RESIDUAL WATER EVACUATION SYSTEM FUNCTIONING WITH PRESSURE WAVES

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Abstract: *The paper presents a new evacuation system for the residual waters and a theoretical approach regarding the functioning of the hydraulic systems, which are working with pressure waves. There are presented the design and the main characteristics of the alternative flow and pressures generator and also of the cannular pump. The final part of the paper presents the equations, which defines the water-evacuated flow in the ideal case of functioning.*

Key words: residual waters, alternative generator, cannular pum, pressure waves

1. THEORETICAL APPROACHES

All known methods of power transmission by fluid, and their applications are based on continues pressure and flow circulation, which are achieved by the pump and collecting by final elements, we considered fluid is uncompressible. Sonic theory is based on elasticity (compressibility) of energy transmission medium. Thus, energy is transmitted forward from point to point by compression and expansion (oscillation) of fluid mass, which has an effect of longitudinal oscillation, which moves along the fluid line.

Fluid mechanics and applications of hydraulics so far, mostly didn't considered the fluid elasticity, mentioned before, but are the most important characteristics of the transmitted medium.

If is considered a hydraulic system in which every working volume of an alternating motor 7 is connected independently, by a phase pipe 6, with the corresponding working volume of an generator 2, then any modification of the volume of the generator will produce an alternative flow and pressure transmitted along the phase line to the motor 7, figure 1.

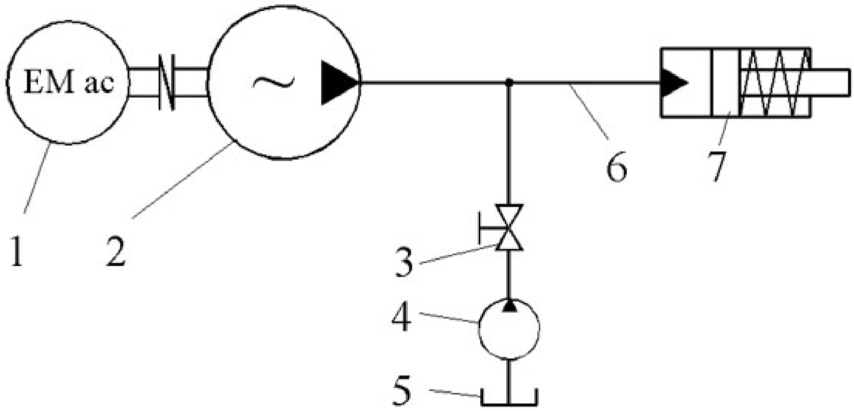

Fig. 1. *Hydraulic system working with pressure waves*

Generally an electric motor 1 (on direct or alternative current) drives the alternative flow and pressure generator. For an optimal functioning the system must be pressurized initially at a static value, with the help of an auxiliary pump 4, after that the line being close with the valve 3.

The equations that defining the instantaneous alternative flow Q_i and also the instantaneous pressure p_i are: [1], [5]

$$Q_i = Q_{a\,max} \cdot sin(\omega_g \cdot t + \varphi_0) \tag{1}$$

and:

$$Q_{a\,max} = \omega_g \cdot e_g \cdot S_g \tag{2}$$

in which: - the amplitude of the harmonic flow, ω_g - the angular frequency of the generator, e_g - generator shaft eccentricity, S_g - piston diameter of the generator, *t* - time and φ_0 is the initial phase angle of the generator shaft.

$$p_i = p_{st} + p_{a\,max} \cdot sin(\omega_g \cdot t + \varphi_0) \tag{3}$$

in which: $p_{a\,max}$ is the amplitude of the harmonic pressure and p_{st} is the static pressure which loading the systems pipes initially.

Making a complete analysis of a hydraulic system working with alternative flow requires to take into account some parameters which define the fall of pressure along the line do to the friction, inertia and elasticity (compressibility) of the fluid.

2. DESCRIPTION OF THE RESIDUAL WATER EVACUATION SYSTEM

The design of the alternative flow and pressure generator is with radial piston and eccentric input shaft, is presented in figure 2.

