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Mathematical Modeling of Reducing Water Consumption in Drinking Water Treatment Facilities

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Abstract. This paper presents an analysis of water consumption volumes during pipe repairs in drinking water supply networks. The internal water consumption of a drinking water treatment plant was studied when determining the volumes of water consumed by the population and industrial enterprises in the drinking water treatment system. In addition, the article examines the analysis of water consumption in emergency situations on urban water supply networks. The analysis of water consumption required for flushing wells and industrial enterprises was studied. The issue of mathematical modeling of internal water consumption of a drinking water treatment plant was studied when determining the volumes of water consumed by the population and industrial enterprises in the drinking water treatment system.

Keywords: drinking water supply; intake of drinking water; unaccounted water costs; washing drinking water wells.

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INTRODUCTION

Extensive scientific research is being conducted in the world on the safety of drinking water supply facilities and the reliability of their use as well as the safe operation of drinking water supply facilities. One of the urgent problems is to prevent negative situations that arise during the design and operation of facilities used in the technology of drinking water preparation. There is an important need to carry out research on the analysis of the amount of water consumption in the process of repairing pipes in drinking water networks.

The development strategy of the New Uzbekistan for the period of 2022-2026 defines the important tasks for "fundamental reforms of the water resources management system and implementation of a separate state program on water economy", which is defined in the 31st goal of rapid development of the national economy and ensuring high growth rates. It is important to implement this task, to carry out scientific-research works aimed at determining the optimal hydraulic parameters of high-pressure flows and developing theoretical foundations and methods of scientific and practical importance [1].

MATERIALS AND METHODS

The purpose of the study is to study the problems of preventing negative situations that arise during the design and operation of facilities used in the technology of drinking water preparation.

Tasks of the research:

- retrospective analysis of research works on the safety and reliability of drinking water supply facilities, safe operation of drinking water facilities;
- carrying out research on the amount of water consumption in the process of repairing pipelines in drinking water networks;

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- proposals, problems and their solutions in the selection of water supply sources.

The designed and used drinking water supply pipelines and water intake facilities were taken as **the object of the research**.

The subject of the study is hydrodynamic processes occurring in drinking water supply facilities.

Research methods. In the course of the research, programming technologies aimed at creating models based on the laws representing hydrodynamic processes in liquids, forming their numerical and analytical calculation algorithms were used.

The scientific novelty of the research is as follows:

- safety of drinking water supply facilities and reliability of their use, processes of safe operation of drinking water supply facilities have been improved;
- in determining the amount of water consumed by the population and industrial enterprises in the drinking water preparation system, the problem of mathematical modeling of the internal water consumption of the drinking water preparation station has been studied.
- the amount of water consumption in the process of repairing pipes in drinking water networks and the process of saving it has been improved.

The practical results of the research are as follows:

- the safety and reliability of drinking water supply facilities, safe operation processes of drinking water facilities have been developed;
- the amount of water consumption in the process of repairing pipes in drinking water networks and the process of saving it has been developed.
- proposals, problems and their solutions in the selection of water supply sources have been developed.

Reliability of the research results is confirmed by experimental verification, which strictly adheres to the general laws of hydromechanics, by comparative analysis, by solving problems related to the interdependence of calculation operations and formulas.

The obtained theoretical results are based on the results of laboratory studies and compared with experimental data.

Scientific and practical significance of research results:

- the scientific significance of the research results is explained by finding the optimal parameters of water discharge pipes by studying the reasons for the safety of drinking water supply facilities and the reliability of their use, the processes of safe operation of drinking water supply facilities.
- the practical importance of the research results is explained by the fact that they are accepted as criteria for determining the safety of the network by finding the kinetic energy control parameters of the flow in drinking water supply and pumping stations.

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RESULTS AND DISCUSSION

Analysis of the amount of water consumption in the process of repairing pipes in drinking water networks of Fergana region

On average 5,000 meters of various size pipes are repaired annually in the city of Fergana and 0.17% of the total amount of water is spent on the processes of emptying and disinfecting pipes. 100 meters of different size pipes are repaired in the city of Margilan and 0.08% of the total amount of water is used for the processes of emptying and disinfection of pipes. On average 5,000 meters of various size pipes are repaired annually in the city of Kokand and 0.12% of the total amount of water is used for the processes of emptying and disinfecting pipes. On average 2,000 meters of pipes of various sizes are repaired annually in the city of Kuvasoy and 0.13% of the total amount of water is spent on pipe emptying and disinfection processes [9].

