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ORGANIZATION OF AUTOMATED TECHNOLOGY OF MIXING WATER FOR PREPARATION OF IRRIGATION WATER IN FIELD CONDITIONS

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Usmanov A.M
Yadgarova D.B.
(National Research University TIIAME)

ABSTRACT

The well-known recommendations for mixing saline water from drainage wells with water of normal mineralization have not yet been implemented in our country on the basis of a structured technological process with automated control and management. The paper presents research materials on the structural organization of the technological process of mixing drainage water and water from a source based on automation of equipment control and control of salinity (mineralization) of water, as well as recommended proposals on theoretical aspects of mixing to build a control system that provides and maintains the required salt concentration values.

Keywords

Technological process, mixing, organization, structure, drainage, well, salinity, collector, equipment, operations, modes, automation, management, control, model.

Introduction. The creation of automated technological processes on the on-farm part of the irrigation system , aimed at the economical use of water resources, as well as improving the melioration state of the soil, is highly relevant along with the drip irrigation technology. Automated technology of water treatment from drainage wells and the collector network as a whole on the WOS and in individual farms, using modern IT tools and digital technologies for monitoring and control is an urgent task. In the conditions of water resource shortage and the impact of global and regional climate change, the on-farm irrigation network needs high-tech management tools and methods, and most importantly, the formation of automated methods not only for saving irrigation water, but also for its production. At the same time, a production solution to this issue in the field seems to be very rational. For this, there is a significant example of the application of the structural organization of the drip irrigation technological process, when equipment is formed in the irrigation zone of the district irrigator, including volumetric water tanks, pumping units, and a pipeline network [1]. For the mixing process, the term

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"production" (preparation) of irrigation water acquires a characteristic meaning, and in field conditions, which, along with drip irrigation, also carries an industrial load. As is known, the organization of the technological process is understood as a rational combination of live labor with elements of the structure, composition of the process, the number and order of operations performed in established modes. Therefore, in this work, the goal was defined - to study the structural organization of the technological process of mixing drainage water and water from the source based on the automation of equipment control and control of salinity (mineralization) of water, as well as to create proposals for theoretical aspects of mixing for the construction of a control system that ensures and maintains the required values of salt concentration. In the course of work, theoretical research, development and construction of automated technology for field conditions of irrigation water production were carried out.

In our country, groundwater constitutes a significant part of the country's water resources and plays an important role in drinking and agricultural water supply, including irrigation and pasture watering. Natural groundwater resources in Uzbekistan as a whole are 24.35 km3 and 7-8 km3 permitted for use [4]. The total volume of return water from various water consumers and water users is 28.3 km3 / year. At the same time, the level of average mineralization of collector-drainage waters (CDW) varies from 1.5-2.5 g / l to 5-6 g / l., similarly underground sources - drainage waters [4]. The use of such resource potential for irrigation is associated with mixing these waters with water of normal (up to 1.0 g / l.) salinity. However, the functioning of such mixing on the basis of structured technologies, and especially automated ones, does not exist in Uzbekistan today. Forecasts by specialists on water reserves and its use are skeptical for the medium term – 12-15 years, and even more so for the long term – 20-30 years.

Solutions and methods. The term "mixing" with the emergence of the idea of "joint use of ground and surface water" [4] is outdated, and not only the term, but also the approach to assessing the process of "mixing" itself. Today, it is appropriate to talk about the creation of a technological process for the production of irrigation water, when there are machines and equipment for this, as well as experience in their operation in other technologies not related to mixing. Such structural components should include well equipment, gates for low-power hydraulic structures assembled with electric drives, flume equipment. All this is inherent in the on-farm irrigation network (FIN) today. That is, a new technological control object (TCO) in the form of mixing technology is being formed at the FIN (in addition to drip irrigation technology).

