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Determination of Optimum Operational Parameters of Pump Stations

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ABSTRACT: The article discusses the optimization of the operating mode of pumping stations, provides a new method for calculating the optimal parameters of a pump unit. Pump stations are the most important constructions of systems of water supply of different function, and their efficiency directly affects efficiency of all system.

KEYWORDS: Pumping station, operating mode, pump head, efficiency, pump head pressure, operating point

I. INTRODUCTION

In pump stations often it is necessary to change an operating mode of pump units depending on the adopted schedule of water giving to the elevated basin which, in turn depends on the nature of power supply of the pump station.

In these conditions use of uneconomical ways of regulation of an operating mode of units considerably reduces energy efficiency of the pump station.

II. SIGNIFICANCE OF THE SYSTEM

The article discusses the optimization of the operating mode of pumping stations, provides a new method for calculating the optimal parameters of a pump unit. The study of literature survey is presented in section III, methodology is explained in section IV, section V covers the experimental results of the study, and section VI discusses the future study and conclusion

III. LITERATURE SURVEY

It is connected with the fact that pump stations are large power consumers and expenses on the electric power in their life cycle make about 74% [1]. In this regard for increase in overall performance of the pump station it is necessary to minimize power expenses which it is reached in operating modes of pumps with the maximum values of the efficiency (E) [2].

IV. METHODOLOGY

At problem definition on optimum regulation of an operating mode of the pump station as criteria can be accepted.

$$\sum_{i=1}^{n} N_{\mathrm{HC}}(t) \Rightarrow \min \qquad (1)$$

$$V = \int_{t_0}^{t_H} Q_{\mathrm{HC}}(t)dt \Rightarrow \max; \qquad \eta_{ns} \rightarrow max \qquad (2)$$

These criteria mean ensuring the minimum consumption of power $N_{HC}(t)$from a system under the set working conditions and the known giving $Q_{HC}(t)$in time before formation of the most necessary volume of water in the top tank at respect for the maximum value of KPD pump station.

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The problem of optimization of the mode of the pump station, the providing respect for the above-stated criteria at the known power and account characteristics of the pump with the given restrictions can be classified as Lagrange's task on a conditional extremum in differential calculus.

$$L = \int_{t_0}^{t_H} (N_H(t) + \lambda_H Q_H(t) dt \rightarrow \max \qquad (3)$$

Where λ_H– an uncertain multiplier of Lagrange, t_H – period of operation of the pump station.

Having taken private derivatives on $Q_{HC}(t)$, having equated them to zero and having solved the received expressions, we will receive conditions of optimality of distribution of parameters.

$$\frac{\partial N_{H1}}{\partial Q_{H1}} = \frac{\partial N_{H2}}{\partial Q_{H2}} = ... \frac{\partial N_{Hm}}{\partial Q_{Hm}} = \lambda_H \qquad (4)$$

Thus, in the work area of characteristic of pumps, in the conditions of $H_n \approx const$for providing an optimum operating mode of the pump unit there has to be a constant ratio between parameters $N_H(t)$ and$Q_H(t)$.

Ensuring operation of the pump unit with the efficiency maximum values is the most important condition of operation of the pump station. The model of an operating mode of the pump unit is described by three main equations which characterize changes of such key parameters as a pressure of $H_н$,productivity (expense) of $Q_н$ and efficiency $\eta_н$.Functional dependences of H_n and$\eta_н$ from $Q_н$ are given in a graphic look on factory characteristics of pumps (fig. 1)

V. EXPERIMENTAL RESULTS

Efficiency values of the pump $\eta_н$ within the work area on the basis of the analysis of numerous graphic characteristics we suggest to express on the basis of the equation like $\eta = \alpha \cdot Q^2 - \delta \cdot Q + \gamma$, and pressure head characteristic of the pump a power function of $H_n = H_0 - K_n \cdot Q^{\beta}$. Pressure head characteristic of the pipeline system, as we know, is described by the Scientific and technological revolution equation $H_{tr} = H^{\Gamma} + K_{tr} \cdot Q^2$. Coefficients α, β, $\delta$and$K_н$are constants and they are defined on the basis of graphic characteristics of $H_н$– $Q_н$or results of tests for each brand of the pump. For increase in objectivity and adequacy of functional dependences coefficients have to be exact therefore they have to be exposed previously to processing and the dispersive analysis.

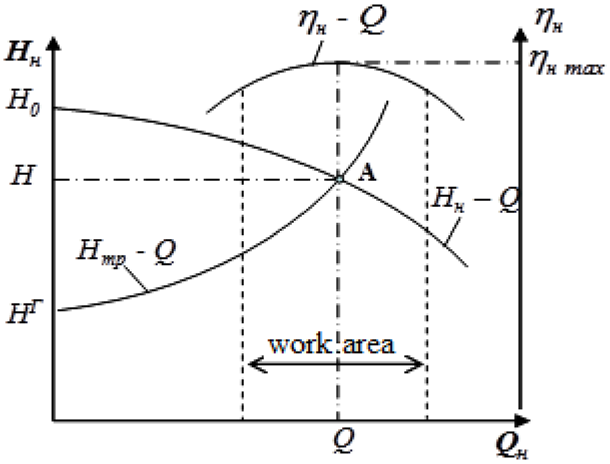

Fig. 1. Graphic characteristics of the pump

K_{tr} is the calculated hydraulic coefficient of the pipeline system and characterizes changes of loss of a pressure in pipelines depending on value Q.

$$K_{tr} = \Sigma \Delta h / Q^2 \qquad (5)$$

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where$\Sigma\Delta h$ – the sum of loss of a pressure in the pipeline system.

The best operating mode of the pump is work with the parameters determined by the provision of a point A on graphics of N_n – Q_n which corresponds to the maximum values of efficiency where curve $H_n = H_0 - K_n \cdot Q^\beta$and Scientific and technological revolution $H_{tr} = H^\Gamma + K_{tr} \cdot Q^2$are crossed (fig. 1).

For definition of provision of a working point And we investigate the equations $\eta = \alpha \cdot Q^2 - \delta \cdot Q + \gamma$on search of its maximum, i.e. finding of finding of maximum values KPD.

It is known that extreme points of rational functions can be determined by finding of their derivative and having equated it to zero and the solution of the received expression

$$\eta = \alpha \cdot Q^2 - \delta \cdot Q + \gamma;'(Q) = (\alpha \cdot Q^2 - \delta \cdot Q + \gamma)' = 2 \cdot \alpha \cdot Q - \delta = 0; \quad Q = \delta / 2\alpha \quad (6)$$

The received value $Q = \delta/2\alpha$defines a point And on pressure head characteristic of the pump where equality of $H_0 - K_n \cdot Q^\beta = H^G + K_{tr} \cdot Q^2$coefficient unknown to us K_{tr} as follows From here

$$K_{tr} = \frac{H_0 - H^\Gamma - K_н \cdot Q^\beta}{Q^2} \quad (7)$$

VI. CONCLUSION AND FUTURE WORK

Thus, the above-stated method of calculation of parameters of the pump allows to define the hydraulic coefficient of the K_{tr}pipelines corresponding without use of bulky hydraulic calculations for calculation of loss of a pressure in pipelines and to find optimum parameters to the maximum of KPD of the pump.

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