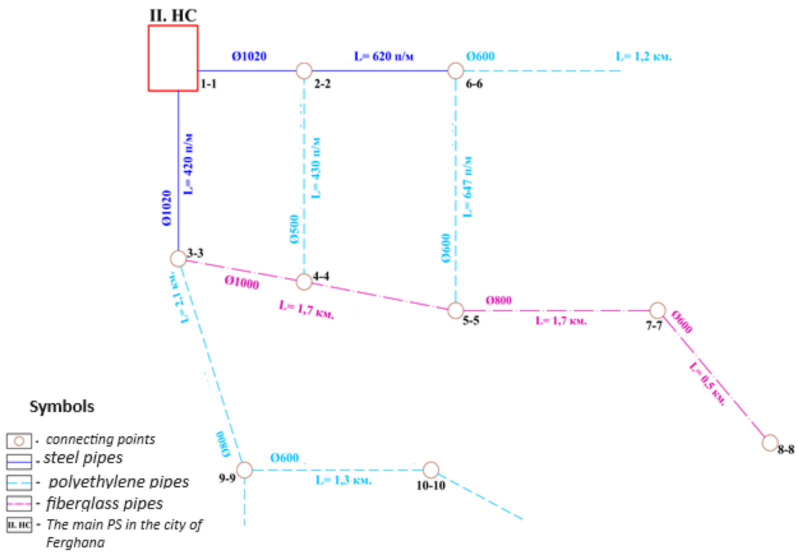

FIGURE 1. The line scheme on which the field experiments were conducted.

TABLE 1. Technological water consumption and water loss.

"Suvoqava" state unitary enterprise's departments	Water reservoir's productive capacity	Water consumption for flushing the well, m^3	Water consumption for preventive, maintenance and current repairs of internal water supply systems	Liquidation of emergencies in systems of collective use and water consumption	Water consumption for the operation of reservoirs, m^3	Water consumption for the operation of 2 lifting pumping stations, m^3
Fergana city	37700000	234316.8	65506.10045	75933.60545	166468.47	57427.6
Margilan city	17200000	151372.8	13871.09	28498.91	12041.34	0
Kokand city	33200000	149299.2	39483.81	79394.74	47341.2	7859.2
Kuvasoy city	9453000	159667.2	11056.85	86015	13030.59	4268.8
Besharik district	3600000	474854.4	0	0	10766.28	0
Uzbekistan district	2500000	147225.6	0	0	10766.28	0
Dangara district	2200000	180403.2	0	0	0	0
Uchkuprik district	4600000	267494.4	0	0	0	0
Buvaida district	4800000	217728	0	0	0	0
Bagdad district	4100000	377395.2	0	0	0	0
Rishtan district	1900000	120268.8	0	0	81182.16	0
Oltiarik district	2300000	64281.6	0	0	0	0
Kushtepa district	200000	176256	0	0	33364.55	0
Yozyovon district	2300000	91238.4	0	0	0	0
Kuva district	1100000	184550.4	0	0	4674.2	0
Fergana district	2200000	141004.8	0	0	2681.81	0
Furkat district	2100000	313113.6	0	0	2684.41	0
Sokh district	300000	20736	0	0	0	0
Total by the region:	135253000	3539635.2	129917.8497	269843	385001.29	69555.6

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Continuation of table 1.

Water consumption for household needs, m^3	Water consumption for the repair of water supply and distribution networks, m^3	Liquidation of emergencies in the networks of transmission and distribution of water and water consumption, m^3	Water consumption for fire prevention and extinguishing, m^3	Total water consumption, m^3	In relation to the productive capacity of the reservoir in %
51446.75	40654.45	6478657.167	1300000	8470412.94	22.47
36262.75	15597.50	558906.05	1250000	2066550.43	12.01
35952.5	19164.06	4641517.80	1260000	6280012.51	18.92
12528.625	12577	1342808	110000	1751952.82	18.53
3285	4516.17	119559.4575	0	612981.31	17.03
2664.5	37692.89	108194.828	0	306544.10	12.26
3832.5	4519.12	101080.968	0	289835.79	13.17
3020.375	4551.06	83274.478	0	358340.31	7.79
3768.625	4466.67	87134.622	0	313097.92	6.52
2600.625	4478.28	111469.454	0	495943.56	12.10
4416.5	4488.16	86674.225	0	297029.85	15.63
3996.75	4497.27	106163.523	0	178939.14	7.78
2837.875	4478.46	75653.9655	0	292590.85	14.63
2947.375	4472.29	98352.888	0	197010.095	8.57
3567.875	4395.45	103422.5325	0	300609.46	27.33
4836.25	4420.39	94640.392	0	247583.64	11.25
2491.125	4496.17	76448.621	0	399233.93	19.01
657	4367.15	11209.2636	0	36969.41	12.32
183868.75	188242.6	14366609	3920000	23052672.97	17.04

