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## **METHODS OF INCREASING ENERGY EFFICIENCY IN PUMPING UNITS**

**Abstract.** In this article, the issues of the economic mode ensured by pressure stabilization in the fluid supply system of pumping units are considered. It is shown that the main control parameter in network pressure stabilization systems is the pressure at the dictation point.

**Keywords:** Pressure, automatic control system, pressure sensor, pump unit, pump speed, pressure, water taps, dead zone.

For a significant group of pumping units, the economical mode is ensured by stabilization of pressure (pressure) in the fluid supply system. Such installations include pumping stations of the second and third elevations of industrial and urban water pipelines, pumping stations of pumping, stations of closed irrigation systems and the like. The need to stabilize the pressure in the network of these stations is due to the variable nature of the water consumption regime. The probabilistic nature of water consumption requires continuous changes in the operating mode of the pump unit. Changes must be made in such a way that the required values of technological parameters (feeds, heads) in the system as a whole are maintained and at the same time the minimum possible energy consumption of the pump unit is ensured.

This problem is solved by an automatic control system (ACS) of the pump installation, stabilizing the pressure in the network at a given value. It is almost impossible to stabilize the pressure at all points of a complex branched network. The

location of the dictation points is determined by hydraulic calculation of the network or empirically, as well as by the results of long-term operational observations. With a significant redistribution of water flows in the network, the dictating point can change its location. When the network is working in conjunction with pumping stations that are close to the consumers, for example, pumping stations, the dictating point can be located on the pressure head of the station. The main control parameter in systems that stabilize the pressure in the network is the pressure at the dictating point (s). Stabilization of the pressure at the dictating point provides the necessary minimum pressure in the network and reduces the energy consumption spent by the pumping station for water supply [1,2].

Below we consider the process of stabilizing the pressure at a dictating point using the example of a simple unbranched water supply network. Suppose that one pump is operating at the station(Fig.1). For normal water supply to consumers at dictating point A, the so-called free head  $H_{fr}$  must be maintained. Point A is located at  $Z_2$  above the water level in the tank. Losses of pressure in the conduit depend on the flow rate to the second degree. Therefore, in order to raise the water from the mark  $Z_1$  to the mark  $Z_2$ , to overcome the hydraulic resistance and provide a given free head, it is necessary to develop the water head

$$H = (Z_2 - Z_1) + H_{fr} + SQ^2. \quad (1)$$

Graphically, the dependence of the required pressure at the outlet of the pumping station on the flow rate is shown by curve 1 in Fig. 2. If this dependence is observed, a stable required pressure  $H_{fr}$  is maintained at the dictating point.

However, this pressure during operation of the pump with a constant speed is only supported in maximum flow mode. The rest of the time, when the pump operates at a low flow rate, for example at 7 h, the system operates at a high pressure. In fig. 2 shows how the pressure changes at different times of the day depending on the change in the water supply of the pump unit.

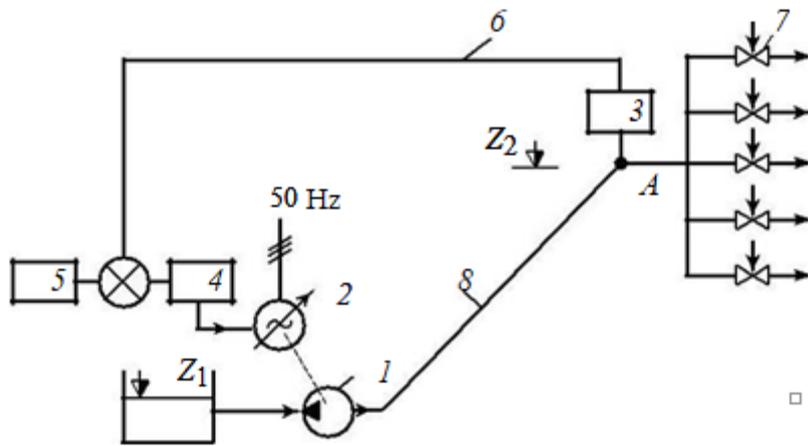


Fig.1. Schematic diagram of the stabilization of pressure in the dictating point A of the water supply network:

1 - centrifugal pump; 2 - adjustable electric drive; 3 - pressure sensor; 4 - PI controller; 5 - master device; 6 - communication channel; 7 - water-folding devices; 8 - water conduit.

In order for the pump installation to work without exceeding the pressure for any water consumption, it is necessary to equip it with an appropriate automated control system (ACS), which includes adjustable electric drive. Such a system consists of a pump unit equipped with an adjustable electric drive, a pressure sensor, a proportional-integral controller (PI controller), a master device and communication channels between the converter and the controller (see. Fig.1). The master device determines the required pressure value at the dictating point of the water supply network. The signals from the pressure sensor installed in the dictating point of the network, and from the master device are fed to the PI controller, where they are compared with each other, processed accordingly and then transmitted to the control system of the controlled electric drive of the pump unit [1,4,6].

