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CONSIDERATIONS ON THE PULSATING CHARACTER OF PRESSURE TRANSIENT OF HYDROSTATIC COMPONENTS

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ABSTRACT

The paper analyzes the dynamic response of the hydraulic units with the specific character of the hydraulic pressure and transitional pulse from such establishments. It is a simplified mathematical model for these components hydrostatic. The model has allowed obtaining an analytical solution for the working pressure of systems hydraulic. Are highlightingal the linkages with dynamic response characteristics,in functional and constructive environment.

KEYWORDS: hydraulic, hydrostatic components, modeling, dynamic analysis

1. INTRODUCTION

It is known from the current practice of operating the hydraulic systems that most components of actuators (pumps, motors, control volume, etc) can reach certain operational conditions, especially in transitional arrangements, the pulsating operation of functional parameters (displacements, pressures, flow rates, etc.). The situations that trigger such transitional situations of working arrangements can disrupt components (overload, change in the level of command, starting and stopping the system, etc.). These transitional situations can encourage the emergence of situations of mechanical resonance with other components of the system which can lead to undesirable dynamic phenomena with direct effect premature destruction of components in the system. The result from this fact is considered in response pressure and can be shown on the mathematical model of the dynamic system of these components.

For example, it is considered the model for density of hydraulic units, described by equations of the form [1]:

$$q.\omega \pm \alpha.p \pm \beta.\dot{p} = Q \text{ and}$$
$$J.\dot{\omega} \pm K.\omega \pm M = q.p \;; \qquad (1)$$

Equations (1) refer to the linear dynamic model of engine hydrostatic pumps and dosing, which neglected certain parts with minor effect on the dynamic behaviour [1], Coulomb-type friction torque losses, losses through ventilation proportional to the flow velocity. Starting from the model (1), by substitution and successive processing, results an inhomogeneously linear differential equation of second order, which confirms the pressure response of the analyzed component

$$a.\ddot{p} + b.\dot{p} + c.p = d \;; \qquad (2)$$

Equation (2) is an equation with constant coefficients. They depend on the constructive, the functional sizes and the specifically used hydraulic agent. This dependence is given by the relationship:

$$a = J.\beta / q \,;\, b = J.\alpha / q + K.\beta / q \,;$$
$$c = K.Q / q + q \,;\; d = M + K.Q / q \,;$$

Where: J - is the moment of inertia of the motor or pump being in the rotating movement with instant angular velocity ω; $\beta -$ is the coefficient that depends on the compressibility of the hydraulic medium; $\alpha -$ the linear coefficient of losses through the device gaps, proportional to the pressure *p*; *K*- the linear coefficient of torque losses, proportional to the instant angular velocity ω; *q*- the specific capacity; *Q*- volumetric flow component (discharged or absorbed); *M*- the active or resistant couple component. Equation (2) allows determining the correspondence between dynamic response analysis and functional, constructive and hydraulic environment component parameters, as proposed.

2. RESPONSE OF COMPONENT ANALYSIS

Studies on numerical models for various components, also on nonlinear or linear models, have highlighted the fact that the response of such transient components is obtained in the form of graphs as in figure.1.[1];[2];[3];[5].