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Analysis of water consumption required for washing water wells and industrial enterprises in Fergana region

We believe that water used for the water intake area should be used for circulating water supply. Ring schemes offer great opportunities to reduce the cost of the water supply system, reduce fresh water consumption and discharge of dirty water. When creating circulation loops, only 70-85% of the process water in process units is used after heating and cooling. In these systems, some of the relatively less polluted process water can also be used. Purified water (15%) is reused. In the circulating water supply system, pumps supply water to consumers through the water supply network. Heated and polluted water from consumers is sent to the wastewater treatment plant through a pipeline system. Purified, but still warm water is collected in a tank, from which it is supplied to the cooling unit by pumps of the circulating water station. [5].

The cooled water is again delivered to consumers by pumps. During the operation of the circulation system, part of the water is lost: it flows, evaporates and flies out of the cooling device; it can be lost due to leaks of contaminated water from consumers and the discharge of non-return water into wastewater. To make up for these losses, a suitable amount of water is taken from the natural source and directed to the water treatment stations through pumps. The purified water is discharged into the pool of cooling devices. To maintain the salt balance from the pool, part of the water is continuously discharged into the sewer [2-5].

Circular systems are built according to technical conditions, environmental requirements and economic considerations [2, 5].

According to technical conditions, it is necessary to use this system, because the discharge of the existing natural water source is not enough for direct water supply. The need for circulation systems is also explained by environmental requirements. When using circulation systems, the amount of dirty water entering the water bodies is reduced. From an ecological point of view, waste-free circulation systems have great value. Instead of clean water, water is used in enterprises without sewage (closed) water supply systems, which have been previously biologically purified and purified up to the standard of technical water quality of industrial and domestic wastewater [5].

Biologically purified wastewater used in technical water supply must meet technical, economic and sanitary-hygienic requirements. Even if it meets the appropriate standards, it is not possible to use such water in the food, meat, dairy and pharmaceutical industries [3].

According to economic considerations, it is possible to reduce costs for the construction of water collection devices, first treatment pumping stations, natural and wastewater treatment facilities in the use of circulation water supply systems [5].

The needs of the enterprise for water of all categories are satisfied by natural sources that meet the following basic requirements:

a) To ensure continuous supply of the necessary amount of water for the future development of the enterprise;

b) The supply of water, the quality of which more fully meets the needs of consumers and is achieved for simple and ecological processing of industrial water;

c) Provides the ability to supply water to consumers at low cost;

d) It should have such strength that water extraction from it should not disturb the existing ecological system.

The correct solution to the issue of choosing a source of water supply for a particular consumer requires a thorough study and analysis of water resources in the area where the consumer is located.

Surface waters and underground waters are used for water supply of industrial enterprises. Natural resources are rivers, lakes, and in some cases seas; underground sources are ground and artesian waters and springs [6].

The water of many rivers has significant turbidity, a high content of organic substances and bacteria and in most cases a significant color. At the same time, water is characterized by relatively less hardness [6].

Lake water is usually distinguished by a very small amount of suspended matter (i.e. low turbidity). The quality of all surface waters is intrinsically dependent on atmospheric precipitation and snowmelt, during floods, their turbidity and bacterial contamination increase, and their hardness decreases.

Underground waters, as a rule, do not contain suspended matter (that is, very transparent), they have low bacterial pollution, but along with these positive qualities, in most cases, they are strongly mineralized. According to the nature of dissolved salts in them, they can have one or other negative properties: high hardness, unpleasant taste and some other properties [6].

The issue of choosing a source of water supply is one of the main issues in the design of drinking water supply facilities, because it determines the presence of one or another facility, and therefore the cost of construction and operation [5].

