WATER CONSUMPTION CONTROL CALCULATION IN HYDRAULIC RAM DEVICE

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Annotation. The article discusses the advantages and disadvantages of hydraulic shock in water supply networks. Experiments have been carried out on hydraulic pump based on hydraulic forging. The hydraulic shock was calculated by controlling the flow of water using a calculation method recommended by L.F. Moshnin. In addition, the causes of hydraulic shock in water supply systems have been identified and simple and reliable methods have been proposed to reduce the effects of hydraulic shock.

Key words: Hydraulic shock, pump aggregate, gate valve, valve.

Introduction. Hydraulic lifting devices are named differently in different sources, such as water lifts, hydraulic pumps, and hydraulic pumps. According to scientists working in the field of hydraulic scanners, their history goes back a long way.

In 1772, the English engineer J. Whitehurst was the first to create a hand-operated device resembling a hydraulic crane called the Whitehurst Device[1]. The first prototype of an automatically controlled hydraulic device was patented in 1797 by a British patent in 1797 for a joint invention by French scientists J. Mongolier and F. Frgand. The U.S. patent was granted in 1809 to researchers J. Serneau and S. S. Hallett. In 1839, Strawbridge, an American businessman, began industrial production of hydraulic presses. In Russia, Professor SD Chistopolsky described the theoretical methods of calculating hydraulic shock absorbers based on N.Yu. Zhukovsky's theory of hydraulic shock in his 1930 book "Hydraulic shock"[2], [3].

The advantage of hydraulic ram devices is that, unlike pump units, no electric motor or muscle power is required for their operation. But the efficiency of such devices does not exceed 0.2-0.5. Therefore, any research to improve the efficiency of their use has become one of the most pressing issues in the development of engineering devices that lift water upwards.

The principle of operation of the experimental device. The principle of operation of a hydraulic ram based on a hydraulic shock event was studied using the device shown in Figure 1.

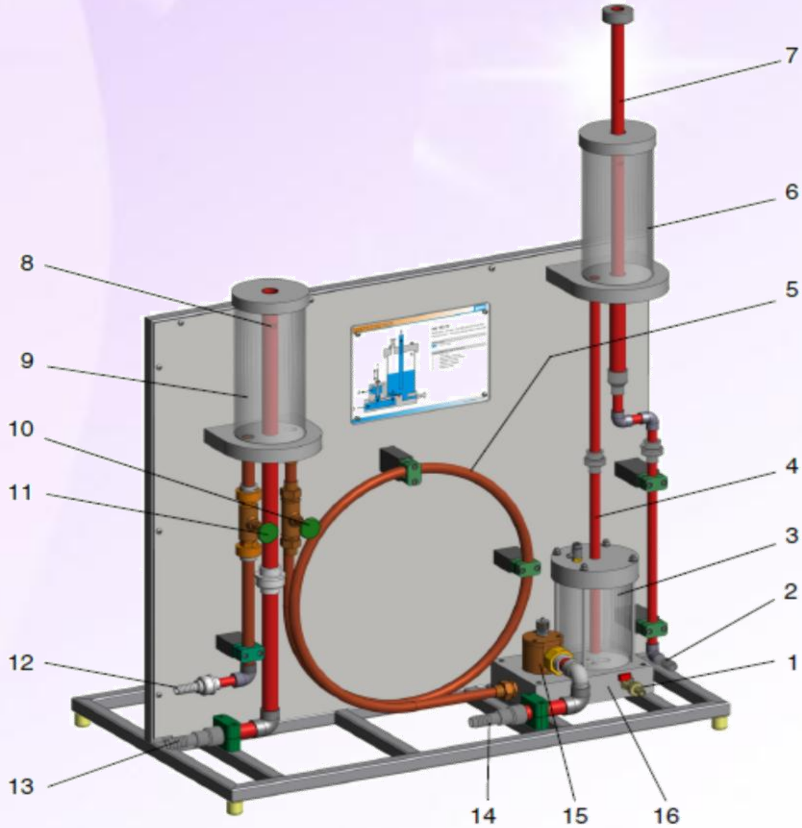

Figure 1. Hydraulic pumping device.

1- device drain; 2-pressure network carrying water; 3- air cap; 4- vertical pipe; 5- impact valve supply network; 6-water pressure secondary tank; 7- overflow pipe, adjustable; 8- overflow pipe; 9- primary water pressure tank; 10- control valve; 11- inlet valve; 12- water pipe; 13-drainage overflow pipe; 14- drainage; 15- waste fluid drain valve; 16- the second valve is located in the air chamber.

The device consists of two water pressure tanks, two valves, an air chamber, inlet and outlet lines and taps. In the initial position shown in Figure 1 above, the taps (8 and 9) mounted on the pipe connecting the pressure grid (1) to the (2) valve hydraulic cylinder are open and 10 taps are closed.

