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A SIMPLIFIED METHOD FOR DETERMINING THE WATER SUPPLY OF CENTRIFUGAL AND AXIAL PUMPING UNITS OF MUNICIPAL WATER SUPPLY SYSTEMS

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Annotation. The article presents a calculation formula and recommends a new simplified method for determining the water supply of pumping units, based on the theory of energy balance of hydraulic machines.
Key words: pumping station, centrifugal, axial pump, water measuring device, turbid water flow, water supply of pumps, dispersed impurities, hydroabrasive wear, energy balance,

The most important element of modern systems of municipal and water management are pumping stations, which are a complex complex of structures and equipment, technical indicators and parameters of which largely determine the reliability, durability and economic efficiency of water supply or discharge. At the same time, pumping stations are the main consumers of energy in these systems. Therefore, the specific energy consumption for the supply and discharge of water depends on how rationally they are designed and operated.

A great contribution to the development of this scientific direction was made by scientists from domestic and foreign scientific schools: K.K. Shalneva, O. Ya. Glovatsky, V.B. Dulneva, V. Ya. Karelina, S.P. Kozyrev, A.D. Pernik, N.I. Pylaeva, M.G. Timerbulatova, L.S. Zhivotovsky, B.I. Karlina, M.M. Orekhelashvili, A.I. Zolotar, R. Knappa, Yu.U. Edel, A.N. Papira, A.P. Yufin, A.M. Arifzhanov, K.Sh. Latipov and others [1,2,3].

Generalization of a large number of theoretical and experimental data, development on this basis of modern designs, recommendations, methods and methods of calculation, sufficiently fully taking into account information about the physical nature of the processes occurring during the operation of pumping units, which is a necessary condition for solving a major problem, which is devoted to the research data.

In order to assess the influence of hydraulic processes occurring inside the pump on reducing water supply in the Namangan Civil Engineering Institute under the guidance of prof. M. Mamazhanov conducted field surveys and experimental studies of pumping units No. 1 and No. 2 of the pumping station "Turakurgan-1" and No. 6 and No. 7 of the pumping station "Irrigator" (Namangan region, Republic of Uzbekistan), equipped with the same centrifugal pumps of the D 4000- 95 (22 NDs with n = 730 rpm).

The object of the research is centrifugal and axial pumps of pumping stations of water supply and sewerage systems. Analytical methods for determining the wear of metals, the method of energy balance of hydraulic machines, and generally accepted methods of laboratory and field testing of pumps and their elements are adopted in the work.

Comparison of the factory characteristics with the data of field tests shows that the experimental points are slightly lower from the pressure line H, but the pump consumes sufficient power. With a fully open valve, the pump head is equal to $H_в$ = 54.8 m, the water supply was $Q_в$ = 698 l / s instead of the design QA = 1000 l / s.

Until now, the wear of the working bodies of centrifugal and axial pumps, depending on the mode of their operation, has been poorly studied, and a method for selecting operating modes, taking into account the wear of their parts, has not been developed. Based on the assessment of the current state of knowledge of the issues of reducing the operational indicators of centrifugal and axial pumps, tasks are determined to increase the efficiency of their work

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The experience of operating centrifugal and axial pumps necessitated scientific substantiation and experimental verification of their efficiency when pumping high-turbidity waters, which lead to intensive cavitation-abrasive wear of their parts associated with high operating costs.

Until now, at many pumping stations, water measuring devices are absent or inactive. The complexity of the implementation of a water metering system is due to many reasons: unreliable operation of water measuring equipment in a turbid water flow, the complexity of its design and the need for periodic checks, as well as high cost, the organization of special teams for the installation and calibration of flow meters, the need for highly qualified service, etc. The proposed methods for determining the water supply of pumps have certain drawbacks and give inaccuracies when calculating the flow Q. For example, clogging of trash grids, closing the gate valve, parallel operation of pumps, air accumulation at elevated points of pressure pipelines, changes in the voltage of the electrical network, etc., affecting change in Q are not taken into account in these techniques [4,5].

Taking into account the above, on the basis of the theory of energy balance of hydraulic machines to determine the water supply of electrified pumping units, the following formula is proposed:

$$Q = K\sqrt{(IU \cdot m - \mu)^{2/3} - (\pm h_{м...в} + h_{ман} + y)} \qquad (1)$$

Where, I and U - respectively, the readings of the ammeter and voltmeter connected to the electrical network; $\mathbf{h_{м.в}}$ and $\mathbf{h_{ман}}$ – respectively, the readings of the monovacuum meter and the pressure gauge installed on the suction and discharge nozzles of the pump; y - height between pressure measurement points; **к,m,** μ - constant coefficients determined by the following expressions:

$$K = \sqrt{K_d + S_H}; \;\; K_d = 0{,}0827 \cdot (d_2^{-4} - d_1^{-4}) \qquad (2)$$

$$m = \frac{\chi}{\beta}; \;\; \mu = \frac{N_{мех}}{\beta}; \qquad (3)$$

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$$\chi = 3 \cdot 10^{-3} \cdot \cos\varphi \cdot \eta_{дв} \cdot \eta_{пер} \quad (4)$$

$S_н$- constant characterizing the internal hydraulic resistance of the pump;

cosφ and $\eta_{дв}$- power factor and efficiency of the electric motor;

$\eta_{пер}$ – Transmission efficiency:

The coefficient is determined by the formula:

for centrifugal pump:

$$\beta = 0{,}435 \cdot (\pi D_2 b_2 - \sigma_2 b_2 Z_л)\sqrt{n_s} \quad (5)$$

for an axial pump:

$$\beta = 0{,}682 \cdot (D_2 - d_{вт}^2)\sqrt{n_s} \quad (6)$$

In the formula D_2 and **D** – respectively, the diameters of the impellers of the centrifugal and axial pumps;

b_2 and **σ_2** – respectively, the width and thickness of the blades around the circumference diameter **D_2**;

$d_{вт}$ - diameter of the axial pump impeller sleeve;

$Z_л$- number of blades;

n_s – coefficient of speed of the pump.