It is necessary to take into account the quality of water and its capacity in choosing a source of water supply,

The choice of water source is mainly determined by local natural conditions, so first topographical, hydrological, sanitary and other studies are carried out [6-9].

It is recommended to use surface water wells for domestic drinking water supply, their refusal requires comprehensive reasons. Norms and rules of urban planning (NRUP) 2.04.02-2019 provides for the use of drinking water for purposes not related to domestic - drinking water supply [5].

When there are several water sources, the available options are compared technically and economically.

Water collection facilities are built to take water from a natural source and partially purify it.

Source selection should be carried out according to the state standards of Uzbekistan (UzSSt) 951-2011 [6].

Analysis of water consumption and quantity in the preparation of technical water for industrial enterprises of Fergana region

Technical water is used in three directions in industrial enterprises:

1. From 70 to 89% of the incoming water for technical purposes is used in industrial enterprises as a refrigerant for cooling the products of heat exchange equipment, or to keep individual elements of devices and machines from overheating. This water is heated by the product being cooled, but is not contaminated.

2. The amount of technical water from 5 to 12% is used for cleaning products or raw materials and as a transportation medium. This water becomes contaminated and heats up if the product is at a high temperature.

3. From 10 to 20% of technical water is lost due to evaporation or enters the composition of the manufactured product (steam sugar, bread, etc.).

Due to economic considerations, ecological requirements, as well as the limitation of water reserves in natural sources, it is recommended to install a circulation system of technical water supply in industrial enterprises. Water is used many times in the circulation system of technical water supply.

According to the change in water quality during operation, circulation water supply is divided into the following:

1. "Clean cycles" - only for hot water in usage;

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2. Dirty cycles - only for dirty water in usage;

3. "Mixed cycles" – when used, the water heats up and gets dirty at the same time.

For industrial water used in industrial enterprises of group 1, the maximum temperature is defined: T < 30°C, its optimal value should be 15°C.

In circulation water supply systems, carbonate hardness of water used as Sa and Mg cold carriers (coolant) should not exceed J_k - 2.8...3.0 mg-eq/l, and the possible concentration of its weight is accepted according to the speed of movement of water in cooling devices.

The technical water demand of the enterprise depends significantly on the type of equipment used and the adopted scheme of the technological process. Q_r is determined only according to the technical data of the water-consuming equipment.

In the literature review [10-12], information is given on the limit norms of water consumption per unit of product (per unit of finished product weight). These data are obtained from the result of processing and determining the average amount of water consumption values (one or another branch of industry). But these standards do not take into account fully the peculiarities of each specific enterprise and can only be used for approximate calculations.

Analysis of water consumption and quantity required for preventive washing of artesian wells

TABLE 2. Water consumption for preventive washing of water wells.

Cities and districts	Production capacity of water reservoir, m^3/year	Number of water wells	Number of washing times of water wells	Water consumption for washing water wells, m^3/year	In relation to the production capacity of water reservoir in %
2	3	4	5	6	7
Fergana city	37700000	113	1	234316.8	0.62
Margilan city	17200000	73	1	151372.8	0.88
Kokand city	33200000	72	1	149299.2	0.45
Kuvasoy city	9453000	77	1	159667.2	1.69
Besharik district	3600000	229	1	474854.4	13.19
Uzbekistan district	2500000	71	1	147225.6	5.89
Dangara district	2200000	87	1	180463.2	8.20
Uchkuprik district	4600000	129	1	267494.4	5.82
Buvaida district	480000	105	1	217728	4.54
Bagdad district	4100000	182	1	377395.2	9.20
Rishtan district	1900000	58	1	120268.8	6.33
Oltiarik district	2300000	31	1	64281.6	2.79
Kushtepa district	200000	85	1	176256	8.81
Yozyovon district	2300000	44	1	91238.4	3.97
Kuva district	1100000	89	1	184550.4	16.78
Fergana district	2200000	68	1	141004.8	6.41
Furkat district	2100000	151	1	313113.6	14.91
Toshlok district	1700000	33	1	68428.8	4.03
Sokh district	300000	10	1	20736	6.91
Total by the region:	135253000	1707	1	3539635.2	2.62

(Note: Column 3 Q_{year}=37 700 000 m^3/year. Column 4 $N_{w.}$= 113. Column 5 p = 1. Column 6 q_w = 234316 m^3/year. Column 7. q_w / Q_{year}= 0.62 %)

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In drinking water supply using artesian wells, 2.62% of the water received annually is used for preventive washing of these wells. This amount is 3539635.2 cubic meters/year. 1707 artesian wells operate in the region.

