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DEVELOPMENT OF MODEL OF THE CONTROL SYSTEM BY PUMP STATION OF THE SECOND RISE

The paper considers the task of efficiency improvement for the controlling over the pumping station due to ensuring the joint operation of the pumps supporting on the output the exact value of pressure or supply. The paper presents the built model of the system controlling the pumping station which allows to provide the joint operation of the pumping aggregates taking into account the ventilator character of loading and quadratic law of frequency management.

Keywords: *model of the controlling system, pump units, pumping station, daily expenses, productivity, optimum operation mode.*

The introduction

Pump stations of the second rise are usually equipped with several pump units (PU), switched in parallel. Shall one of the aggregates fail, the other will be switched instead but with the different parameters. The problem is to ensure their simultaneous operation. Especially urgent will this problem arise in Ukraine, where the majority of the pump stations are still equipped with the Soviet PU with the exhausted resource of non-failure operation. Therefore the development of the city water supply system model enabling to calculate the optimum variants of the decision when maintaining the joint PU work is urgent.

The choice of optimum combinations and productivity of the switched PU is given in works [1, 2] where the expenditures on electricity are chosen as the target function; imposed restrictions on ensuring the necessary or not less as the necessary supply with the consideration of the constant pump operation. The received decisions allow to solve a problem of series mode of PU, without the consideration of the pump joint operation.

There is the known functional schema of the extreme power efficiency systems of the pump station controlling suggested in [3], where the necessary pressure and supply are ensured by the regulator of technological parameter; the efficiency of the pump is considered during the change of its productivity; the minimum of losses in the engine is ensured. The suggested functional schema does not allow to carry the controlling over the pump station and to ensure the joint PU operation with the network of water supply.

The objective

The objective of work is to increase the controlling efficiency over the pump station due to ensuring the joint pump operation and maintenance of the exact pressure value or supply on the output of the pump station (PS).

Statement of a problem

It is necessary to develop the city water supply system which considers the hydroenergetic peculiarities and PU parallel operation as well as the initial technological parameters of the water supply system.

The basic part

The schedule of water consumption [4] is calculated according to norms of water consumption by the population, the enterprises, the fire system and other needs of the city, according with which the station should provide the corresponding supply value within every hour of the day to cover the needs of the city in water supply. Following the characteristic of a water supply network this supply value corresponds to the certain value of pressure. To maintain the coordinated work of a water supply network with the PS, the submission from the water supply should be to equal to the total submission of PS on its output [5]. For this purpose it is essential to regulate the productivity of the station. It can be active or passive regulation. Using throttling as the most simple means of regulation, the electric energy is spent inappropriately as the engines work in the nominal mode, and the productivity of their operation can essentially differ from the nominal. Besides, such way of regulation leads to the fast exhaustion of a service life and, accordingly, to the reduction of its operation term. Using the additional equipment for the PU productivity regulation also leads to additional expenses and is appropriate under certain circumstances [4]. The most efficient way of regulation is the PU productivity regulation by changing the number of its rotations [5]. With the number of PU exceeding 2, the productivity of the station can be regulated also by switching or shutting off certain PUs [1, 2]. The question is which of PU should be switched or switched off at a definite period of time. The equal wear of the equipment resources is used as the choosing criteria during the execution of the PS controlling systems. This means that the switching or shutting off of the PU station stipulates for the balancing the residual resource of the pump equipment (basically of the pump and the electric motor). As the switching or shutting off of the PU leads to the spasmodic change of the station productivity which, not always meets the necessary value of productivity, this way of regulation becomes more efficient for ensuring the frequency controlling over the electric motors of the PU that remained in operation [6].

