machines. The cycles are divided into equal parts along the abscissa, i.e. by the time. The values of the pressure curves in the working chambers are recorded onto the ordinates. The curves P1, P2 and P3 are the recorded pressures acting on the rear part of the cylinder, the operating chamber and the front part of the cylinder, respectively.

The forces F1, F2 and F3 acting on the piston are calculated.

$$F1 = P1\ S1,\ N, \tag{1}$$

$$F2 = P2\ S2,\ N, \tag{2}$$

$$F3 = P3\ S3,\ N, \tag{3}$$

where S1, S2 and S3 are the rear, middle and front work surface areas of the piston, m^2, respectively.

$$R = F1 + F2 + F3,\ N \tag{4}$$

The resultant force R acting on the piston is calculated and it is plotted on the display (Fig. 3).

The resultant force diagram is approximately divided in an operational tp and a reverse to motions.

The surface areas of the impulses I1, I2, I3, I4 and I5 and the static moments of the impulses M1, M2, M3, M4 and M5 are determined. As it is shown in Figure 2 the oscillogram is conditional.

The number of displayed impulses vary depending on the type and design of the machine. In all cases we will have the three impulses I2, I3 and I4, and the impulses I1 and I5 may be missing.

$$I_i = \int_{t_i}^{t_1} R dt, Ns \quad (5)$$

$$M_i = \sum I_i t_i, Ns^2 \quad (6)$$

where I_i is the elementary surface area on which the impulse Ns is broken,

t_i - the distance from the center of the elementary area to the corresponding boundary of the cycle, s.

For the moments M1, M2 and M3, the distances ti are reported toward the ordinate t = 0, i.e. at the start of the cycle, and for M4 and M5 - at the end of the cycle.

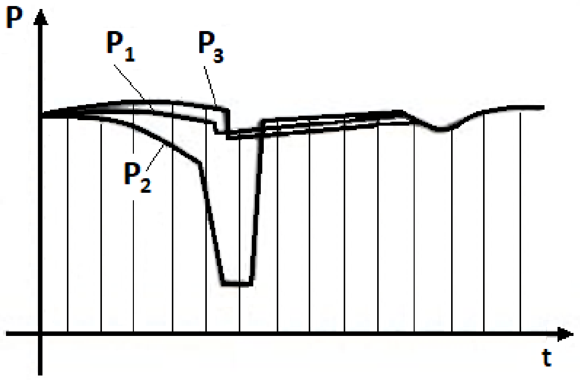

Fig. 2. An oscillogram of the operational cycle of the machine

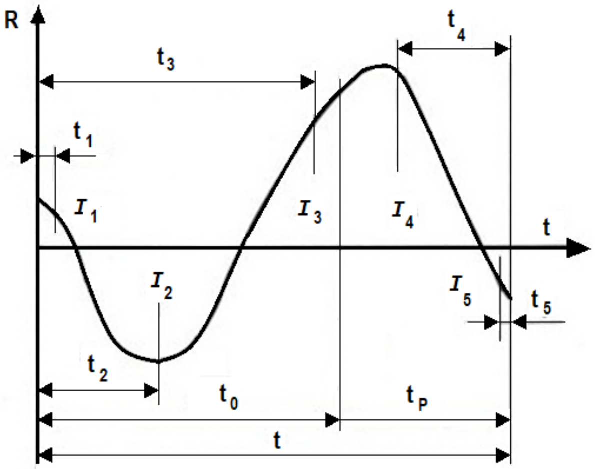

Fig. 3. A diagram for the R-force calculation

The movements made by the piston in the operational and reverse motions are determined.

$$l_0 = \frac{M_1+M_3-|M_2|}{m_6}., \text{m}, \quad (7)$$

$$l_p = \frac{M_4-|M_5|}{m_6}, m \quad (8)$$

where m_6 is the piston mass in kilograms.

In a machine, there is always an equality of the lengths of the operational and the reverse motions. Therefore, if such equality is not achieved, the calculation continues, without an intervention of the operator, until it is balanced at a new location of the distribution line and the size of the impulses I_3 and I_4.

After the equalisation of I_r and I_0, the basic parameters of the investigated machine are determined.

The pre-stroke speed of the piston.

$$V_y = \frac{I_4-|I_5|}{m_6}, m/s \quad (9)$$

The energy of the stroke.

$$A_y = \frac{m_6.V_y^2}{2}, J \quad (10)$$

The same physical laws are valid for the hydraulic hammers, as for the electric machines, i.e. the strokes frequency and the stroke power are in a direct proportionality (Hristova, T. et al., 2018)

$$n = \frac{60}{t_ц}, min^{-1} \quad (11)$$

$$P = \frac{A_y n}{60.10^3}, kW \quad (12)$$

The rebound speed of the tool piston.

$$V_0 = \frac{I_1+I_3-|I_2|}{m_6}, m/s \quad (13)$$

The rebound coefficient.

$$K_0 = \frac{V_0}{V_y}. \quad (14)$$

When performing the computing programme, the piston areas, the cycle time and the three registered pressures are imported. This is done for all sections which the processed cycles were split from.

The cycle is approximately divided into an operational and a reverse motion. The value of the resultant force at the beginning of the cycle is verified by a check-up. If it is higher than 0, I_1 and M_1 are calculated, and if it is less than 0 - I_2 and M_2. Permanent checks are made for the moment when the resultant force will change its character and then the next impulses and their moments are automatically computed. After the static moments and the impulses, the lengths of the operational and the reverse motions are calculated and compared. If any difference is found, as mentioned above, the dividing line is displaced. The programme provides an automatic shifting of the dividing line in one direction or another, depending on the ratio between the operational and the reverse motions. If the values of t_0 and t_r are equalised with the set accuracy, the calculations continue for all the other parameters of the machine. As a final result, the values of all the parameters of the machine are displayed and the resultant force curve is plotted.

The processing of the oscillograms of the operational processes is usually brought to a processing of the indicative pressure diagrams.

This is most common for the machines with a free piston. In the case of drilling machines with a connected piston /with a dependent rotation of the drilling tool/ this methodology does not give enough accurate results. For these machines it is necessary to register and to arrange the operational processes that characterise the movement of the piston, the corps and the drilling tool.

The considered methodology for the processing of the operation oscillograms and the calculation programme made by a model of it are used in the study of a number of pneumatic and hydraulic drilling and breaking machines in the laboratories of the University of Mining and Geology - Sofia. The rationalisation of this activity has been achieved through the elaborated calculation methodology. There is an opportunity for a practical application of the well-known method for processing the oscillograms of the operational processes.

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