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TECHNICAL-ECONOMIC VIEW OF THE REPLACEMENT OF PUMPS WITH VARIABLE VOLUME PUMPS A CONSTANT VOLUME OF THE FREQUENCY CONVERTER

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ABSTRACT: One of the key trends in the construction of the hydraulic drive is the formation of a unified energy system consisting of production or transport machines, drive motor and hydraulic systems. Different construction modifications necessary to align the power hydraulic systems and engine power with the necessary power required by a mechanism that is driven. In carrying out this task, the dominant function of the systems for regulating capacity and pressure pumps. In recent years, in a narrow segment of the application instead of the hydraulic pump capacity regulator used drives-regulation by changing the position of the working element is replaced with the speed control operating elements.
Keywords: hydraulic system, pump control, frequency control, power pump

1. INTRODUCTION

The hydraulic system as a transformer and a carrier of energy used for more than one hundred years and during that relatively short lifetime has experienced a large number of structural transformation. Classic distribution valves with end positions of the working piston structure tailored to the requirements of production and mobile machines they are reducing volume and weight, and increasing operating pressures, flow, speed and accuracy of response time, service life, reliability and efficiency ratios.

The moment these and other improvements cannot effectively and /or rational answers to ever-higher demands, there is a new structural forms of hydraulic components. First, at the end of the second world war servo, then proportional to the last decades intensively developed different constructions built-in valve, with hydraulic and electromagnetic control. The development of electronics is creating new spaces for the development of hydraulics, not only in the field of construction components, but also management systems.

Known principles of transformation of mechanical into hydraulic energy in the pump, its transportation to the actuator mechanism and re-transformation into mechanical energy. Within these, the basic functions, the design of the hydraulic drive must meet other important requirements-energy losses in this way must be minimal.

The total energy loss within the hydraulic system is the result of: a) the pressure drop, b) volume losses within components, c) non-compliant the pump (higher capacity and higher pressure) with maximum and fit.

The level of losses (a,b) reduced by the appropriate structures of hydraulic components, a second level of losses(b) is by its nature complex, and is solved by adjusting the pump with the requirements sether in every moment of the work of the hydraulic drive.

2. PRINCIPLES OF ADJUSTMENT OF THE CHARACTERISTICS OF PUMPS STRUCTURE AND REQUIREMENTS HYDRAULIC DRIVE

2.1 Hydraulic control capacity volume pumps

From the known relationship of power fluid power, pressure and flow:

$$P = \frac{p\,(bar) \cdot Q(l/min)}{600} = f(p \cdot Q),$$

ratio of the total, useful and power loss due to loss of fluid current pressure and flow is shown in diagram form($P = p \cdot Q$) – Figure1.

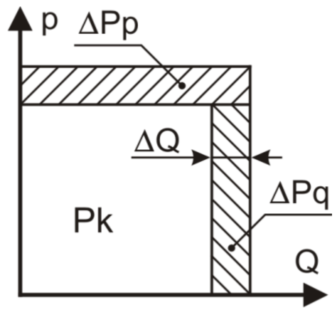

Figure 1. The distribution of the total available capacity pumps, lost power because of the pressure drop- ΔP_p; lost power due to the loss of flow- ΔP_Q and useful power- P_k

The pressure drop and flow in the hydraulic system are the result of losses in the hydraulic components and for them we can say that they are within acceptable limits, normal. However, if the inside of the hydraulic system reduces the damping the flow of oil, at unchanged requires pump pressure is increased to a level that is adjusted to the pressure limiting valve. The resulting excess oil is drained to the tank and increase:

- » total power fluid current (or pumps): $P_{fs} = p_{vp} \cdot Q$, and
- » power losses pump $P_{gfs} = p_{vp} \cdot \Delta Q$.

where: p_{vp} – pressure set on relief valve; ΔQ – oil flow which goes through the pressure limiting valve dra insin to the reservoir.

Described losses reduce the coefficient of utilization of the hydraulic system as a whole. If the hydraulic system, instead of a constant pump capacity installed variable volume pump (vane or piston-axial) and its capacity to comply with the necessary, power fluid stream is reduced to $P_{fs} = p_r \cdot Q_r$, where: p_r-working pressure; Q_r –regulated pump flow.

The mechanism described alignment capacity pumps belong to the group control the flowline (Figure 2, flow control "a").

