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"QURILISHDA YASHIL IQTISODIYOT, SUV VA ATROF-MUHITNI ASRASH TENDENSIYALARI, EKOLOGIK MUAMMOLAR VA INNOVATSION YECHIMLAR" MAVZUSIDAGI RESPUBLIKA MIQYOSIDAGI ILMIY-AMALIY KONFERENSIYA TASHKILIY QO'MITASI

Improving the methods of alternative design of water supply and distribution systems

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Abstract: This article presents methods of alternative design taking into account the calculation of the optimal mode of operation of water supply and distribution systems at the stage of operational management, since this makes it possible to develop a measure to save electricity required to create the pump pressure at which the need for water is met. As a rule, of the many options for water supply modes, the option with the minimum dispersion is the optimal one in terms of electricity costs. It is possible that the principle of stabilizing the pump pressure over time should also be used in the operational management of water supply and distribution systems, since in this case the amount of operating costs is minimized. If this principle receives a theoretical justification, it will significantly simplify the calculations for distributing loads between pumping stations of water supply and distribution systems. In this case, it will be possible not to carry out cumbersome and labor-intensive calculations associated with calculating for determining the cost of electricity for each option

Keywords: Theories and methods of calculating systems, pumping stations, optimal operating mode, distribution function, regulating volumes of tanks, water supply mode, operating costs, dispersion, operating organizations, water supply systems, projects

1. Introduction

The current state of the theory and methodology for calculating water supply systems is such that it does not allow, based on data on water demand, forecasting load fluctuations, etc., to calculate the optimal operating mode of the system structures either at the operational management stage or during their design. At the same time, the need to solve this problem is very great, especially in modern conditions, when it is important to develop measures to save electricity spent on supplying water to consumers. Therefore, the problems of optimizing the operating modes of water supply system structures have to be solved only by comparing options. It should be taken into account that each new option for water supply modes requires almost the entire volume of design calculations. In this regard, in design practice, various options for water supply modes are very rarely considered and economically assessed, although the work of leading research institutes shows [1,4] that by optimizing these modes, specific energy costs (kv h / m^2) can be reduced by 15-20%.

2. Materials and Methods

Changing the water supply modes of the pumping stations of the water supply and distribution (SD) systems is possible only when these systems have regulating capacities. Otherwise, the water supply modes must fully correspond to the water consumption modes, i.e. fully compensate for any random changes in loads at consumers of the SD systems. A_t present, Building codes and regulations 02.04.02-97 provides for the determination of regulating capacity volumes of capacities based on data on hourly consumption schedules. The result of many years of practice in using these recommendations is that the capacities available in cities are essentially not used for the main purpose - regulating hourly unevenness. since their volumes are small and operating organizations seek to use these capacities only as emergency ones.

In the works of the research institute [2,5], an attempt was made to develop new methods for determining regulating capacities. One of these methods takes into account that the regulating daily volume required to compensate for load fluctuations (under the condition of uniform operation of the head structures of the water supply system recommended by Building codes and regulations 02.04.02-97 is a random variable distributed according to a law very close to normal. Analysis of the distribution functions of these random variables showed that the probability of exceeding the volumes calculated according to the recommendations of Building codes and regulations is very high and amounts to 0.3-0.4. This predetermines the insufficiency of the volumes of the tanks under construction for the purposes of regulating hourly unevenness of water consumption. In this regard, it is proposed to determine the regulating volumes of the tanks so that the probability of exceeding their calculated values is 0.005.

3. Results and Discussion

In this case, possible daily excesses during the operation of the SD system will be very rare (2 times a year) and, most importantly, insignificant, no more than 5% of the calculated values of the regulating volumes, i.e. they can be easily compensated for by the emergency water reserves always available in the tanks (these rare excesses can be considered a kind of accident).

Values of tank volumes for regulating hourly unevenness (W_{hour}) in shares of daily water consumption depending on the hourly unevenness coefficient K are shown in Table 1.

Table 1

К	Wч	К	Wч	К	Wч
1,10	0,05	1,35	0,15	1,70	0,26
1,15	0,07	1,40	0,17	1,80	0,29
1,20	0,09	1,45	0,18	1,90	0,31
1,25	0,11	1,50	0,20	2,00	0,34
1,3	0,13	1,60	0,23	2,50	0,44

The given values of W_{hr} exceed those currently accepted in the practice of designing water supply systems in large cities by 40-60%. In addition to the volumes for regulating hourly unevenness, the volumes intended to compensate for the daily unevenness of water consumption (W_{day}) are of interest. Such capacities are not yet used for water supply systems in large cities, although analysis shows their high economic efficiency.