Water consumption of industrial enterprises for drinking purposes can be determined according to the state standards of Uzbekistan (UzSSt) 2.04.01-97 and (UzSSt) 2.09.02-97. The choice of the source of drinking water supply is made according to the requirements of the state standards (SS) 17.1.1.04-97.

The total hourly consumption of household drinking water at the enterprise is determined as follows:

$$Q^P_{H-ter.} = Q^P_{gen.} + Q^P_{sh.} + Q^P_{ter.} + Q^P_{ent.kitch.}, \quad \frac{m^3}{t} \tag{1}$$

where $Q^P_{gen.}$ is the amount of water consumption for bathing and washing hands, quenching thirst, etc. of employees of the enterprise; $Q^P_{sh.}$ - the amount of water consumption for shower equipment; $Q^P_{ter.}$ - the amount of water consumption for territorial irrigation; $Q^P_{ent.kitch.}$ - the amount of water consumption in enterprise kitchens.

Analysis of water consumption in the cities of Fergana region to eliminate emergencies of water supply networks

In the city of Fergana, on average 10 accidents occur in a year, and 0.20% of the annual amount of drinking water is used in these cases. On average 12 accidents occur in the city of Margilan in a year, and 0.17% of the annual amount of drinking water is used in these cases. On average, accidents occur 12 times a year in the city of Kokand and 0.24% of the annual amount of drinking water is used in these cases. In the city of Kuvasoy, on average 20 accidents occur in a year, and 0.91% of the annual amount of drinking water is used in these cases [9].

Suggestions, issues, and solutions for selecting water supply sources

Water sources, the quality of which meets the requirements of purity and cleanliness, are provided primarily for household drinking water supply, in this regard, underground sources should be used in most cases. If the natural underground water reserves cannot meet the needs, artificial replenishment of the underground water reserve is envisaged based on technical and economic evidence. In cases where there are no sources of groundwater and the amount of underground drinking water reserves is large, it is allowed to use these waters for other purposes (technical production, irrigation, etc.) in the household water supply with the consent of the bodies protecting and regulating water reserves [6].

The possibilities of using sources for drinking water supply are determined based on the following [6]:

- the state of cleanliness of the lands where the water collection facilities are located and adjacent areas - water supply for underground sources;
- the state of cleanliness of water collection lands, upper and lower water collection sources - for surface sources of water supply;
- water quality of water supply sources;
- their level of confidence in naturalness and neatness and their views on neatness.

Water pipes, water collection facilities and sources of water supply must be protected from pollution by organizing sanitary protection zones in accordance with the current legislation.

The selection of water supply sources should be justified by the results of topographical, hydrogeological, ichthyological, hydrological, hydrochemical, hydrobiological, hydrothermal, and other relevant studies and inspections. The organization responsible for selecting the water supply sources should coordinate physical, hydrogeological, hydrological, and topographic research and inspections

The study of water supply sources is carried out according to [6].

Surface and underground water sources serve as sources of water supply.

The following are the sources of water supply [6]:

a) surface waters, including flowing waters (rivers, artificial ditches), ponds (lakes, reservoirs, artificial lakes);

b) underground waters, including underground springs, streams, seeps, wells, artificially filled and other waters. It is necessary to consider the possibility of using purified waste water for water supply of industrial enterprises.

As a source of water supply, it will be possible to use filled reservoirs, ponds with water from natural surface sources.

In the water supply system, it is permissible to use several sources with different hydrogeological and hydrological characteristics.

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It should be carried out in accordance with the rules for the selection of sources of drinking water supply [6] and the requirements of Sanitary rules and regulations (SRR) No. 0025-94 of the Republic of Uzbekistan. It is permissible to agree on the sources of water supply accepted for use according to the manual "Agreement and permit procedures for the use of special water" approved by the State Nature Protection Committee of the Republic of Uzbekistan.

It is permissible to use mineral and geothermal water for production water supply, provided that it is properly purified and meets the requirements of cleanliness.

