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Influence of the Properties of Water and Suspension on the Operating Modes of Ultra-High-Speed Filters

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ABSTRACT

The reasons for the impact of the physical and chemical properties of the source water on the effect of clarification, dirt holding capacity and pressure loss in the filter load were investigated. The processes occurring in the granular filter loading during cleaning are described. The pattern of suspension distribution in the loading layers corresponds to the laws of the process of water clarification during filtration.

Ultra-high-speed filtration stations are widely used both for coarse clarification of natural waters and for obtaining high quality water. As a result of numerous studies of natural water purification by ultra-high-speed filtration, carried out by the famous Russian scientist G.N. Nikiforov and his students found that with the same load and initial filtration rate, the performance of the filter is influenced by the physicochemical properties of the source water and suspension in it. The change in these properties is directly reflected in the effect of clarification of the source water, dirt capacity and pressure loss in the filter load. The reason for the impact lies in the laws of the water clarification process.

Considering the process of water purification in fast filters as a set of processes of adhesion and suffusion of suspended particles on the surface of the grains of the filter load, prof. D.M. Mintz suggested that when water is clarified by filtration, the following processes occur in the filter loading:

1. Retention of large impurities from water and charged particles of the same name as the filter material in the upper layer of the load and in the labyrinths of its pores.

2. Contact coagulation, or sticking of the suspension to the grains of the load due to the forces of physico-chemical interaction between them.
3. Adsorption of small particles from water on the surface of suspended suspended matter particles.
4. Separation from the grains of the load of previously adhered particles in the upper layers, their transfer and retention in the underlying layers of the load under the influence of the forces of a moving water flow.
5. Removal of a stable suspension into the filtrate, which is not retained during filtration.

The task of the ongoing research is to obtain formulas for determining:

coefficient α according to the data of physical and chemical analyzes of the source water and suspension in it;

the dirt capacity of the load and the effect of clarification of the source water depending on the value of α, the granulometric composition of the load and the filtration rate.

Depending on the properties of water and suspended matter, all of these processes can equally affect water clarification, or some of them will be predominant. The state and type of suspended matter in the loading pores will be different.

According to Professor D. M. Mints, a flaky moisture-absorbing suspension occupies a large volume in the pores of the load, but in dried form it has a small weight. A heavy suspension in a dense body occupies a small volume in the pores. The decrease in the pore volume in the process of filter silting determines the dirt holding capacity and pressure loss in the load.

The calculation method for high-speed filter stations is based on the dirt capacity of the load, taking into account the ability of the suspended suspension to occupy different volumes in the pores. This ability is characterized by the value of the volumetric coefficient α (in m^3/kg), showing what volume in the wet state a weight unit of dry suspension occupies in the pores [5,6]. The value of the maximum dirt capacity of the load ultimately dictates the composition of the station and the scheme for automating its work.

Dirt capacity, pressure loss in the load and the volumetric coefficient are interconnected in the following well-known formulas:

$$К_n = К_0 \cdot \left(1 - \frac{\alpha M_n}{W_z m_0}\right)^3; \; h = \frac{V_n \cdot h_{sl}}{К_n}; \; \alpha = \frac{W_{vz}}{M_n}; \; M_n = \frac{M_f \cdot t_n}{t_{fs}^{f}}; \; M_n = M_{ref} \cdot Э$$

In the formula, $К_0$, $К_n$ are the filtration coefficients of the net load and at the calculated moment;

M_n — weight amount of suspended solids in the filter load by the calculated moment;

W_z —filter loading volume;

m_0 - average porosity of the load in the filter;

v_n— filtration rate at the calculated moment;

h_{sl} — loading layer height in filter;

W_{vz} — volume occupied by suspended matter in the loading pores;

M_f — maximum dirt capacity of the load;

t_{fs}^{f} — duration of the filter cycle (from washing to washing) in automatic mode;

Э — the effect of clarification of the source water;

M_{ref} — the amount of suspension that entered the filter with the source water by the calculated moment.

As can be seen from the formulas, the coefficient α has a great influence on the operation of the filter.