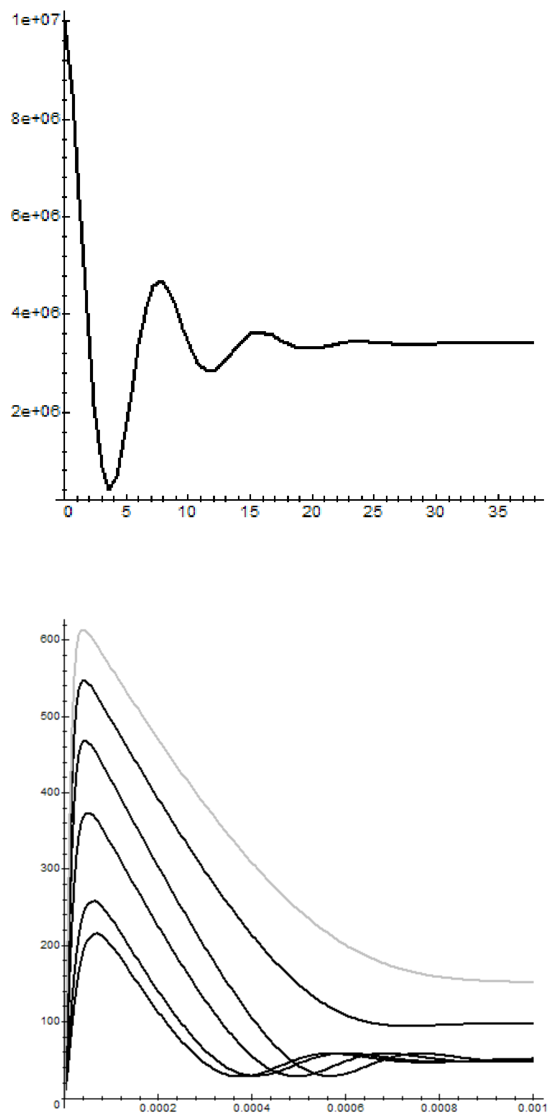

Fig.1. Dynamic response of pressure in hydraulic volumetric units (numerical analysis); ordered - presume (N/m^2, bar); basis- time (sec, min).

And experimental studies [1];[5];[6], have shown the same alert pressure variation at transient operation, fig. 2.

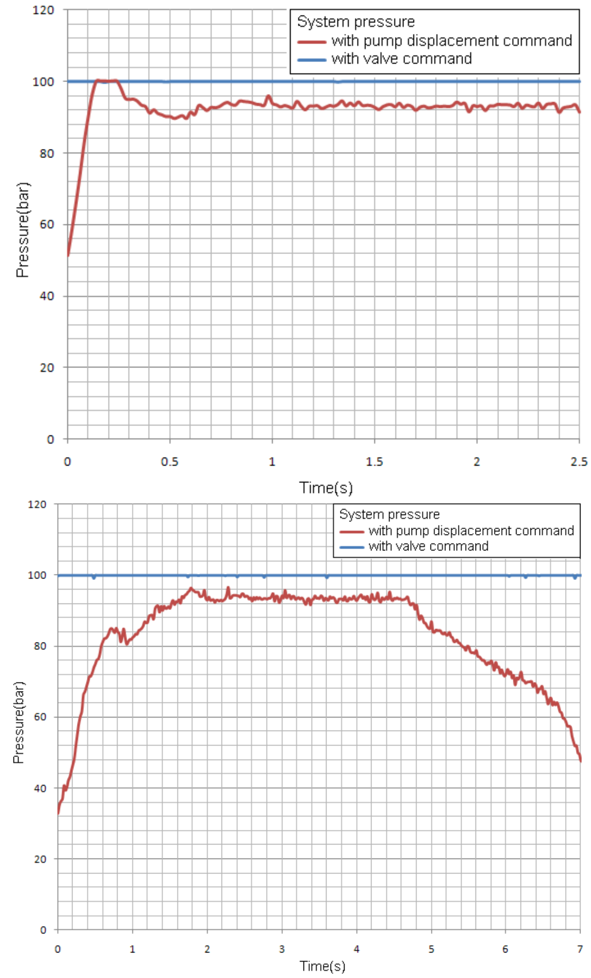

Fig.2. Dynamic response of pressure in hydraulic volumetric units (experimental analysis); ordered - presume (bar); basis- time (sec).

a) Primary circuit pressure variation in the signal stage of excitation control system of flow on the pump;
b) Pressure variation on the ramp signal primary circuit of excitation control system of flow on the pump.

The analytical solution for equation (2) confirms both the numerical answer obtained on the model (1) how and the answer experimentally. To emphasize the physical layout of dynamic equation, equation (2) pressure is put in the form:

$$\ddot{p} + 2n\dot{p} + \omega_o^2 = d/a\,; \qquad (3)$$

The meaning of terms in equation (3) is the following [7]:

n- damping factor; ω_o – natural pulsation; d/a- factor of excitation.

Analytical solutions of the equation (3) are:

- For $n^2 - \omega_o^2 = \omega_1 < 0$ subcritical operation is obtained with the solution:

$$p = p_r + e^{-nt}(p_1 \cos\omega_1 t + p_2 \sin\omega_1 t) \; ; \quad (4)$$

- For $n^2 - \omega_o^2 = \omega_1 > 0$ overcritical operation is obtained with the solution:

$$p = p_r + e^{-nt}(p_1 e^{\omega_1 t} + p_2 e^{-\omega_1 t}) \; ; \quad (5)$$

- For $n = \omega_o$, critical operation is obtained with the solution:

$$p = p_r + e^{-nt}(p_1 t + p_2) \; ; \qquad (6)$$

It means that the quantities of solutions (4), (5) and (6) are: $\omega_1 -$pseudo-pulsation of transient pressure, $\omega_1 = \omega_o \sqrt{1-\xi^2}$;

$\omega_o -$ pulsation of pressure;

$\xi = n / \omega_o -$ damping ratio;

p_r- steady pressure (regime pressure);

p_1 și p_2 – constant dependent on the initial conditions of the dynamic process with pressure-type meaning.

