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METHODS AND ADJUSTING CIRCUITS FOR SPEEDS AND RPM FOR HYDRAULIC MOTORS

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Abstract: *The use of a larger scale for hydraulic actuating for industries which complain the equipment with high density of high forces, required developing of adjusting and control methods of these systems. Adjusting the displacement speed of a linear hydraulic motor, respective for RPM developed by a hydraulic rotary motor is realized by applying the volume method or resistive method. A special case is represented by closed hydraulic circuits where id used primary, secondary or mixt adjustment for variation of a hydraulic rotary motor RPM.*

Key words: *linear speed, rpm, adjusting circuit, volume method, resistive method,*

1. INTRODUCTION

Starting from the basic laws of mechanics, hydraulic machines and hydrostatic transmissions can be deduced the model for realizing the variations of speeds, forces and torques for linear and rotary hydraulic motors

Analyzing the conservations and continuity laws of the flow, results that the linear hydraulic motor speed and RPM of rotary motors can be adjusted by quantity adjustment of liquid which pass through active section, respective working volume in time unit. The liquid quantity can be adjusted direct, acting to pump flow, this type of adjustment is named volume adjustment. For a hydraulic scheme where is made a volume adjustment can be wrote the following basic relation:

$$v_i = \frac{Q_{p_i}}{S_i} \quad (1)$$

$$for\ Q_p \in \left[Q, Q_{p_{max}}\right]\ si\ v \in [0, v_{max}]$$

where: v – linear speed of the hydraulic piston;

- v_i – linear speed of hydraulic piston at moment "i";
- v_{max} – maximum speed of linear piston;
- Q_{pi} – pump flow at moment "i";
- Q_p – pump flow;
- Q_{pmax} – maxim flow of the pump;
- S_i – area of linear motor piston;

2. ADJUSTING METHODS OF SPEED AND RPM FOR HYDRAULIC MOTORS

In the figure below is presented the adjustment hydraulic scheme of speed for linear hydraulic motor (fig 1) by direct adjusting from quantity fluid flow in the pump. In this situation the adjustment is made to a variable pressure, the pressure limitating valve in this case is normaly closed.

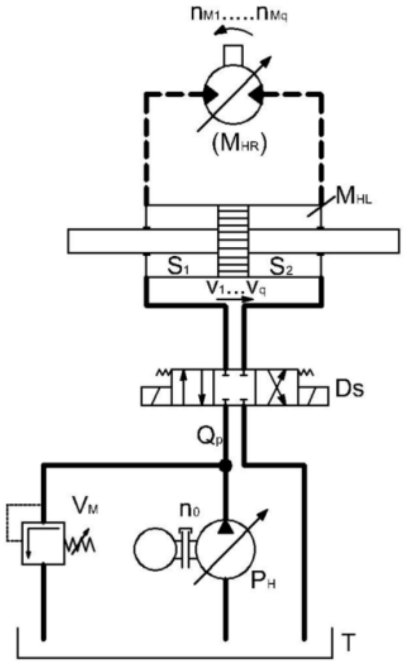

Fig.1. Hydraulic scheme for adjusting the speed of a hydraulic rotary motor through the volume method

The second type of adjustment is shown in figure 2 where the provided flow by the hydraulic motor is adjusted with the help of a resistance named throttle. This type of adjustment of speed/rpm is named resistive method. In this case, the adjustment is realized for constant pressure, SD valve, this is a normal opened, and through this is evacuated continuously a quantity of ΔQ = Qp — Qdr.

In the case of this method, due to lost flow through normal opened valve appears a loose of power ΔP = ΔQ · p. Due to this reason, the resistive method for adjustment is not recommended to use for circuits which develop high powers.

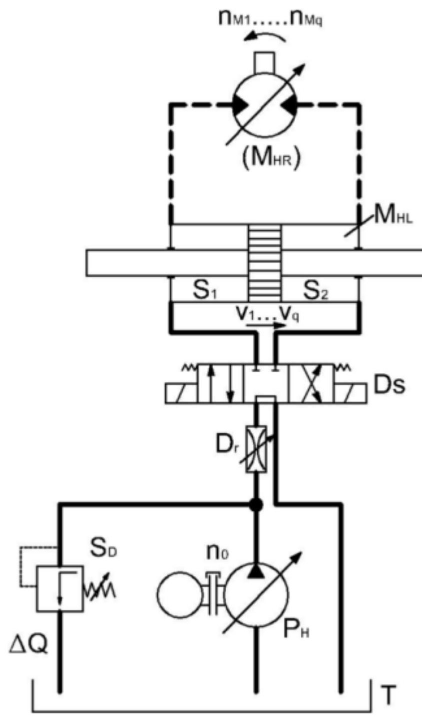

Fig.2. Hydraulic scheme of adjusting the speed of a linear hydraulic motor through resistive method