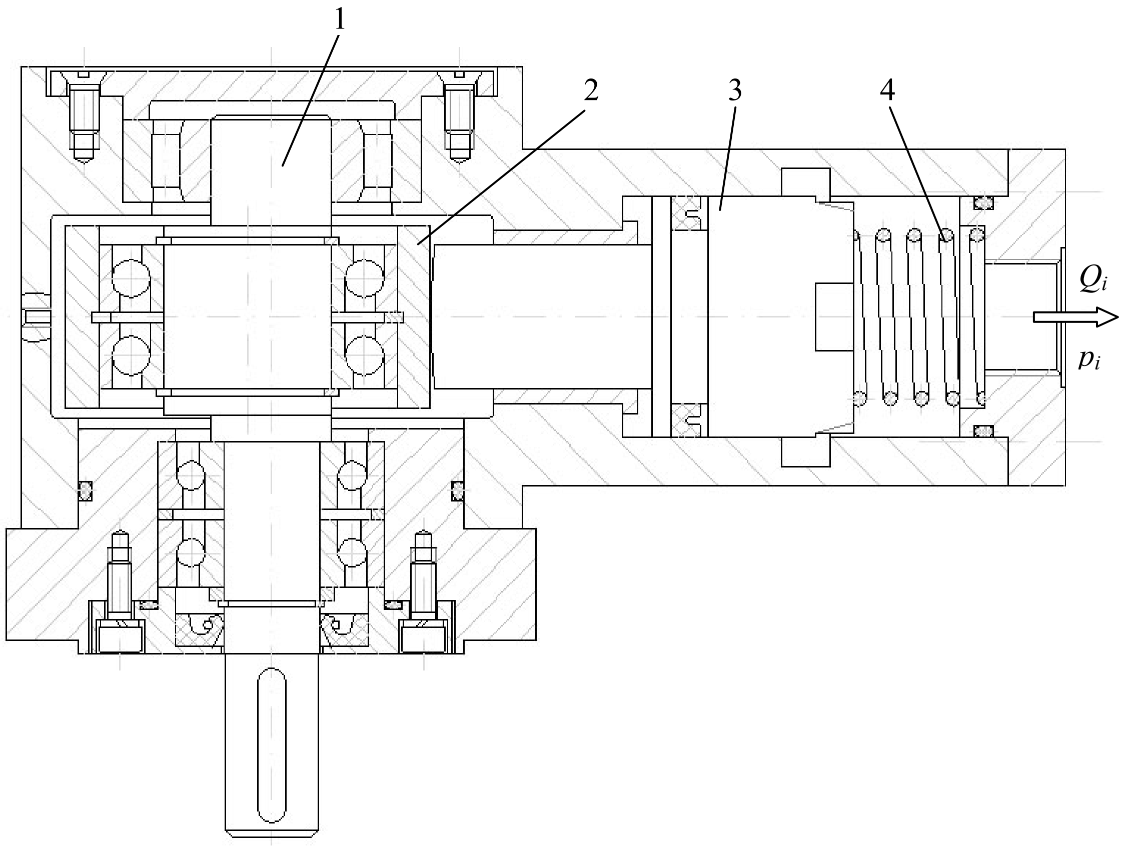

Fig. 2. *The design of the alternative flow and pressure generator*

Each rotation movement of the eccentric input shaft 1 of the generator will push forward the radial piston 2, against the spring 4, in that way in the system line advancing alternative flows and pressures. The retraction stroke of the piston is realized with the help of the compressed spring, which is providing a permanent contact of the piston rod with the eccentric ring 2.

The main characteristics of the designed generator are:

- shaft eccentricity, $e_g = 5$ mm;

- piston stroke, $h_g = 10$ mm;
- piston diameter, $d_g = 40$ mm;
- geometric volume of generator, $V_g = 12.566{,}37$ mm^3.

The alternative flows and pressures provided by the generator will drive a linear motor contained in a compact construction of the water evacuation pump. The design of cannular water evacuation pump is presented in figure 3.