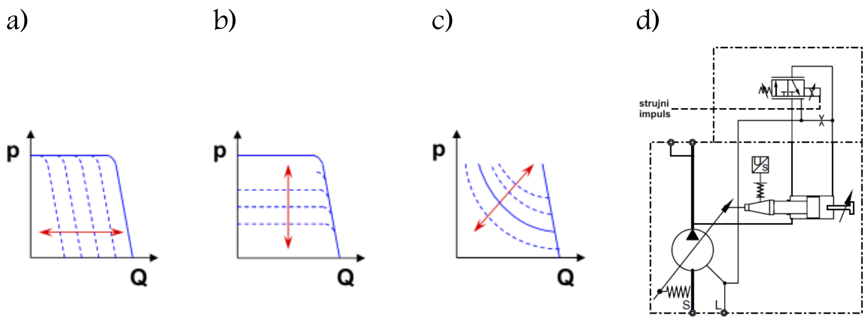

Figure 2. The principles of the regulation capacity volumetric pumps per line capacity (a), pressure (b), the power curve (c) and hydraulic pump control scheme along the line capacity to limit the line pressure (d)

When we talk about the basic principles of the regulation should be pointed out that in addition to the line of flow there and the line pressure control (Figure 2, b) and power curve (Figure 2, c) the capacities pump changes as a function of pressure, but so that the power always maintained at a level of the calculated values.

In order to achieve complete harmony between the pump and the hydraulic system of the machine that the contractual have been developed in addition to a mono-described regulator (pressure regulator, power, hydraulic controller, actuator) and the combined regulators, such as the controller is shown in Figure 2 (d).

The key limitation of the application of hydraulic regulator on the pump where it is possible to change the size of the working chamber by changing the eccentricity (vane and piston radial) or inclined at an angle mechanism that ensures the formation of working chambers (axial piston pump with swash plate or tilting drum). Capacity gear pumps with external or internal gear, orbitralnih, piston with linear arrangement of the working elements and screw cannot be operated via hydraulic regulation.

Good features hydraulic pump regulation are: a) the ability to manage and control pumps duplex operation and the formation of closed hydraulic circuits; b) capacity regulation is changing the specific volume, not speed, and inertial forces do not affect the speed of response; c) controlling the position of the working elements of the pump may be internal or external pressure; d) specific volume control is performed in the whole range of the declared capacity (0 do q_{max}); e) a brief response time which depends on the size of the specific volume pumps - ranging from 50 to 350 ms; f) the possibility of hydraulic constraints of the pump (the pressure - on the regulation of pressure or power capacity to the internal or external pressure); g) the possibility of electronic control of occupied position of the working elements of the pump in relation to the set value and the correction system feedback; h) at the change of status does not change the noise level.

The main disadvantages of hydraulic regulator are: a) the restriction of installation based on the structure of working elements of the pump - can be mounted on the rack, orbitralne and other pumps in which it is not possible to change the working volume by moving the working elements; b) are complex structures; c) the cost of the controller increases proportionally with increasing demands.

2.2. Changing the volume capacity of the pump variable speed-frequency inverter

Frequency inverters are electronic devices that enable speed control of three-phase asynchronous motors on that the input supply voltage and frequency constant values are converted in to variable size. The principle of regulation and regulation characteristics rpm induction motor functionally different from the direct-current control system and servomotors.

With asynchronous motor current that produces flux and the torque current are unique, unlike of DC motors in which they are separated. As in induction motors of this current cannot be measured separately, they must be mathematically converted into a vector controller. To achieve this, frequency inverters feature a real-time mathematical model of the engine, which requires constant monitoring of information flows and the position of the rotor, in order to continuously predict the position of flux. In this way, the flux is controlled current and the torque current and the torque of rotation remains unchanged.

Drives the late sixties began to use the first systems to transport water using a familiar feature of centrifugal pumps to be changes in the number of revolutions of the impeller moves characteristic of p-Q by line pressure (p) and thus changing its capacity. Application development management working pump characteristics obtained as systems to maintain the required capacity of the pump as a function of changes in pressure and /or the default rate to be maintained constant.