Dirt capacity and the effect of clarification, in turn, still depend on the granulometric composition of the load and the filtration rate. In the absence of data on these three indicators (α, M_f and E), the calculation of filter stations is not possible.

Data on α, M_f, E can be obtained experimentally on a pilot plant. However, not in all cases of design, it is possible to conduct experiments over a long period to obtain the calculated values.

Recently, ultra-high-speed filtration stations have been used not only for the purification of natural water in industrial water supply systems, but also for the treatment of wastewater for the purpose of their use in circulating water supply systems. In this regard, taking into account the need for mandatory calculation of all designed stations, the task arose to establish analytical dependencies for determining α, M_f and E.

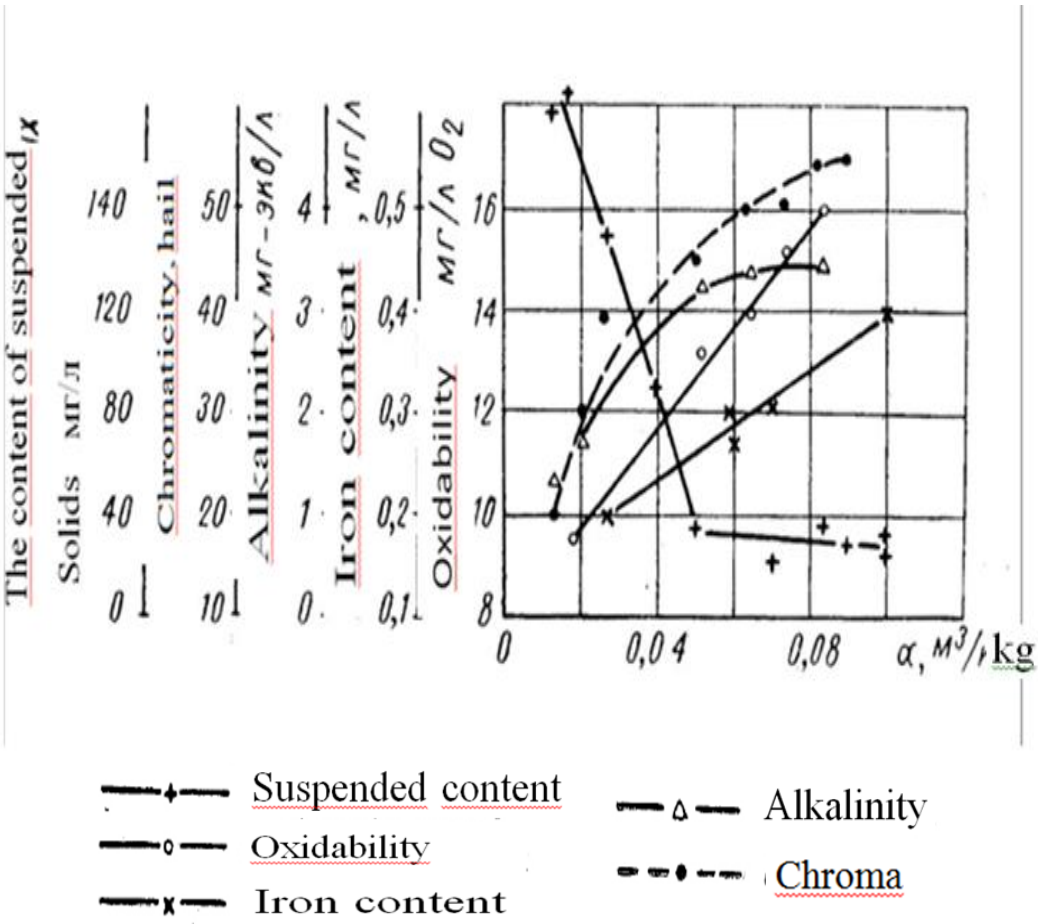

Fig.-1. Graph of the dependence of the coefficient α on the quality indicators of the source water

In order to identify the dependence of the coefficient α on the quality indicators of the source water and suspension in it, according to the data of physicochemical analyzes, we processed the results of a number of experiments on natural water filtration. The experimental data confirm the assumption of the existence of certain dependencies, the form of which is shown in Fig. 1.

