ANALYSIS OF EFFICIENCY OF CONTROL METHODS OF HYDRAULIC DRIVE MOTORS

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ABSTRACT

Currently, a number of machines and equipment with a hydraulic system are widely used in the mining industry, construction and agriculture. In order to increase the stable and reliable operation of the hydraulic system of these machines, there are several ways to regulate them, this article discusses the types of control methods and measures to improve the efficiency of their main indicators.

Keywords: throttle, hydraulic drive, spool, switchgear, auxiliary device, flow, load, dependence.

INTRODUCTION

Hydraulic drive is a set of hydraulic machines, hydraulic equipment, hydraulic lines (pipes) and auxiliary devices, and it is called a hydraulic system designed to transfer energy and convert movement through a fluid. At the same time, regulation and reversal of the speed of the output device, as well as the transfer of one type of movement to another, can be carried out simultaneously. The hydraulic machines that are part of the hydraulic system are pumps and hydraulic motors, and there can be several of them.

Hydraulic devices are devices for controlling hydraulic operation, with the help of which it is regulated, as well as means of protecting it from high and low pressures of the liquid.

LITERATURE ANALYSIS AND METHODOLOGY

Hydraulic equipment includes chokes, valves for various purposes, and distribution devices for changing the direction of hydraulic fluid flow.

Auxiliary devices are called conditioners of the working fluid, which serve to ensure its quality and condition. These are various particle separators (filters), heat exchangers (heaters and coolers), hydraulic tanks and accumulators.

The hydraulic control elements are interconnected by hose hydraulic lines through which the working fluid moves.

The main principle structure and interrelationship of the hydraulic system is shown in Fig. 1.

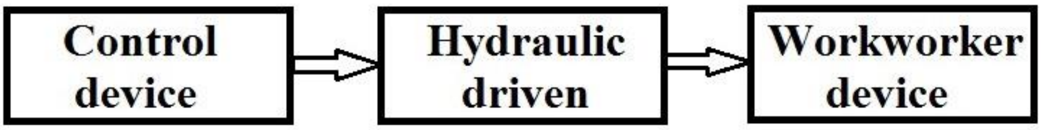

Figure 1. The main principle structure of the hydraulic system

Taking into account the above, now the main task is to organize and manage hydraulic systems in order to bring them to the optimal operating mode.

The main part. A comparison of the most widely used hydraulic regulation methods (two options for throttle and volumetric) should be made according to three indicators:

- description of the load;
- useful work coefficient;
- costs of hydraulic operation and equipment use.

Comparison of the download description.

The load characteristic of the hydraulic drive describes the degree of stability of the speed of the output link (stock, shaft) under a variable load. Usually, perhaps a great degree of stability is required, meaning that the smallest set of hydraulics is used.

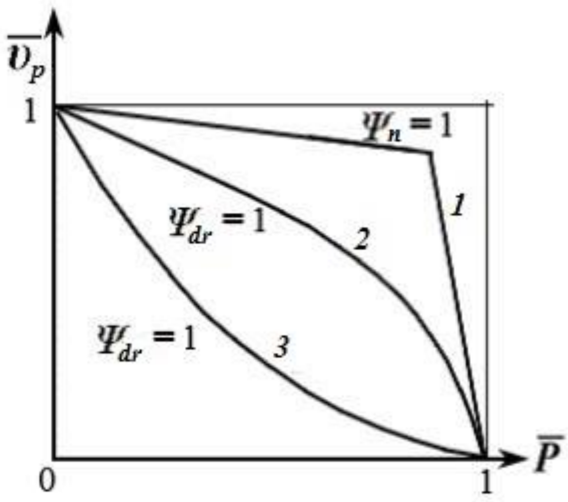

Figure 2. Volumetric and drosselli graph of the arbitrary dependence of the volume of work built for the same values of the maximum speed and braking load at the time of regulation

Figure 2 shows the load curves, that is, the dependence of the speed of the output link yp on the load P on it, constant values of the working volume of hydraulic machines during volumetric regulation and for different degrees of opening of the regulating throttle during throttle regulation, as well as the maximum speed and are built for the same values of the braking load.

As can be seen from Figure 2, the volumetrically regulated hydraulic system has the greatest stability (line 1). When the throttle is started in series (line 2), the regulation is significantly worse, and when the throttle is turned on in parallel (line 3), the regulation with the throttle is even worse.