Suppose that at the next time  $t_2$ , the consumer, closing one of the water taps, reduces the water withdrawal from the system. A reduced pump flow  $Q_2$  corresponds to an increased head  $H_2$  and a reduced head loss  $h_2$ . Due to the changes in the system operating mode, the pressure at point A can be written as  $H_{A2} = H_2 - h_2$ . As can be seen from fig.3,  $H_{A2}$  is greater than the set pressure value  $H_{set} = H_{A1}$ .

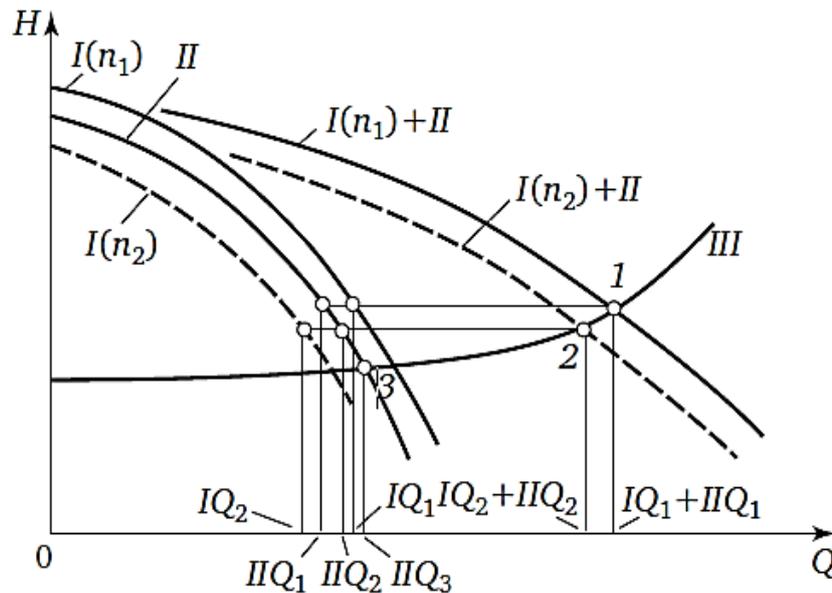


Fig.2. Schedule of joint operation of the network and pumps (regulated and unregulated): $I(n_1)$  - pressure characteristic of an adjustable pump at a speed of  $n_1$ ;  $I(n_2)$  - the same for  $n_2$ ;  $II$  - pressure characteristic of an unregulated pump;  $I(n_1)+I(n_2)+II$  - total pressure characteristics of both pumps at  $n_1$  and  $n_2$ , respectively;  $III$  - characteristics of the pipeline

In fig. 2 is a graph of the joint operation of the network and two pumps: regulated and unregulated. As in the previous case, when the water consumption changes and the pressure increases at the dictating point, the speed of the adjustable pump decreases, and when the pressure decreases, it increases. But at the same time, the characteristic of an adjustable pump changes its position, while an unregulated pump remains unchanged. For this reason, although the pumps operate with the same pressure, their supply is different. With a decrease in speed, the variable displacement pump operates at a lower flow rate, while the noncontrollable flow increases. Other operating parameters of regulated and unregulated pumping units (efficiency, power, etc.) also differ. In the event of a significant change in water consumption, there comes a time when the flow of the regulated pump decreases to zero, and the flow of the uncontrolled pump increases to a certain value of  $IIQ_3$  (see Fig. 2). At this time, the pressure of an unregulated pump becomes greater than a regulated one. The check valve of the adjustable pump closes, and if it is absent, water flows through the pump in the opposite direction. As a rule, when equipping the pump unit with an adjustable

drive, the presence of a check valve is mandatory. Due to the senselessness of this mode, self-propelled guns at this point in time turn off the uncontrolled pump and force the speed of the controlled pump to the maximum value. To exclude the occurrence of such modes, modern frequency converters are endowed with a special function that prevents such a mode. With a further decrease in water consumption, the regulation process is carried out only by changing the speed of the adjustable pump. If an adjustable pump, due to increased water consumption, reaches the maximum possible speed, but, despite this, cannot provide water in the required quantity, and the pressure at the pump station outlet begins to decrease sharply, then the self-propelled gun should give an impulse to turn on the unregulated pump and reduce the frequency rotation of the adjustable pump to the desired value[1,7,8,9,15].

It should be borne in mind that the process of changing water consumption does not always go monotonously. Often, when the supply limit value  $Q_3$  is reached, the process can stop and go in the opposite direction. In such cases, a situation arises in which an uncontrolled pump will repeatedly turn on and off. To avoid such phenomena, self-propelled guns must contain a locking device that allows you to turn off or turn on an unregulated pump only if there is a steady trend in water consumption. In some cases, for example, if water consumption for a long time fluctuates around the boundary value of  $Q_3$ , it is advisable to equip both adjustable electric drive pumps so that in this mode they both work with a reduced speed. When installing different types of pumps at the pumping station, in order to avoid the formation of the so-called dead zones (DZ), it is advisable to equip the largest pumps with the most gentle characteristic with an adjustable electric drive.

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