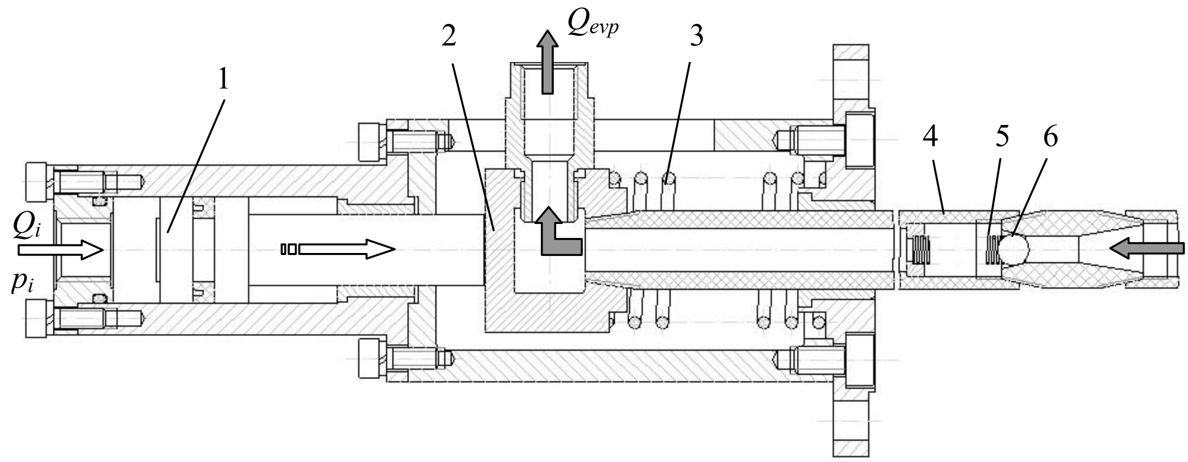

Fig. 3. *The design of the cannular water evacuation pump*

The pressure wave transmitted by the generator along the connecting line will provide the advance movement of the motor piston 1. The piston rod drive in the advance movement the cannular pump elements 2, 4, 5 and 6, compressing in the same time the spring 3, which will provide the retraction stroke of the pump subassembly and also the motor piston.

The cannular pump subassembly is connected with many pipe sections in which are mounted some ball type check valves. Each advance movement of the motor piston provides also an advance stroke for the pipes 4 in the basin containing residual waters. The contact pressure created by the pumped liquid will move the ball 6 against the spring 5 and allow in the same time to him to advance along the pipe. The retraction stroke, with the help of the spring 3, will determine the ball, acted also by the spring 5, to close the passage, preventing in that way the backward flow of the pumped liquid.

The main characteristics of the designed cannular pump are:

- variable piston stroke, $h_p = 0 \ldots\ 25$ mm;
- piston diameter, $d_p = 30$ mm;
- evacuation cross-section, $S_c = 50{,}26$ mm^2.

3. ASPECTS REGARDING THE FLOW RATE OF THE PUMP

The flow rate of the residual water evacuation pump can be determined for the ideal case, in which the pressures fall along the line, do to the friction, the inertia and the compressibility of the hydraulic oil, used in the main assembly of the system, and also the water losses in the cannular pump are neglected.

We consider that the geometric volume of generator is: [2], [4]

$$V_g = h_g \cdot \frac{\pi \cdot d_g^2}{4} = \frac{1}{2} \cdot \pi \cdot e_g \cdot d_g^2 \tag{4}$$

Also, considering that the entire volume is consumed by the evacuation pump motor, we obtain:

$$h_p = \frac{2 \cdot e_g \cdot d_g^2}{d_p^2} = h_g \cdot \frac{d_g^2}{d_p^2} \tag{5}$$

The design of the entire system was made to obtain a stroke and also speed amplification for the water pumping elements. Taking account by the construction parameters of the system, and using the relation (5) we obtain an amplification rate between the generator and motor pistons, defined by the relation: $h_p = 1{,}78 \cdot h_g$.

The maximum flow rate of the generator is defined by: [2]

$$Q_g = V_g \cdot n_g \tag{6}$$

in which n_g is the rotational speed of the generator shaft.

The residual water evacuated flow Q_{wef} , using the continuity equation, is: [2], [4]

$$Q_{wef} = v_c \cdot S_c \tag{7}$$

Assuming that the motor piston speed v_p is equal with the pumping subassembly speed v_c and they are defined by:

$$v_p = v_c = \frac{h_g \cdot d_g^2 \cdot n_g}{d_p^2} \tag{8}$$

Then, using the relations (7) and (8), the flow rate Q_{wef} of the evacuation pump is:

$$Q_{wep} = \frac{h_g \cdot d_g^2 \cdot n_g \cdot S_c}{d_p^2} \tag{9}$$

It can be noticed the fact that even the flow rate of the pump is proportional with the rotational speed of generator shaft this value must be upper limited do to the construction particularities.

4. CONCLUSIONS

The generator and the cannular pump construction was made to demonstrate some functioning principles in laboratory conditions and they can be easily adapted for various industrial purposes.

Also, the entire system was designed taking account the benefits given by the hydraulic transmission which is using the pressure waves and alternative flows.

The modular design of the pumping device allows the easily replacement of the cannular pump subassembly with another, same as the elastic membrane model.

5. REFERNCES

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