Manage capacity pumps a constant volume capacity happiness is rarely in structures of hydraulic drives. Only in the last twenty years, in parallel with the development of construction, improvement of technical characteristics and the fall in the price per kW of power, drives modestly, but casco all are used in the construction of hydraulic systems. For this trend was necessary development in the construction of gear pumps, actually their breakthrough in the area of higher working pressures (250 to 300bar) and higher capacity.

Celebrities are good characteristics of frequency inverters: a) programming continuous regulation of the number of revolutions at constant torque; b) the possibility of programming the ramp; c) defining the starting process; d) a relatively high degree of accuracy of repeated state; e) allowed for short overload and up to 50%; f) increasing the speed and the capacity of the pump in relation to the nominal and the other.

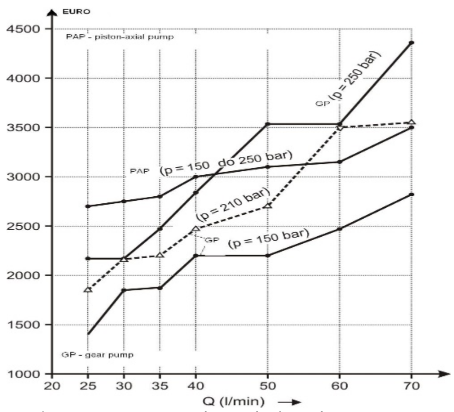

Figure 3. Graphical display prices piston-axial pumps and hydraulic gear pumps with frequency converter

The most important characteristics that limit is range of applications in the hydraulic drive are: a) delay the response speed due to the shifting weight of the rotor electric motors and pumps; b) the lack of controls to achieve the programmed capacity, c) limit the minimum permitted number of revolutions of the pump; d) high producer price; e) a narrow field of application of pumps of constant capacity and others.

3. COMPARISON OFTECHNICAL ANDECONOMICPARAMETERS

Comparison of technical parameters of regulation capacity hydraulic pumps and drives is shown in Table1, and economic in Figure 3.

With hydraulic drives in which it is possible to apply hydraulic regulator or inverter producer price continent pump and controller becomes a priority for the decision. Therefore, a comparative price analysis of axial piston pumps with hydraulic regulator and gear pumps with frequency converter in the work area capacity of 25to 70 l/min and operating pressures of 150,210 and 250 bar (the chart in Figure 3).

Table1.Comparison of technical parameters of hydraulic and frequency converter

Description features	Hydraulic regulator	Frequency converter
Type pumps	vane, piston-axial, radial piston	theoretical: all types in practice: gear
Limitation of specific volume and pressure pumps	1000 cm^3 – piston axial	80 cm^3 – gear with external gear
	350 bar – piston axial	250 bar – gear
Manage regulator	p; Q; P	p; Q
The principle of regulation	changes in the eccentricity or angle	changes in the number of revolutions
The control range of the declared capacity	Q_d do 0	Q_d do 0,2· Q_d kod 10 Hz Q_d do2,0· Q_d kod 120 Hz
Limit the number of revolutions of the pump	always constant	500 - 700
The appearance of inertial forces	no	when changing the state
Response time	50 do 350 ms – depending on the specific volume	depends on the specific volume and the motor power

A comparative analysis was performed for pumps and drives the program the world's leading manufacturers. The diagram above, it is concluded that from the standpoint of economy, in the area of lower pressure, a combination of the gear pump and the frequency converter is more favorable than the piston-axial pump with hydraulic regulator. In parallel with the increase of the operating pressure increases price + pump and inverter, so that at a working pressure of 210 bar, this advantage is lost already at the pump capacityof55 l/min, working pressure250bar code capacity of 42l/min.

4. CONCLUSIONS

The exposed analysis, designed and constructed structures hydraulic drive and hydraulic characteristics of the recording system with a pump whose capacity is altered by changing the number of revolutions (frequency converter), removed any doubts about the possible substitution of conventional hydraulic controllers with frequency inverters. Of course, in addition to bear in mind a number of restrictions which significantly narrowing the scope of such replacement. With hydraulic drives in which it is possible to replace the dominant influence on the application of the system of regulation of pump capacity has the relationship of prices which are different power pump graphically shown in the diagram. Area profitability of the frequency regulator in relation to hydraulic, with the same capacity of the pump depends on the pressure and everything is on a higher application range of frequency inverters is narrow and vice versa. There is no universal rule, so every hydraulic system and pump should be the subject of analysis.

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