Considering that any regulation leads to change of either the PU characteristic or the water supply net, the problem of achievement of equality of supply from the schedule of water supply to the total supply of PS with the certain value of pressure on its output becomes complicated because the change of supply value changes the pressure. Thus, to receive the value of PU supply on the station ($Q_1, Q_2, ..., Q_n$ where n - the number of the in parallel working PU), total supply value on the station (Q) and pressure on its output (H) with which the joint PS operation together with the water supply net are ensured which stipulates for the city requirements in water to be calculated using the equation system:

$$\left.\begin{array}{l} H = H_c + R_c Q, \\ Q = Q_1 + Q_2 + \ldots + Q_n \\ H = \nu^2{}_1 H_{0.1} - R_{b.1} Q_{1,} \\ H = \nu^2{}_2 H_{0.2} - R_{b.2} Q_{2,} \\ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \\ H = \nu^2{}_n H_{0.n} - R_{b.n} Q_{n.} \end{array}\right\}, \qquad (1)$$

where H_c - the static pressure necessary to rise the liquid up to the certain height (a geodetic pressure); R_c - hydrodynamical resistance of a network of water supply; v_n - relative speed of rotation of the driving wheel of n-th pump; $H_{0.n}$ - pressure which develops n-th pump at zero submission; $R_{b.n}$ - internal resistance of n-th pump; Q_n - submission of n-th PU.

On fig. 1 the model of a control system PU (CSPU) is presented.

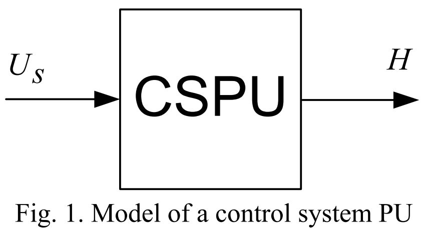

Fig. 1. Model of a control system PU

Supply of Q on the output of each PU answers the certain value of a setting pressure U_s and is calculated on the mathematical model of the system converter of frequency-asynchronous motorcentrifugal pump (CF-AM-CP). If the specified model shall be additionally equipped with the model of the water supply network (NWS), then considering the ventilator loading character, the model of system the CF-AM-CP-NWS will look as on fig. 2.

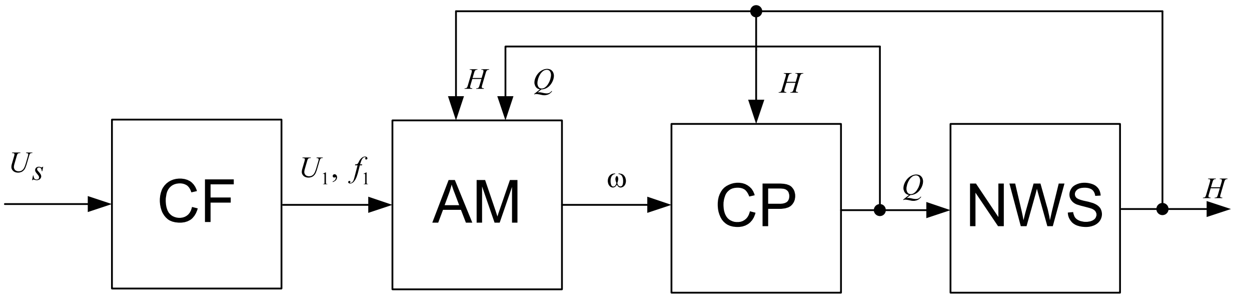

Fig. 2. Model of system the CF-AM-CP-NWS

The feedback on the AM on pressure and supply is stipulated for by the loading with CP acting as such. The moment of resistance on a shaft of the engine [7]:

$$M_r = \frac{\rho g Q H}{\omega \eta_m}, \tag{2}$$

where ρ - density of a liquid, kg/m^3 (for water of =1000 kg/m^3); g - acceleration of free falling, g=9,81 m/s^2; Q - productivity turbo mechanism, m^3/s; H - pressure, m; η_m - efficiency of turbo mechanism with the given mode of its operation; ω - angular speed of working body of the pump, rad/s.

The feedback on CP on supply is caused by the equation of the pump which connects the pressure on its output with the productivity and relative speed of rotation which, for pumps with flat characteristics, looks like:

$$H = \nu^2 H_0 - R_b Q. \tag{3}$$

According to (3) block diagram of the pump, on the input of which there will be submitted the relative speed of rotation of the working body, and with the productivity on the output, is presented on fig. 3