RESULTS

Comparison with useful work coefficient.

Figure 3 shows the PS graph of the dependence of the efficiency of the useful work coefficient on the adjustment parameter of hydraulic systems.

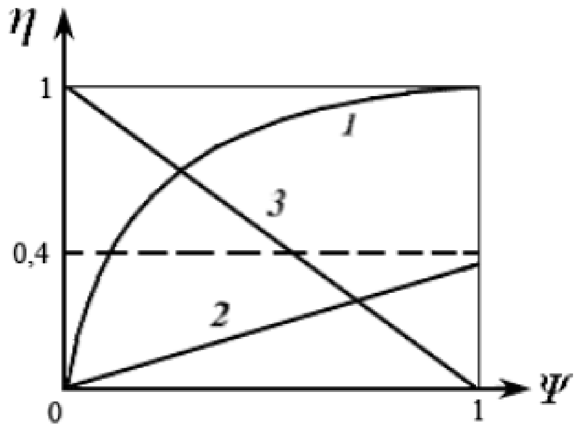

Figure 3. Graph of the dependence of the efficiency of the useful coefficient of work on the parameter of adjustment of hydraulic drives Ψ

For volumetric regulation, curve 1 is built on the following relation:

$$H = \eta_n \, \eta_d \, \eta_m \qquad (1)$$

In the absence of losses in the pump, hydraulic engine and pipes, we study the effectiveness of the useful coefficient of operation of hydraulic drive, that is, $\eta_n = \eta_d = 1$. Then the full efficiency of hydraulic drive is $\eta_g = \eta_{pp.u}$ it will be equal to.

The efficiency of the fully useful working coefficient of hydraulic drive is equal to the efficiency of the pump useful working coefficient, the efficiency of the useful working coefficient of the control process and the efficiency of the useful working coefficient of the hydraulic motor. For example, the hydraulic cylinder is equal to:

$$\eta_{g.p} = \frac{Pv_p}{N_i} = \frac{p_n Q_n}{N_n} \cdot \frac{p_d Q_d}{p_n Q_n} \cdot \frac{Pv_p}{p_d Q_d} = \eta_n \eta_{p.u} \eta_d\,; \tag{2}$$

$\eta_{p.u}$ to analyze u, we use dimensionless quantities, that is, according to the indicators given to their maximum possible values.

For a hydraulic cylinder, such values are as follows:

- relative loading equal to the relative pressure difference in hydraulic cylinders is as follows:

$$p_d = \frac{p_d}{p_n} = \frac{P_d}{p_n F_d} = \frac{P_d}{P_{max}} = P_d\,; \tag{3}$$

- the relative speed of the piston is equal to the relative flow given to the hydraulic cylinder in the form of:

$$v_p = \frac{v_p}{v_{p.max}} = \frac{v_p F_d}{v_{p.max} F_d} = \frac{Q_d}{Q_n} = Q_d\,; \tag{4}$$

- relative area of the drossel hole (drossel opening level):

$$F = \frac{F_{dr}}{F_{dr.max}} \tag{5}$$

F_d is the ratio of PN pressure of the pump used in the hydraulic engine, and Q_d is the proportion of pump supply directed to the hydraulic engine.

(2) it follows from the formula,

$$\eta_{p.u} = \frac{p_d F_d v_p}{p_n F_n v_{p.max}} = \frac{P_d}{P_{d.max}} \cdot \frac{v_p}{v_{p.max}} = p_d Q_d \tag{6}$$

$P_d = 0\ va\ F_{\text{др}} = F_{dr.max}$ by placing its exponents in the above expression, through this expression $v_{a.max}$:

$$v_{p.max} = \mu \frac{F_{dr.max}}{F_d} \sqrt{\frac{2p_n}{\rho}} \tag{7}$$

We accept that Drossel's consumption coefficient μ does not depend on the degree of its opening. Then the relative speed of the hydraulic cylinder piston will be as follows:

$$v_p = \frac{v_p}{v_{p.max}} = F\sqrt{1 - P_d} = F\sqrt{1 - p_d} = Q_d \tag{8}$$

from this

$$P_d = p_d = 1 - \frac{v_p^2}{F^2} \tag{9}$$

Then from the expression (6) we can take two different options for determining the coefficient $\eta_{p.u}$:

$$\eta_{p.u} = \mathrm{F} p_d \sqrt{1 - p_d} \tag{10}$$

$$\eta_{p.u} = v_p\left(1 - \frac{v_p^2}{F^2}\right) \tag{11}$$

As can be seen from these formulas, the efficiency of the maximum useful coefficient of work is achieved at F=1, that is, when the drossel is fully opened. We find the values of u_p and p_d (10) and (11) expressions, the effectiveness of which is maximum, by maximum research of the coefficient of useful work.