Structure. Accordingly, the composition of such technology can serve as a basis for organizational structuring at the WTP, in field conditions, of the

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technological process of mixing saline water from vertical drainage wells or return collector waters with water from a source with normal mineralization. Such structuring is shown in Fig. 1. As we can see, in the central part there is a tray - mixer 2, where saline water from well equipment 1 enters, through a storage tank 3 with a valve and from a source 4, through a valve - "clean" water. Then through the valve and storage tank 5 for irrigation using a pump.

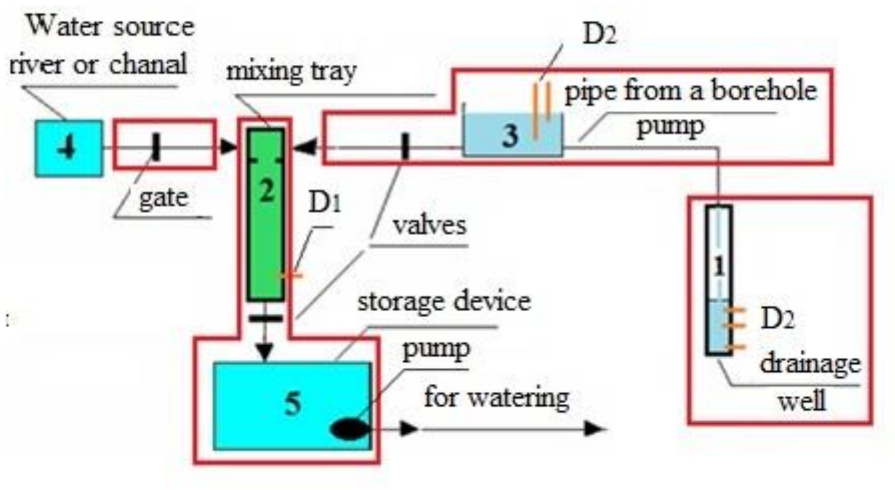

Fig. 1. Equipment and sections of the irrigation water preparation process.

Thus, it is possible to distinguish 4 sections, in which various operations are performed: 1 - pumping water from the well; 2 - mixing water in the mixer and feeding it to the storage tank; 3 - transporting water through the storage tank to the mixer; 4 - transporting water from the source to the mixer. Equipment. The following equipment is involved in the above operations: a well (drainage water) or a collector (return water), a submersible pumping unit, or a pumping unit for pumping water from the collector, water pipelines, actuators (dampers, valves), a mixing tray with water storage tanks. Also level sensors, salinity, water metering, control cabinets and a KTS (a complex of technical means, including controllers).

Modes. The formation of modes in such a technological process is seen as coordinated and proceeding from the source of “clean” water and the well operating mode. The storage tanks and partially the mixer assume a certain “damping” of the process under the influence of the well operation.

Theoretical aspects of mixing. The technological process of mixing is schematically shown in Fig. 2. In this figure, channels 1 and 2 of water supply from source 4 and from well 3 (Fig. 1) are numbered;

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2 $Q_{2,}c_2$

through Q, C with the corresponding indices we denote the water flow rate and the concentration of minerals. For concreteness C1<C2. It is obvious that the concentration of minerals in the resulting mixture satisfies the condition C1 ≤ C ≤ C2 (1). It is required to construct a control system that provides and maintains some required values of mineral concentration C=Ct at the mixer outlet. The required value of mineral concentration also satisfies the inequality C1 ≤ Ct ≤ C2 (2).

Basic relations: For mass flow rates through channels 1 and 2 we have

$$\begin{cases} m_1 = m_{1в} + \mu_1 \\ m_2 = m_{2в} + \mu_2 \end{cases} \quad (3)$$

Here m1b, m2b are the masses of pure water; μ_1, μ_2 are the masses of minerals contained in the water. The unit of measurement for these quantities is [MT-1]. For the mass flow rate at the mixer outlet, in steady-state mode, we can write:

$$m = m_1 + m_2 = m_{1в} + \mu_1 + m_{2в} + \mu_2 = m_b + \mu \quad (4)$$

Degree of mineralization in the first channel:

$$x_1 = \frac{\mu_1}{m_1} = \frac{\mu_1}{m_{1в}+\mu_1} = \frac{1}{\frac{m_{1b}}{\mu_1}} \quad (5)$$