According to the same experiments, the dependence of the distribution in the loading layers of the delayed suspension by weight and properties is shown in Fig. - 2. The heavy suspension remains mainly in the upper layers of the loading, the lighter one penetrates deeper. The pattern of suspension distribution corresponds to the regularities of the process of water clarification during filtration

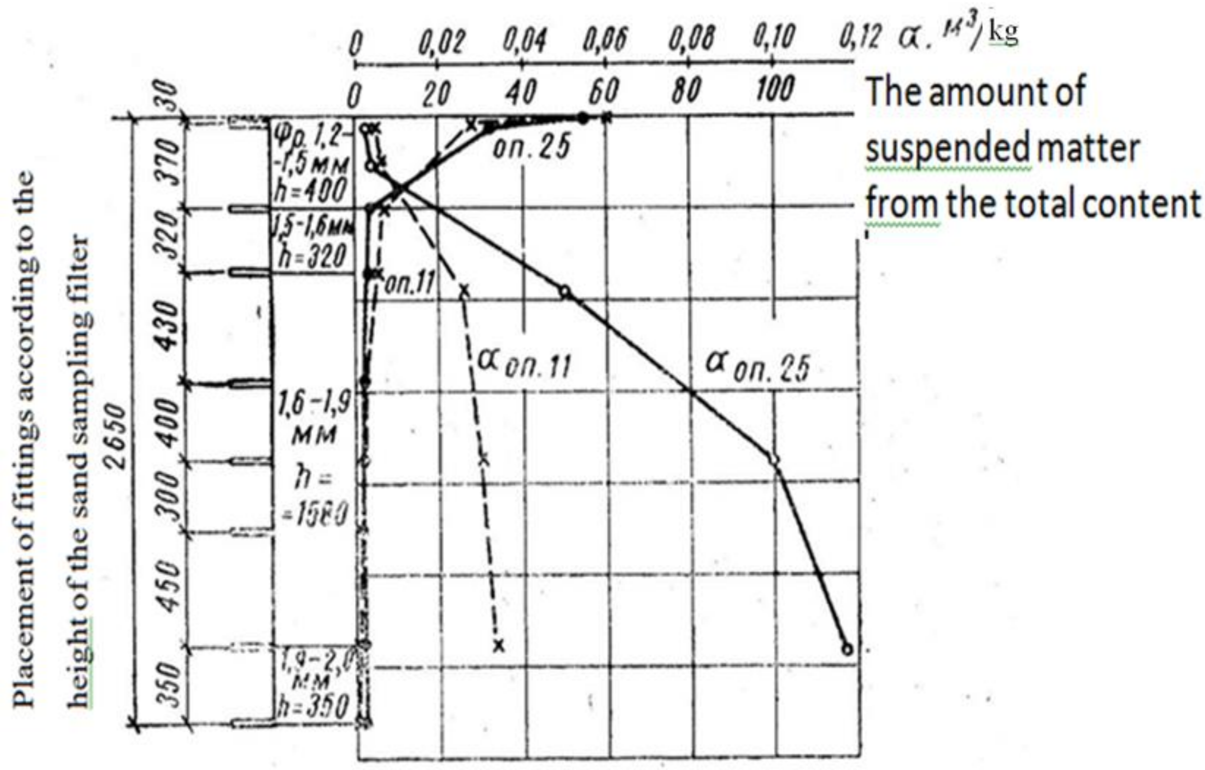

Fig. 2. Graph of the distribution of suspended matter and the value of the coefficient α in the layers of the filter loading

From the analysis of the formulas given above, we can assume that the direct significance of E from α and m0 also exists and will be linear.

The data presented in Figures 1 and 2 are preliminary. Additional experimental data will be presented after special studies are carried out at a pilot multi-purpose plant under production conditions with natural waters having various physical and chemical indicators, the implementation of which is scheduled for the second stage of research.

The results of the research will make it possible to reasonably solve the issues of designing filter stations for water supply systems for household and drinking and industrial purposes.

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