To do this, we differentiate the expression (11) according to u_p when F=1 and equate the derivative to zero:

$$\frac{d\eta_{p.u}}{dv_p} = 1 - 3v_p^2 = 0 \tag{12}$$

The optimal relative speed here (where the efficiency of the useful coefficient of work is maximum) will be equal to:

$$v_{v.opt} = Q_{p.opt} = \frac{1}{\sqrt{3}} = 0{,}58 \tag{13}$$

In this case, the value of the maximum useful coefficient of work will be equal to the value of:

$$\eta_{p.u..max} = \left(1 - \frac{1}{3}\right) \cdot \sqrt{3} = 0{,}385 \tag{14}$$

For serial starting drosselli derivative derived from the formulas (11), (14), Line 2 is considered to be a useful coefficient of efficiency dependence on the built regulatory parameter:

$$\eta_{p.u.max} = \left(1 - \frac{1}{3}\right) \cdot \sqrt{3}\psi = 0{,}385\psi \tag{15}$$

To enter Drosselli into work in parallel, a connection using the formulas (4), (5) (Line 3) is obtained:

$$\eta_{p.u} = v_p = 1 - \frac{\psi\sqrt{P}}{Q} \tag{16}$$

DISCUSSION

Figure 4 shows the dependence of the efficiency of the useful coefficient of work, built on the above formulas, on the relative speed of the output zvenos. The numbering of dependencies was carried out in the same order as the previous pictures.

Analysis of graphs in Figure 3 and 4 shows that the efficiency of the highest useful coefficient of work of hydraulic drive is achieved by volumetric regulation, relatively lower - by parallel drosselation with drossel, and even lower - by sequential addition with drossel we will be able to see the drosselle launch.

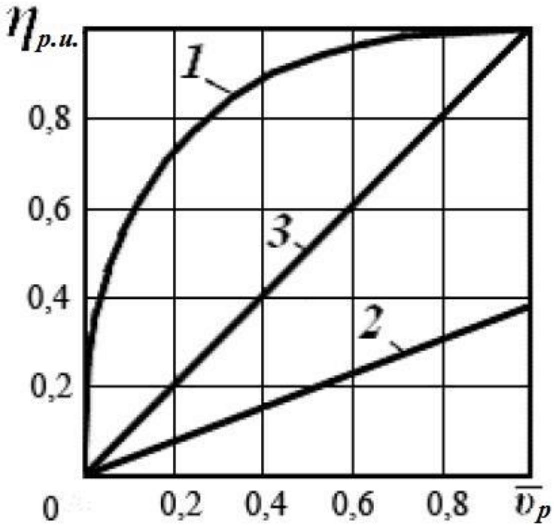

Figure 4. Graph of efficiency indicators of various launch procedures

CONCLUSION

Therefore, from the graphs in the pictures presented above, we can see that the two most important indicators – in terms of load description and efficiency, volumetric regulated hydraulic drive has the best indicators. However, when choosing a method of regulating hydraulic drive, economic indicators should also be taken into account.

Hydraulic machines that can be regulated - pumps and hydraulic motors – are much more expensive (5-10 times) than unregulated ones. When using adjustable hydraulic drives, you need to include Salmo in large capital expenditures, but due to the high utility coefficient of efficiency, they achieve savings in operating costs (energy costs). Therefore, the volumetric regulation of hydraulic drive is generally considered appropriate to use in cases where operational energy indicators are important, in particular for hydraulic drives with high power and long-term operating modes. Hydraulic drives with Drosselli-controlled and inexpensive (for example, shesternyali) pumps are usually suitable for use in low-power systems and short-term operating modes.

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