Power expended on mechanical friction **$N_{мех}$** is a constant value and is defined as the sum of the powers spent on friction of the outer surfaces of the disks against the liquid **$N_{т.д.}$** and friction in bearings and seals **$N_{т.п.}$**:

$$N_{мех}=N_{т.д.}+N_{т.п.}, \quad (7)$$

For axial flow pumps, the power spent on friction of the discs against the liquid, **$N_{т.д.}=0$**, and for centrifugal pumps:

$$N_{т.д.} = 0{,}88 \cdot 10^{-3} \cdot u_2^3 \cdot D_2^2 \quad (8)$$

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where $\mathbf{u_2}$ is the circumferential speed of the impeller.

Power $N_{т.д.}$ determined when the pump is running without liquid filling (empirically), or you can take 1% of the power on the pump shaft N.

For centrifugal pumps having characteristics with a continuous decrease in the pressure line, the determination of S_H is carried out by testing them in two modes: with a full open valve, measuring Q_A and H_A, and with a closed valve, according to the formula:

$$S_H = (H_0 - H_A)/Q_A^2 \qquad (9)$$

For centrifugal pumps with characteristics H = f (Q) with an ascending branch, and axial pumps, pressure lines of which have an inflection, tests must be carried out in the working area of the characteristic, i.e. measure Q_A and H_A with a full open valve and Q_B and H_B with its partial closing. Then S_H is calculated by the following expression:

$$S_н = (H_в - H_A)/ (Q_A-Q_в)^2 \qquad (10)$$

Operational and technological processes associated with the lack of control of water supply, emergency situations and poor-quality repair, installation and commissioning work. It is noted that some issues related to the hydraulic processes of water supply structures, hydromechanical processes occurring inside the pump, and operational processes associated with the lack of water supply control require scientifically based decisions.

An analysis of the operating conditions shows that at many pumping stations, due to the lack of water measuring equipment, design values are used to control the water supply of the pumps, which is fraught with significant errors. The lack of water metering at the pumping station and, as a result, the inconsistency of its supply and water consumption leads to frequent starts and stops of the units and, as a result, to premature wear of their elements, as well as excessive power consumption and significant water losses for discharge, etc. The results of experiments on studying the nature of changes in the concentration and dispersion of suspended solid particles showed that the highest monthly average concentration of sediments is 2.5..3.8 kg / m3, and sometimes during the flood period the maximum turbidity of water reaches 7 kg / m3. In the composition of solid mechanical impurities, a significant amount is made up of particles with a grain size of 0.1-0.05 mm. Observations have established that the amount of siltation at various stations amounted to 20 to 60%. As a result, the hydraulic resistance increased, which led to a decrease in the water supply of the pumps.

The wear of parts of centrifugal and axial pumps in full-scale conditions is also studied and the dependences of wear on the characteristic dimensions and duration of their operation are given. The results of micrometric measurements of the working parts of the pumps showed that the blades of the impellers along the length and width wear out unevenly both in size and shape. This is due to the fact that when the hydroabrasive flow moves in the space between the blades, the kinetic energy of solid particles and their local concentration increase due to an increase in the values of the centrifugal and Coriolis forces along the radius of the impeller.

In centrifugal pumps, the most intense wear occurs at the outlet sections of the impeller blades and their sealing elements. When pumping turbid water for 2000 hours, the sealing clearances of type D pumps with a head of 75 - 80 m are 2.8-3.1 mm. With an increase in the end clearance of the impeller of an axial pump from the effect of a slotted cavitation-abrasive flow, the pressure value and the local concentration of solid particles in the flow play the leading role. The dynamics of increasing the end clearance of the impeller of an axial pump shows that the chamber is worn out more intensively than the ends of its blades. This is due to the fact that a pulsating alternating load acts on the surface of the chamber due to the pressure difference on the working and rear surfaces of the blades.

The error in determining the pump flow by formula (1) did not exceed 1.5 ... 2%. The proposed method is reliable, simple, and cheap and does not require complex devices and highly qualified service. The calculation formula for determining water supply most fully takes into account all the main parameters of pumping units in operating conditions. The technical and economic efficiency of the proposed method in comparison with others lies in the fact that the costs of water meters are completely eliminated, the maintenance personnel is reduced and the measurement accuracy is increased.

The design formula and the proposed method for determining the water supply of pumping units will reduce the unproductive pumping of water due to inconsistency in the schedules of water supply and water consumption, which, as a result, leads to frequent starts and stops, excessive consumption of electricity and significant water losses for discharge.

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