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FILTRATION OF NATURAL WATER WITH INCREASED UPFLOW SPEED

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ABOUT ARTICLE

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Abstract: The article presents the results of laboratory studies of the possibility of water purification from suspended solids by filtration with an upward flow of purified water at constant high speeds, and a high loading retention capacity is proved.

INTRODUCTION

Legislative acts and Decrees of the Government of the Republic of Uzbekistan provide for a sharp increase in the requirements for the quality of drinking water supplied to the population, as well as for the quality of treated wastewater discharged into water bodies; creation of closed water supply systems, facilities for post-treatment of wastewater and reuse for irrigation and technical water supply [1, p.108].

In the practice of water treatment for municipal and industrial water supply, the most proven, effective and reliable method for treating large water flows is filtration. Prospects for the development and increase in the capacity of circulating industrial water supply systems raise issues of intensifying the operation of water supply facilities, increasing the technical reliability of their operation, and improving technical and economic indicators. Of particular importance is the intensification of water treatment equipment at existing treatment facilities of industrial enterprises [2, pp. 7-8].

One of the methods of intensification of granular filters is also filtration with increased speeds, exceeding the filtration speed adopted for fast filters. This type of filtering through granular loading has found wide application in the purification of natural waters used for industrial needs, in the purification of water in the systems of circulating water supply of industrial enterprises, and, finally, in the post-treatment of domestic and industrial effluents for their reuse. At present, two main types of filtering structures are used in high-speed filtration cleaning:

1. Pressure granular filters operating at a constant increased filtration rate (sometimes they are called ultra-high-speed filters) [3,4].

2. Pressure granular filters operating in ultra-speed filtration mode with a continuous decrease in filtration rates as the load becomes silted.

The use of high filtration rates has been known for about a hundred years. The first high-speed filter station equipped with constant-speed filters was built in 1937 in Germany and used for chemicalless water treatment. Particularly widespread use of high-speed filtration began after the Second World War in Western Europe, Japan, and the USA, where this method of water purification was called ultra-high-speed filtration. The authors of the ultra-high-speed filtration method are R. Nebolsin and R. Sunday, employees of the hydraulic engineering laboratory of the US Corporation [5,6].

The first ultra-high-speed filtration stations designed for water purification in the recycling water supply systems of metallurgical enterprises were built in Fukuyama (Japan) and Geri (USA). Later, filter stations of this type were built at many enterprises in France and Italy, etc.

Along with such an advantage of ultra-high-speed filtering stations as a high specific productivity of structures (the productivity of structures per unit of their construction volume), their main disadvantage is filtration at a constant high speed, at which, as the filter load becomes silted, there is a continuous increase in shear stresses affecting contaminants trapped on the surface of the pore channels of the filter media. As a result of such an impact, contaminants can be carried out from the load into purified water long before the moment of full use of the available pressure.

More technologically advanced and appropriate from this point of view is the method of high-speed filtering, proposed by the Russian scientist G.N. Nikiforov [7,8].

The famous Russian scientist G.G. Rudzsky investigated the efficiency of ultra-high-speed filter stations of the battery type of the system of prof. G. N. Nikiforov in the swimming pool, with deep purification of pre-coagulated water in the system of circulating process water supply [9,10]. Water from the pool, supplied to ultra-high-speed filters, was subjected to periodic coagulation with aluminum sulphate. The station is successfully operated and currently in St. Petersburg, providing a high effect of clarification (the content of suspended solids is less than 0.5-1.0 g/m3, color 3-5 degrees).

Up to now, pressure filters loaded with quartz sand have been used in the purification of water from suspended solids by filtration. The main disadvantage of high-speed pressure filters of this design is the supply of source water from top to bottom in the direction of increasing size of the filter load.

At the same time, due to the fact that contaminants are distributed mainly only in the upper layers of the load, and the lower part of its volume practically does not participate in cleaning, the possibilities of the ultra-high-speed filtration method are used only partially.

This circumstance does not allow using the dirt capacity of the entire volume of the filtering load, reduces the duration of the inter-flushing period of the filters and, accordingly, leads to an increase in water consumption for the own needs of the filtering station.

The use of coarse-grained quartz sand loads of uniform particle size distribution is associated with high material costs, since it requires sorting the source material in quantities that are many times greater than what is required to fill the filters [11, 12].

The use of two-layer loadings (anthracite + sand) is associated with the need to organize a very laborious and expensive process of crushing and sorting anthracite. It should also be noted here that, until now, two-layer coarse-grained ultra-high-speed filters have been used only for partial mechanical treatment of oil-scale wastewater [13, 14]. There are no data on the effectiveness of their use in the purification of natural waters containing highly dispersed suspended solids.