The parameters set in this case will be:

$$v_i = \frac{Q_{dr_i}}{S_1}; \quad (2)$$

$$\text{for } Q_{dr} \in [Q_{dr_{min}}, Q_{dr_{max}}]$$

$$v \in [v_{min}\ , v_{max}]$$

where: v – displacement speed of linear hydraulic motor;

v_{min} – minim displacement speed of linear hydraulic motor;

v_{max} - viteza maxima de deplasare a motorului hidraulic liniar;

v_i – displacement speed of linear hydraulic motor at moment "i";

Q_{dr} – flow through throttle;

Q_{dri} – flow through throttle at moment "i";

Q_{drmin} – minim flow through throttle;

Q_{drmax} – maxim flow through throttle;

It should be noted that the resistive adjustment provide a greater accuracy of adjustment and a better stability of motion than the volume, reason for which is used more frequently in advance kinematic chains for tooling machines (for low speeds), and the volume adjustment in main force kinematic chains (for high speed and power).

A distinct case and a special kinematic analysis must be accorded to hydraulic systems with closed circuit to obtain circular motion. Such a system with closed circuit for adjustment of output rpm to a rotary motor is shown in figure 3.

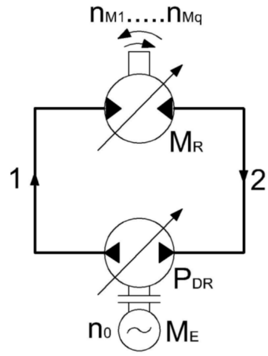

Fig.3. Hydraulic scheme for adjusting rpm of a rotary hydraulic motor with closed circuit

The figure represents a closed hydraulic scheme where both pump and motor can be adjusted by volume variation. Analyzing hydraulic scheme and considering the rotary hydraulic motor will consume a flow Q_M and can be written the relations: .

$$Q_p = q_p \cdot n_0; \quad (3)$$

$$Q_M = q_M \cdot n_M \quad (4)$$

Where : Q_p – flow provided by the pump:

Q_M – flow consumed by motor;

q_p – unit volume of the;

q_M – unit volume of rotary motor.

n_0 – driving rpm of the pump;

n_M – rpm provided by rotary motor;

If it is looking at the ideal case , where the flow provided by pump, through pipe 1, is provided consume of rotary motor, we can deduce the relation:

$$Q_p = Q_M; \quad (5)$$

$$q_p \cdot n_0 = q_M \cdot n_M; \quad (6)$$

$$n_M = \frac{q_p}{q_M} \cdot n_0; \qquad (7)$$

If is introducing the notion of adjustment size (adjustment coefficients) above relation can be written otherwise. Will be noted the constructive-dimensional characteristics with C_p and C_M and the adjustment ones with e_p and e_M or α_p and α_M. Introducing the new sizes in the above formula, the upset flow by the pump and the consumed one by the motor will be written as:

$$Q_p = C_p \cdot e_p \cdot n_0; \qquad (8)$$
$$Q_M = C_M \cdot e_M \cdot n_M \qquad (9)$$

where:Q_p – flow provided by pump;
Q_M – flow consumed by motor;
C_p – coefficient which take into account the constructive - dimensional characteristic of pump;
C_M - coefficient which take into account the constructive - dimensional characteristic of motor;
n_0 – driving RPM of pump;
n_M – RPM provided by rotary hydraulic motor;

If will be taken into account the eccentricity (noted in this case with "e") and the inclination angle for pumps with radial and axial pistons (noted with "α"), the adjusted sizes with help of can be modified variation of pump flow or RPM of hydraulic motor, will be obtained the following adjustment reports:

$$\psi_p = \frac{e_p}{e_{p\,max}} \leq 1; \qquad (10)$$
$$\psi_M = \frac{e_M}{e_{M\,max}} \leq 1; \qquad (11)$$
$$\psi_p = \frac{\sin \alpha_p}{\sin \alpha_{p\,max}} \leq 1; \qquad (12)$$
$$\psi_M = \frac{\sin \alpha_M}{\sin \alpha_{M\,max}} \leq 1; \qquad (13)$$

Where :ψ_p – adjustment pump report;
ψ_M – adjustment motor report;
e_p – adjusted eccentricity of pump;
$e_{p\,max}$ – maximum adjusted eccentricity of pump;
e_M - adjusted eccentricity of motor;
$e_{M\,max}$ – maximum adjusted eccentricity of motor;
$\sin \alpha_p$ – inclination angle for pump;
$\sin \alpha_{p\,max}$ – maximum inclination angle for pump;
$\sin \alpha_M$ - inclination angle for motor;
$\sin \alpha_{M\,max}$ - maximum inclination angle for motor;