When the pump unit is started, the valve is gradually opened as a stream of water flows through the pipe (6) to the bottom of the hydraulic cylinder and rises. [4], [5]. The opening of the valve in this order prevents the formation of hydraulic shocks in the pressure line (1). Experiments show that an average pressure of 0.03-0.04 MPa is required to fully open 100 and 200 mm valves.

When the pump unit is switched off, the water flow moves in the opposite direction under the static pressure, closing the check valve (3) in the pressure network. When the valve is completely closed, the water flow in the pressure line (1) flows backwards (3) through the round holes in the valve (5) towards the suction line. At the same time, due to the difference in pressure on both sides of the check valve (3), the water flows through the pipe (7) to the top of the hydraulic cylinder (3) and the valve is completely closed. In this case, the water flow is controlled by means of a tap (9).

Calculation of hydraulic shock in water flow control. In order to prevent hydraulic shock in the water supply network, the cutting surface is gradually closed. In some cases, it may be necessary to calculate the time interval to control the shutter. The closing time of the electrified valve is given in its passport, t time requires checking for shock[6]. For example, in electrically operated valves with a nominal diameter of 100 mm to 1200 mm, the closing time is from 0.8 to 4.6 minutes, and in similar pile valves from 0.7 to 5.3 minutes, depending on the diameter. For hand-operated valves up to 300 mm in diameter, $t = 20 \div 70\, sec$ or average $t_{o\prime rt} = 45$ sec. At the beginning of the water supply network there is a pump or a pressurized water structure, the pressure of which is equal to H_p. At the end of the section, a valve is installed at point B. Here, at free pressure, the loss of pressure at time t is $h_p = H_0 - h_0$.

To simplify the calculation, the working pressure is $H_p = H_0$ [7], [8]. In this case, Professor L.F. Moshnin analyzes the sequence of calculation of the pipe for hydraulic shock as follows[9]:

1. The propagation velocity C is determined;

2. The phase length $\tau_0 = \frac{2l}{c}$ is calculated and the shut-off time t is compared with τ. If $\tau_0 \geq \tau$, then there is a direct hydraulic shock. If $\tau_0 \leq \tau$, there is a reverse shock and it is calculated in phase;

3. If there is a reverse shock during closing of the valve, the number of phases of vibration of the pressure is calculated:

$$n_f = \frac{\tau_1}{\tau_0} \quad (1)$$

4. The following three equations are solved together to determine the phase pressure in the reverse pulse:

$$\vartheta = \frac{C}{2gK_g} + \sqrt{(\frac{C}{2gK_g})^2 + \frac{H_0 - h_0 + h_m}{K_t}} - 2\frac{\varphi_g}{K_g} \quad (2)$$

$$\varphi_0 = \frac{C}{g}(\vartheta_0 - \vartheta) - \varphi_g \quad (3)$$

$$H = H_0 - \varphi_0 - \varphi_g \quad (4)$$

here K_t- coefficient of pressure loss in pipes and valves;

ϑ- the velocity of a fluid that is assumed to be constant in the phase under consideration, m/sec;

$h_m = \Delta H$- hydraulic shock module:

$$h_m = \frac{C\vartheta_0}{g}$$

$$K_t = K_0 + K_1 \quad (5)$$

here K_0- coefficient of pressure loss in the pipe:

$$K_0 = \frac{h_p}{v_0^2}$$

K_1- the coefficient of hydraulic loss of pressure in the valve is determined experimentally for different opening of the valve:

$$K_1 = \frac{0.01605}{(1 - \frac{x}{D})^{2.6837}}$$

x- the value of closing the shutter hole with a disc, m;

φ_g- the length at which the wave reaches the shutter during viewing, m;

φ_0- the wavelength at which the wave rises from the shutter at the time of viewing, m;

H- hydraulic forging at the end of each phase, m

Conclusion. The calculation of hydraulic shock in water supply networks[4], [10] and the choice of attenuators should take into account the specific characteristics of wastewater, changes in the movement of the hydraulic shock wave due to the release of various gases from the water during the unstable flow.

Simple and reliable methods should be chosen to reduce the effects of hydraulic shock, and hydraulic shock absorbers should be installed. When selecting hydraulic shock absorbers, it is recommended that there be few contaminants in the wastewater environment and that no wastewater leaks out during operation.

An energy-efficient hydraulic lifting device that lifts water upwards can operate efficiently in two different modes. This is the mode with the highest water transfer efficiency and the mode with the highest efficiency. One of the most important elements of a hydraulic tapping device is its supply network, which ensures the reliable operation of the device.

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