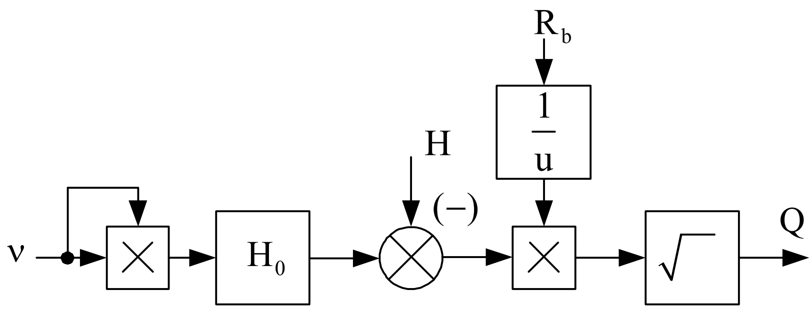

Fig. 3. Block diagram CP

Having taken the block diagram represented on fig. 2 as the initial one, it is possible to build the multilinked system of water supply in a network. Fig. 4 presents the controlling system of the station of the second rise which consists of three PU.

Joint work of three PU is provided with the industrial controller (PC) the output signals of which are the signals of the task of each CF. The input signals are the necessary value of supply at each hour of the day and other information necessary for realization of the system calculations (1). According to the program of the controller there is the calculation and the commands on switching on/off of the PU and value of its productivity.

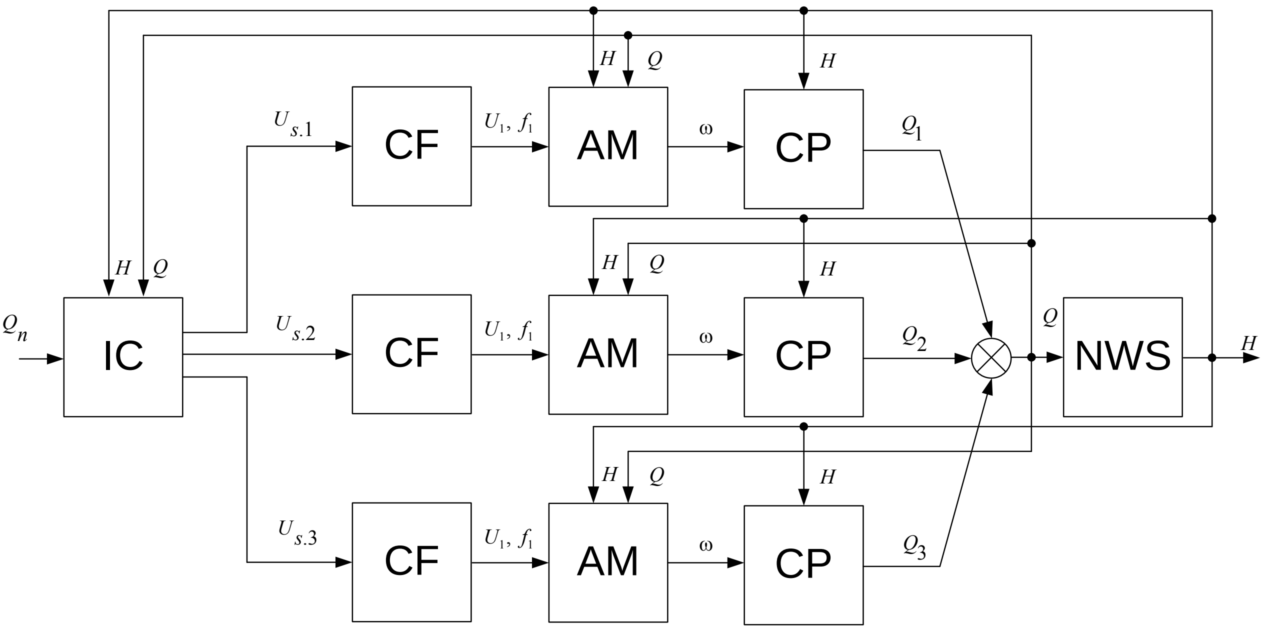

Fig. 4 Controlling system of station of the second rise which consists of three PU

Conclusions

Thus, elaborate model of the control system of the pump station of the second rise which provides for an opportunity of the joint work of the station pump units, maintaining on its output the necessary value of the pressure or productivity. The application of the developed model will allow to carry out the preliminary choice of variants of the optimum decisions or the most appropriate alternatives for the efficiency of each PU by the certain criterion, for example on station electric energy consumption. The choice of one of the decision variants comes true for the joint operating PU considering the ventilator character of the loading on the PU driving engine observing the law of frequency controlling U/f^2=const.

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