From our point of view, an important direction in the search for ways to improve the efficiency of pressure ultra-high-speed filters is filtration in the direction of decreasing size of the loads.

Therefore, this work, aimed at creating the design of an ultra-high-speed pressure filter with a clamped layer of quartz loading, in which the movement of purified water occurs from the bottom up and determining its main technological parameters in the laboratory, had serious scientific and practical significance and its results are equally relevant for both conditions Namangan region, and the Republic of Uzbekistan as a whole.

The purpose of this work is to determine the effectiveness of the use of high-speed filters with an upward flow and a clamped load for the purification of natural waters containing up to 100–150 g/m3 of suspended solids.

Research methodology. The study of the effectiveness of the ultra-high-speed filtration method with an upward flow and a clamped load of quartz sand in the direction of its decreasing fineness was carried out on a large-scale filter model mounted in the laboratory of the department of the Namangan Constraction Engineering Institute, presented in Fig.1.

The water of rivers and reservoirs of the Namangan region is characterized by a relatively low content of suspended solids, dissolved salts and a slightly increased content of hydrocarbonate ions, which determines the alkalinity of water and contributes to the effective flow of the coagulation process.

The experimental filter was loaded with sand from the Aktash quarry of non-metallic materials located in the Turakurgan district of the Namangan region. The following four schemes of the particle size distribution of the filter media were investigated (see Table 1.):

Table 1.

Scheme No.	dmin, mm	dmax, mm	de, mm	Kn
1	0,5	2,0	1,3	1,73
2	0,75	2,0	1,4	1,69
3	1,0	2,0	1,5	1,67
4	1,0	2,0	1,6	1,46

The loading height was taken for all schemes to be 1.6 m.

It was planned to conduct studies in two-speed modes: in the filtration mode with constant high speeds (ultra-speed filtration) and in the super-speed filtration mode with a constant decrease in the filtration rate during the interwash period of the filter operation, while maintaining a constant pressure loss in the filtering load.

When planning the experimental work, which was carried out using the Greek-Latin square, to select the values of the primary factors - the content of suspended solids in the source water, the initial filtration rate, the equivalent diameter of the load, and the intervals between their levels, data from previously performed studies and operating experience of ultra-high-speed filters were used.

The most expedient way to solve the tasks set was experimental studies carried out in laboratory conditions at a facility that fully simulates the developed technological scheme.

For this purpose, a large-scale model of a pressure filter with an upward flow and a clamped load was constructed in the laboratory, which is the main unit of the experimental setup, on which full-scale technological processes were reproduced with subsequent accuracy for practical conditions.

Results of experimental studies and analysis of the obtained results. The efficiency of granular filters of any type is characterized by their ability, under certain technological parameters of the operating mode, to retain mechanical impurities in the filtered water.

The main initial data for the study of the process of water purification by filtration were the quality of the water entering the filter, the particle size distribution, the nature of the surface of the grains and the height of the filter load, the filtration rate, which characterizes the amount of water that has passed through a unit area of the filter per unit time.

The experimental setup consisted of the following main parts: an artificially turbid water preparation unit, a reagent facility, and a pressure filter with an upward flow (pic. 1).

Water from the city water supply 1 was supplied to tank 2, where a concentrated suspension of the turbidity was prepared. Mixing of water with turbidity was carried out by simultaneous supply of compressed air from blower 3 and circulation of the suspension in the tank using pump 4. The same pump supplied the prepared suspension through pipeline 5 to a constant-level dosing tank 6. To control the flow rate of concentrated suspension on the pipeline part of the suspension from the dispenser tank for filtration, an adjusting valve 7 and a rotameter 8 were mounted.