Based on data on actual daily consumption in several large cities of the republic (for 3-4 years), a formula was obtained for determining W_{day} in shares of average daily water consumption - depending on the ratio of the maximum productivity of the head structures of the water supply system Q_{gd}

Q to the maximum daily water consumption Q^{max}:

$$\frac{\overline{Wday}}{\overline{Qday}} - \frac{0{,}007}{(Q_{h.b.})/Q_{day}^{max^6}}$$

At $Q_{h \cdot b} = Q_{day}^{max}$ size W_{day} =0 and capacities for regulating daily unevenness are not needed. With other ratios $Q_{r.c.}$ and Q_{day}^{max} using this formula, you can determine the value of Wsut and, by calculating the costs of constructing tanks and head structures, find the minimum value of these costs. Calculations have shown that for large cities, W_{day} can be about 10-20 % $\overline{Q_{day}}$.

At the same time, the cost of the system is reduced by 3-5%. Thus, it is possible to increase the total regulating volumes of all tanks in the SD systems of large cities. However, the placement of these volumes, their distribution between clean water reservoirs and tanks on the network (towers, counter-tanks, etc.) is a rather complex task. The specified distribution is determined by the water supply mode adopted during the design - with a uniform supply, the entire volume should be placed in tanks on the network, the more uneven the water supply mode is, the greater part of the volume should be placed in clean water tanks. Due to the fact that the change in electricity costs for water transportation, the problem can be solved if there is a method for calculating these costs for any arbitrarily specified water supply mode [3,6].

Water consumption and water supply modes can be specified by non-traditional step graphs of hourly water consumption, and simplified mathematical description of the expected distribution function of hourly water consumption in the estimated year of operation of the system

$$Q = T^k,$$

where Q – the amount of water consumed in the PRV system (varies from 0 to 1 and is expressed as a share of the total water consumption for the period T);

T - is the current time, expressed as a fraction of the total period of water consumption, taken to be equal to 1;

K - is the coefficient of hourly unevenness of water consumption (water supply).

The actual scheme of the SD system is replaced by one of several typical schemes, for each of which formulas are proposed for determining the energy costs depending on arbitrarily specified combinations of supply and water consumption modes. In each of the typical schemes (systems with a tower or reservoirs at the beginning of the network, systems with counter-reservoirs and control units, two-zone SD systems, etc.), the water supply network is replaced by an equivalent pipeline with a flow rate uniformly distributed along its entire length. Changes in the cost of the water supply network when changing water supply modes are not taken into account. Network costs can be optimized using known methods of technical and economic calculation after the most advantageous water supply mode has been determined. The optimal water supply mode is selected by comparing the values of the reduced costs for each of the water supply mode options planned for consideration (usually 5-7). In this case, capital expenditures on the construction of SD systems (pumping stations, water pipelines, tanks) are determined by the consolidated indicators of the specific cost of construction - averaged or adopted taking into account the materials of projects previously implemented in this SD system. Operating costs (costs for paying for electricity) are determined by formulas that take into account a number of parameters characterizing a specific SD system and always known during its design. Hydraulic calculations are made in order to adjust some initial data.

4. Conclusions

Special feature of the described method is the consideration of a comprehensive economic assessment of the territory of cities, which is allocated for use for the SD structures. Their use allows in some cases to justify by economic calculations the need to construct SD system structures (mainly control units) in those areas of the city where this is required to significantly reduce energy costs and increase the reliability of water supply. Due to the reduction in the labor intensity of calculations for choosing the most economic water supply modes when justifying the direction of development of the SD system, it is possible to consider a fairly large number of system schemes (for example, with water supply to tanks on the network through specially allocated transit water pipelines or directly through the network during periods of reduced water consumption).

As a rule, from many variants of water supply modes, the optimal variant in terms of electric power results is the one with the minimum dispersion of pressure values at the outlet of the largest pumping stations of the system. This means that when designing, it is necessary to accept the characteristics of pumping stations of SD systems with regulating tanks so as to achieve a relatively constant required pump pressure at different periods of the day, and not to strive to maintain a constant pump flow, as suggested by a number of researchers. It is possible that the principle of stabilization of pressures over time should also be used in the operational management of PRV systems, since in this case the amount of operating costs is minimized. If this principle receives a theoretical justification, it will significantly simplify the calculations for the distribution of loads between pumping stations of PRV systems.

In this case, it will be possible to avoid cumbersome and labor-intensive calculations associated with calculating specific values of energy costs for each load distribution option, but only to select the option of the predicted load schedule of pumping stations in which the dispersion of pressures over the forecast period is minimal.

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