In evaluating the use of water reserves for water supply purposes, the following should be taken into account:

- 15-20-year perspective of the calculation procedure and water management balance by sources;
- requirements set by consumers for water quality;
- the water quality characteristics of the sources, the aggressiveness of the water and the prospect of possible quality changes, with the calculation of the adjustment of the discharge pipeline and waste water flow;
- qualitative and quantitative characteristics of pumps and their arrangement, changes in watercourses, durability of banks;
- possibility of freezing and drying of sources, presence of snow piles, erosion and flood (flow of water in mountainous areas), as well as other natural disasters in reservoirs of the source;
- autumn-winter procedures of sources and features of freezing in them;
- water temperature by months of the year and development of phytoplankton at different depths;
- specific characteristics of spring-summer floods;
- underground water reserves and conditions of nutrition, as well as their deterioration due to changes in natural conditions and anthropogenic effects (waterlogging, irrigation, artificial extraction of water and the like);
- quality and temperature of underground water;
- opportunities to build or artificially fill underground water reserves;
- requirements of sanitary-epidemiological service agencies for water protection and regulation of its use, fish protection, etc.

Ensuring the guarantee of water consumption below the water distribution points in the adequate assessment of the water resources of the surface sources of water supply, satisfying the water needs of the population in the residential areas of the watershed in every season of the year, industrial enterprises, agriculture, fisheries and other water sources, as well as water supply sources it is necessary to ensure neatness requirements for protection [6].

In cases of insufficient water consumption in surface water sources, it is necessary to envisage natural water flow tracing during one hydrological year (seasonal tracing) or over many years (multiannual tracing), as well as water discharge from other surface sources based on technical and economic evidence.

In case of insufficient consumption of water in the sources, the level of supply of some water consumers and high prices or other difficulties for increasing water is determined in agreement with organizations for the protection and use of water reserves and the Ministry of Health of the Republic of Uzbekistan [6].

Assessment of underground water resources and reserves, documents such as "Classification of the use of underground water resources" and "Guide for the adoption of the classification of the use of underground water resources for drinking and technical water mining basins" of the State Committee on Geology and Mineral Resources of the Republic of Uzbekistan, hydrogeological research

(it is permissible to develop on the basis of searching, using preliminary, partial allocations). The study of mining basins should ensure a fully reliable assessment of underground water reserves, their quality and environmental protection in their use. Drinking and technical water reserves, underground water reserves, large industrial enterprises of the capital of the Republic of Uzbekistan and the Republic of Karakalpakstan, regional centers and cities under the care of the Republic of Uzbekistan, as well as complex hydrogeological conditions and significant man-made power, which were searched for in accordance with the decisions of the Cabinet of Ministers of the Republic of Uzbekistan Water supply for water reservoirs in the project above 15,000 m^3/day is required to be approved by the State Committee on Mineral Reserves of the Republic of Uzbekistan.

In the event that it is necessary to restart the operational reserves previously approved by the State Committee on Mineral Reserves of the Republic of Uzbekistan, if the growth of the operational reserves does not exceed 15 thousand m^3/day, re-approval of the operational reserves is not required [6].

In our republic, large-scale measures are being taken to create and improve mathematical models of hydraulic processes, to create new methods of complex hydraulic calculations that ensure the safe operation of water supply facilities, in order to solve the issues of assessing the state of drinking water supply and their use. The Development Strategy of New Uzbekistan for the period 2022-2026 defines important tasks of “Implementing a separate state program for the radical reform of the water resources management system and water management”, which is defined in the 31st goal of the accelerated development of the national economy and ensuring high growth rates. It is important to implement this task, to carry out scientific-research works aimed at determining the optimal hydraulic parameters

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of high-pressure flows, developing theoretical foundations and methods of scientific and practical importance.

In determining the amount of water consumed by the population and industrial enterprises in the drinking water treatment system, the internal water consumption of the drinking water treatment station is not taken into account in most cases [13-15]. This situation leads to inaccuracies in finding the total amount of water. In order to eliminate these ambiguities, we will consider the mathematical modeling of internal water consumption in the drinking water preparation system on the example of Fergana region [8, 9]:

$$Q_{gen.} = f(\,Q_{in.}; N; q_{gen.}; n; m; p; p_1; w) \quad (2)$$

Where: $Q_{in.}$- internal water consumptions for technical maintenance of wells and water extraction (m^3/year)
N – the number of districts;
$q_{gen.}$- amount of water used for general water intake facilities, (m^3/year);
n – the number of water intake wells;
m - the number of washing wells in 1 year;
p - pressure in the flush pipe, (MPa);
p_1 - pressure during pipe washing, (MPa);
w - the amount of water used for flushing the pipe (m^3/year);
$p = 7$ MPa $= const$, the pressure in the pipes was assumed to be constant;
$p = 6$ MPa $= const$, the pressure during pipe flushing was assumed to be constant.

$$Q_{gen.} = w + q_{gen.} \quad (3)$$

$$\frac{dQ_{gen.}}{dt} = \frac{dw}{dt} + \frac{dq_{gen.}}{dt} \quad (4)$$

where dt - the time during which the hydrodynamic process takes place (hours).