On the second channel:

$$x_2 = \frac{\mu_2}{m_2} = \frac{\mu_2}{m_{2в}+\mu_2} = \frac{1}{\frac{m_{2b}}{\mu_2}} \quad (6)$$

For the degree of mineralization of prepared water the following relationships apply:

$$x = \frac{\mu}{m} = \frac{\mu}{m_в+\mu} = \frac{\mu_1+\mu_2}{m_1+m_2} = \frac{\mu_1+\mu_2}{m_{1в}+m_{2в}+\mu_1+\mu_2} \quad (7)$$

By transforming expression (7) we can obtain:

$$x = \frac{x_1 m_1 + x_2 m_2}{m_1 + m_2} = \frac{m_1}{m} x_1 + \frac{m_2}{m} x_2 \quad (8)$$

Thus, the degree of mineralization of the outlet water is determined as the weighted average sum of the degrees of mineralization of the input flows. The relationship between mass and volume is:

$$m = \rho Q \quad (9)$$

where ρ is the density, its dimension is [ML-3]; Q is the volumetric flow rate, the unit of measurement is [L3T-1]. Obviously, Q=Q1+Q2 (10). Taking into account the last two expressions, it is easy to obtain from expression (8):

$$x = \frac{x_1\rho_1 Q_1 + x_2\rho_2 Q_2}{\rho_1 Q_1 + \rho_2 Q_2} = \frac{x_1\rho_1 Q_1 + x_2\rho_2 Q_2}{Q_1 + Q_2} \cdot \frac{1}{\rho} = \frac{x_1\rho_1 Q_1 + x_2\rho_2 Q_2}{\rho Q} \quad (11)$$

The output flow density is determined through the input flow density from the expression:

$$\rho = \frac{\rho_1 Q_1 + \rho_2 Q_2}{Q} \qquad (12)$$

Then

$$x = \frac{\rho_1 Q_1}{\rho_1 Q_1 + \rho_2 Q_2} x_1 + \frac{\rho_2 Q_2}{\rho_1 Q_1 + \rho_2 Q_2} x_2 \qquad (13)$$

The concentration of minerals is defined as the ratio of their mass to the volume of the solution, that is,

$$c = \frac{\mu}{Q}, \quad [M\ h^{-3}] \qquad (14)$$

Therefore, for the output stream we obtain

$$c = \frac{\mu_1 + \mu_2}{Q1 + Q_2} = \frac{\frac{\mu_1}{Q_1} Q_1 + \frac{\mu_2}{Q_2} Q_2}{Q_1 + Q_2} = \frac{c_1 Q_1 + c_2 Q_2}{Q_1 + Q_2}. \qquad (15)$$

On the other side

$$c = \frac{\mu_1 + \mu_2}{Q1 + Q_2} = \frac{x_1 m_1 + x_2 m_2}{Q_1 + Q_2} = \frac{x_1 p_1 Q_1 + x_2 p_2 Q_2}{Q_1 + Q_2}. \qquad (16)$$

From the comparison of expressions (15) and (16) we obtain the relationship c = xp. Expressions (15), (16) show that the concentration of minerals in the resulting flow is equal to the weighted sum of the concentrations of minerals in the input flows.

A similar approach in the theory of this mixing issue has a continuation in terms of the technological schemes of the mixing itself, the strategy of process control and the construction of a model of the control object. These issues are studied and will be covered in subsequent works.

Conclusions. In conditions of water resource shortage, the technology of irrigation water production (water treatment) acquires a relevant meaning, to solve a number of issues of which the present work was aimed. It was found that a rational approach to solving such an issue should be the creation of water treatment technology on the irrigated areas of the WTP, following the example of drip irrigation technology. The new organizational structure of such a process is based on mixing saline water from drainage wells, or from return water, or both with non-saline water from traditional sources. The work established the composition of equipment, control and automation of the process, considered the theoretical aspects of mixing to create an automated control model.

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