3. FACTORS OF DYNAMIC BEHAVIOR

From the identification of coefficients (3) with dynamic characteristics dignified by the solutions (4), (5) and (6) we are able to determine the functional dependency relations for hydraulic components with functional sizes and hydraulic agent. The considered parameters are:

- The damping factor of the pressure:

$$n = \frac{\alpha . J . E + K . V_o}{2 J . V_o} \; ; \qquad (7)$$

- Pulsation of pressure:

$$\omega_o = q \sqrt{\frac{E}{J . V_o} \left(\frac{K . Q}{q^2} + 1 \right)} \; ; \qquad (8)$$

- The damping ratio:

$$\xi = \frac{\alpha . J . E + K . V_o}{2 J . V_o} \Big/ q \sqrt{\frac{E}{J . V_o} \left(\frac{K . Q}{q^2} + 1 \right)} \; ; \quad (9)$$

- Steady pressure:

$$p_r = \frac{M . q + K . Q}{q^2 + KQ} \; ; \qquad (10)$$

The variation of pressure, described by the solutions (4), (5) and (6) and characterized by the parameters of the relations (7), (8), (9) and (10) is shown in Fig. 3.

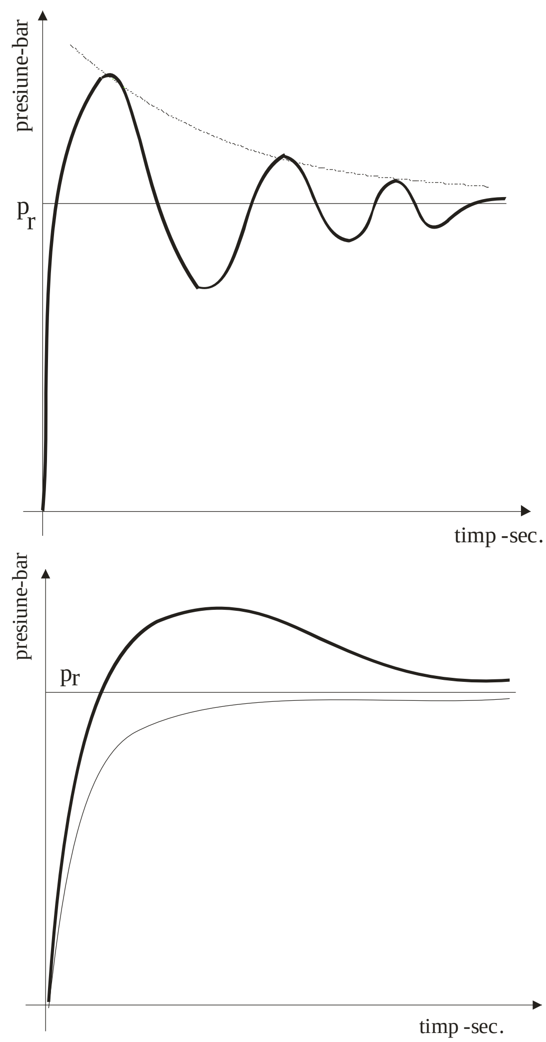

Fig.3.The solutions of the equation (3)
a) subcritical function;
b) supercritical and critical operation

4. CONCLUSIONS

The comparative analysis of the pressure responses for dynamic behaviour of hydraulic volumetric units reveals the folloning concluding remarks:

1. The variation of pressure in time, at least apparently, shows the same shape for both numerical nonlinear dynamic model, for the linear model, the experimental model, and analytical solution for dynamic model (3);

2. Dynamic behavior of a hydrostatic pump or motor unit is characterized by variation of pressure and angular velocity to the shaft, with large variations of instant value around the amount of the stabilized regime. Critical, subcritical or overcritical behavior, depends on the combination of functional,

constructive and specifically used hydraulic environment parameters, and it is described by the dynamic parameters defined with on the of relations (7), (8), (9) and (10);

3. From the analysis of relations (7), (8), (9) and (10) we may find that the phenomenon of rapid stabilization of pressure and velocity in transitory regime depends directly on the hydraulic unit capacity - q, the rigidity of hydraulic fluid, E and the fluid volume V_o between the analyzed hydraulic unit and the load; on the moment of inertia J of components in motion with the unit; α - specific factors of the volumetric and mechanical losses and K-specific factors of the volumetric and mechanical losses.

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