We can express the internal water consumption in the maintenance of wells and water extraction by the following differential equation:

$$y = f(x) \quad (5)$$

$$\Delta y = f(x_o + \Delta x) - f(x_o) \quad (6)$$

where $x = x_o + \Delta x$ is the current state of the hydrodynamic process
x_o- the initial state of the hydrodynamic process
$\frac{dq_{gen.}}{dt}$ - instantaneous water consumption during the hydrodynamic process (m^3/s)

So, if we apply formula (3) to formula (6):

$$\Delta Q_{gen.} = f\big(w + q_{gen.}\big) - f(w) \quad (7)$$

Formula (6) determines the average water consumption during the duration of the hydrodynamic process in the general system. $q_{gen.}$ in the formula (7) includes:

$$q_{gen.} = q_1 + q_2 + q_3 + q_4 + q_5 + q_6 + q_7 + q_8 + q_9 \quad (8)$$

where: q_1- water consumption for washing the water intake well (m^3/year);
q_2- water consumption for preventive, current and perfect repair of indoor plumbing systems (m^3/year);
q_3- water consumption to eliminate emergency situations in collective systems (m^3/year);
q_4- water consumption for the operation of drinking water storage tanks (m^3/year);
q_5- water consumption for the operation of the second lifting pumping stations (m^3/year);
q_6- water consumption for household purposes for the drinking water station (m^3/year);
q_7- water consumption for the repair of water transmission and distribution networks (m^3/year);
q_8- water consumption to eliminate emergency situations in water transmission and distribution networks (m^3/year);
q_9- water consumption for fire prevention and extinguishing (m^3/year).

If we differentiate formula (8) over time, we get the following formula:

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$$\frac{dQ_{gen.}}{dt} = \frac{dq_1}{dt} + \frac{dq_2}{dt} + \frac{dq_3}{dt} + \frac{dq_4}{dt} + \frac{dq_6}{dt} + \frac{dq_7}{dt} + \frac{dq_8}{dt} + \frac{dq_9}{dt} \quad (9)$$

we integrate the formula (9):

$$\int_0^{365} \frac{dQ_{gen}}{dt} = \int_0^{365} \frac{dq_1}{dt} + \int_0^{365} \frac{dq_2}{dt} + \int_0^{365} \frac{dq_3}{dt} + \int_0^{365} \frac{dq_4}{dt} + \int_0^{365} \frac{dq_5}{dt} + \int_0^{365} \frac{dq_6}{dt} + \int_0^{365} \frac{dq_7}{dt} + \int_0^{365} \frac{dq_8}{dt} + \int_0^{365} \frac{dq_9}{dt} \quad (10)$$

Formula (10) expresses the change $q_{gen.}$ and q_1, $q_{2,}$, $q_{3,}q_{4,}q_{5,}q_{6,}q_{7,}q_8$, q_9 during the year.
we integrate the formula (7):

$$\int_{t_1}^{t_2} Q_{gen.}(t)dt = \int_{t_1}^{t_2} \left(w + q_{gen.}\right)(t)dt - \int_{t_1}^{t_2} w(t)dt \quad (11)$$

The formula (11) represents the change of internal water consumption in the drinking water preparation system in the time interval from t_1 to t_2.

CONCLUSION

The problems of preventing negative situations arising during the design and operation of facilities used in drinking water preparation technology have been studied.

Retrospective analysis of scientific and research works on safety and reliability of drinking water supply facilities, safe operation of drinking water facilities has been performed.

The amount of water consumption and the process of saving it during the process of repairing pipes in drinking water networks have been improved.

1. A mathematical model for determining water consumption in the internal systems of water intake facilities has been developed.
2. Amounts of loss of drinking water during the operation of facilities have been studied on the example of Fergana region.
3. The problem of modeling the use of information technologies in modeling the formation of hydraulic processes in pipelines has been studied.

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