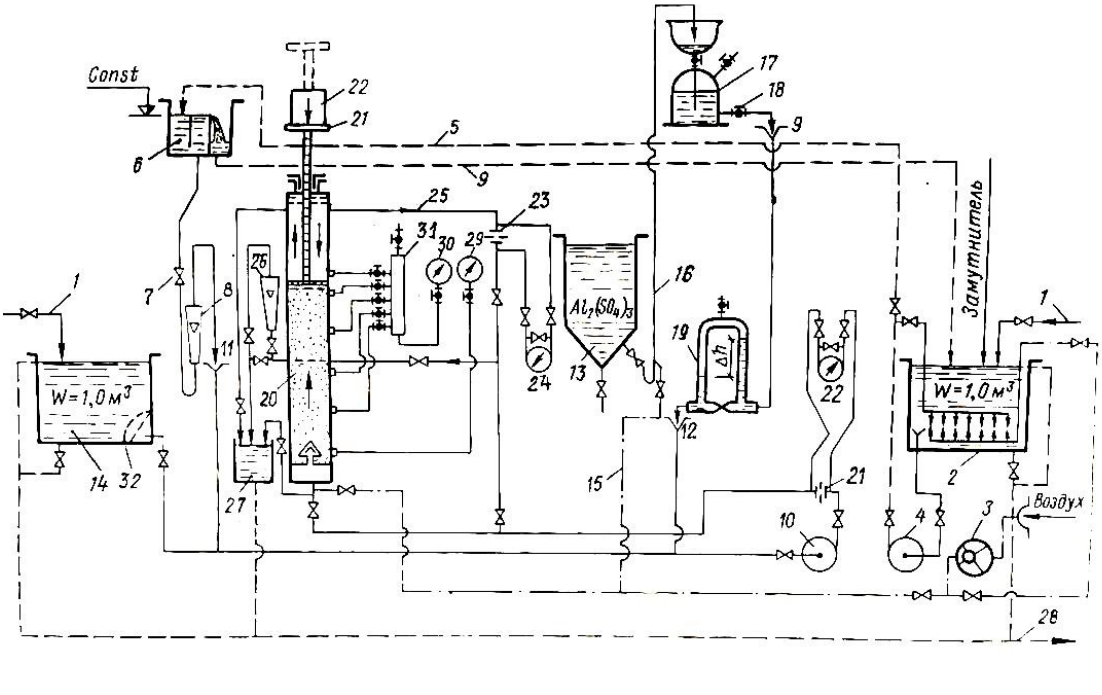
To receive a dosed amount of a concentrated suspension, a funnel 11 was mounted on the suction line of pump 10. Simultaneously with the supply of a concentrated suspension, a coagulant solution prepared in tank 13 and city tap water from tank 14 were supplied to the suction line through funnel 12 to dilute the suspension to the required concentration. From the tank 13, the coagulant solution was pumped through the compressed air supplied through the pipe 15 to the airlift 16 to the constant dose dispenser 17, on which an adjusting valve 18 was installed to control the dose of the coagulant. concentration was fed into the lower part of the filter 20.

To measure the total amount of initial turbid water at a filtration rate of more than 40 m/h, a narrowing device-chamber diaphragm 21 was installed on the pressure pipeline of the pump 10, complete with a float differential pressure gauge-flowmeter 22.

To measure the performance of the filter at filtration rates, a similar differential pressure gauge-flowmeter 23-24 was used, designed for a lower capacity and mounted on the filtrate pipeline 25.

To measure filtration rates of less than 20 m/h, a rotameter 26 brand PC-5 with a bypass line was installed in the continuation of that pipeline.

To receive the filtrate and water from washing, an intermediate measuring tank 27 was installed, from which the waste water was sent to the sewer 28. The pressure loss in the filtering load was determined using two exemplary pressure gauges 29 and 30. The pressure gauge 29 was connected to the lower part of the housing to the cap distribution device and measured the pressure at the inlet to the filter. In the second pressure gauge 30, which measured the pressure at different points of the load and on its surface, pressure pulses were transmitted through the distribution comb 31, the installation of which made it possible to measure not only the total pressure loss in the filter, but also made it possible to determine the pressure loss in individual layers of the load at any point in time. To prevent accidental objects from entering the pumps, meshes 32 were installed in tanks 2 and 14 at the inlet to the suction lines.



Picture1.Scheme of the experimental setup

The choice of schemes of particle size distribution and loading height was made on the basis of an analysis in the field of ultra-high-speed filtration, previously given studies and taking into account the peculiarities of the principle of operation of the considered filter, in which the movement of the purified water occurred in the direction of decreasing grain size of the load and the largest amount of contaminants was retained in the lower layers with a larger load. The lower layers of the load with a thickness of 0.4-0.6 m, which received water with the highest content of mechanical impurities, consisted of sand with a particle size of 1.65-2.0 mm.

When the filter is operating in the ultra-high-speed filtration mode at a constant speed, it was originally planned to study the cleaning efficiency based on the data of other authors [2,7] at four speeds: 15,30,45,60 m/h.

Maintaining a constant filtration rate (ultra-speed filtration) with a constant increase in pressure loss in the filter as the load became silted was achieved by reducing the resistance at the filter outlet by opening the valve at the filter outlet according to the readings of the differential pressure gauge-flowmeter.

When studying the efficiency of the filter in the ultra-high-speed filtration mode, the initial filtration rates were taken, according to the literature data and operating experience of existing ultra-high-speed filtration stations, to be 45-60 m/h.