As q_p was named unit volume of pump and q_M unit volume of motor, these can be considered that are flow, respective capacity what has the pump or motor at a RPM. These parameters can be adjusted further like maximum value of these and will be noted q'_p and q'_M. Introducing new notations in formulas can be written like:

$$q'_p = \frac{Q_{p\,max}}{n_p} = \frac{C_p \cdot e_{p\,max} \cdot n_p}{n_p}; \qquad (14)$$
$$q'_p = C_p \cdot e_{p\,max}; \qquad (15)$$
$$q'_M = \frac{Q_{M\,max}}{n_M} = \frac{C_M \cdot e_{M\,max} \cdot n_M}{n_M}; \qquad (16)$$
$$q'_M = C_M \cdot e_{M\,max}; \qquad (17)$$

If in flow relations are introduced eccentricity of pump and motor (e_p and e_M), expressed in function of adjustment reports and can be taken in account the equation of unit volumes for pump and motor, will obtain:

$$Q_p = C_p \cdot \psi_p \cdot e_{p\,max} \cdot n_0 = q'_p \cdot \psi_p \cdot n_0; \ (18)$$
$$Q_M = C_M \cdot \psi_M \cdot e_{M\,max} \cdot n_M = q'_M \cdot \psi_M \cdot n_M; \ (19)$$

Considering the ideal case in which entire flow supplied by the pump will come to motor when RPM of hydraulic rotary motor, expressed by size adjustment, can be written as:

$$n_M = \frac{q'_p}{q'_M} \cdot \frac{\psi_p}{\psi_M} \cdot n_0 \qquad (21)$$

The above relation will be called, for the studied case, adjusting characteristic or setting characteristic of rotary hydraulic motor frequencies. It may be noted that rpm of hydraulic motor can be adjusted through changing unit volume of pump (primary adjustment) or through modifying of both unit volumes (mixt adjustment).

In the next figure is shown the diagram of adjusting rpm of rotary hydraulic motor in function of adjustment reports. Analyzing graph representation, can be observed that adjustment of low rpm for motor is using primary adjustment, and for high rpm, the secondary one.

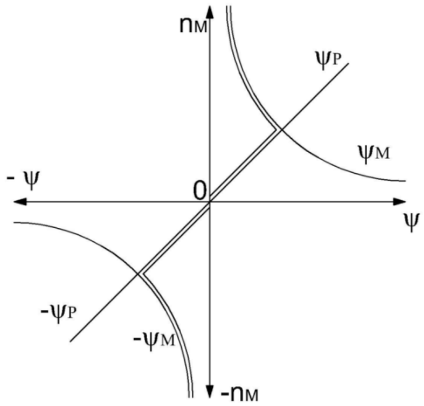

Fig.4. Adjustment chart for rpm of a rotary hydraulic motor in function of adjustments reports

To eliminate the inverting negative eccentricity shocks "e", respective the angle "α", of motor is recommended that this adjustment to be realized to pump, and not to motor, where can appear big variations of rpm. Analyzing the chart presented above can be deduced the optimally adjustment curve, which is represented by the thick line. The optimally shape of adjustment curve indicate a linear variation through pump and a hyperbolic one through motor.

3. CONCLUSION

In the present paper are shown some methods and hydraulic circuit related to these, for adjusting the displacement speed of a linear hydraulic motor piston, respective for rpm developed by the rotary hydraulic motor.

If for an opened hydraulic circuit can be used the two methods shown in paper (volume and resistive), for a closed hydraulic circuit will appeal to unit volume adjustment of pump (primary adjustment), unit volume adjustment for motor (secondary adjustment) or the adjustment of both unit volumes (mixt adjustment).

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METODE ȘI CIRCUITE DE REGLARE A VITEZELOR SI TURATIILOR PENTRU MOTOARE HIDRAULICE

Abstract: *Utilizarea la o scara tot mai larga a actionarilor hidraulice pentru industriile care reclama echipamente ce dezvolta densitati de forta mari a impus dezvoltarea unor metode de reglaj si control a acestor sisteme. Reglajul vitezei de deplasare a unui motor hidraulic liniar, respctiv a turatiei dezvoltate de un motor hidrualic rotativ este realizat prin aplicare metodei volumice sau a metodei rezistive. Un caz aparte il reprezinta circuitele hidrualice inchise unde se utilizeaza reglajul primar,secundar si mixt pentru variatia turatiei unui motor hidraulic rotativ.*

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