Compliance with the main feature of ultra-high-speed filters - maintaining a constant pressure loss in the filter during the interwash period while simultaneously reducing the filtration rate as the load becomes silted - was carried out according to the readings of pressure gauges installed at the inlet to the filter and at the outlet of it by gradually reducing the supply of initial water to the filter.

Switching off the experimental filter for washing was carried out by reducing the filtration rate to 7.0 m/h. The choice of the value of the final filtration rate, which determines the duration of the filtration cycle under experimental conditions, was based on the actual data of the operation of a number of high-speed filtration stations.

In the process of purification of the source water by filtration, such indicators of water quality as the content of cations and anions, hardness as a result of water treatment with a coagulant and filtration, practically did not change and did not affect the purification effect. Therefore, during the experiments, their determination was not carried out.

To control the efficiency of coagulation of the source water, simultaneously with the determination of the content of suspended solids in the same water samples, the values of the pH value and color were determined. To determine the pH, a pH-meter brand pH-673 was used, a color-electrophotocolorimeter brand KFK-2.

The task of researching the efficiency of the filter with an upward flow and a clamped load at a constant filtration rate included determining the effect of cleaning the source water from mechanical impurities during the inter-flushing period of the filter, its duration, the nature of the change in head loss and dirt capacity of the filter load.

Studies have shown that when filtering at a constant speed, the range of changes in the cleaning effect turned out to be very wide 64.7-96.7%, while the highest cleaning effect was observed only during the first hour of filter operation, then there was a sharp increase in the turbidity of the filtrate, which practically made unsuitable for further use in the water supply system.

The results of experimental studies of the water purification process of the Great Namangan Canal at a pilot plant with a capacity of 10.0 m3/hour are presented in Table 2.

Averaged technological indicators of the pilot filter operation

Table-2.

experience number	Turbidity of initial water M0, g/m3	Initial filtration speed v_0, m/h	Equivalent loading diameter loading diameter d_e, mm	Lightening effect E, %	Filter cycle duration, t, hour	Pressure loss in the filter h, m	Coefficient "v", hour-1
1.	31,5	45	1,3	92,1	16,5	1,80	0,329
2.	62,5	45	1,6	91,8	16,7	1,84	0,325
3.	91,5	45	1,4	95,1	12,7	2,24	0,427
4.	118,0	45	1,5	96,5	10,4	2,24	0,522
5.	32,5	50	1,5	90,5	17,2	2,16	0,357
6.	63,0	50	1,4	91,6	16,6	2,30	0,370
7.	92,0	50	1,6	92,7	13,8	2,40	0,445
8.	122,0	50	1,3	96,3	9,8	2,70	0,627
9.	32,0	55	1,6	87,8	18,0	2,30	0,381

10.	62,5	55	1,3	91,2	14,8	2,42	0,463
11.	91,0	55	1,5	90,7	13,5	2,50	0,508
12.	122,0	55	1,4	93,6	9,9	2,60	0,692
13.	30,0	60	1,4	89,1	17,2	2,08	0,440
14.	58,5	60	1,5	90,8	15,6	2,13	0,486
15.	89,5	60	1,3	89,8	11,6	2,8	0,653
16.	118,5	60	1,6	92,7	10,1	2,24	0,750

The slippage of mechanical impurities into the filtrate in this case is explained, firstly, by a large amount of suspension in the source water, as well as by a continuous increase in pressure loss that took place throughout the entire inter-flushing period of filtration and, accordingly, led to an increase in stresses that cut off impurities trapped on the loading surface. which were carried out by the water flow from the filter layer.

CONCLUSION

Based on the results of studies of the water purification process at an experimental water treatment plant, the following conclusions can be drawn:

1. Laboratory studies of high-speed pressure filtration with an upward flow of purified water in the direction of decreasing grain size of the load proved the high retention capacity of the load. Thus, the effect of water purification to remove suspended solids during the interwash period of the filter operation, which reached 10-18 hours, was stable and amounted to 87-97%, while the dirt capacity of the load reached 20 kg/m downflow filters operating under similar conditions;

2. A design of a pressure filter has been developed that provides effective purification of pre-coagulated water containing suspended solids by feeding it from bottom to top in the direction of decreasing grain size of the load in the mode of pressure ultra-high-speed filtration.

3. The use of ultra-high-speed pressure filtration in the direction of decreasing grain size of the load allows, in comparison with the conventional method of ultra-high-speed filtration under the same conditions, to reduce operating and reduced costs by 30-35 percent.

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