Perfection of Drinking and Technical Water Supply Systems in the Implementation of the Concept a Heat and Power Complex for Highly Efficient Use Of Secondary and Renewable Energy Sources

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Abstract. A number of the aspects influencing economic indicators of work of baromembranny installations by preparation of water of the surface water sources for drinking and technical water supply of private housing constructions is considered. Technical water supply in this case is intended for the system of feed of the heat power complex working on secondary and renewables. In article advantages of the flow diagrams of surface preparation the reduced quality water approved under production conditions, in particular, high-performance of chromatity sizes are proved. Comparative evaluation test of a filtrate when using various options of prerefining of water - with use of macroporous ion-exchange resins, installations of nanofiltration, cation-exchange flocculants is given.

1. Introduction

As part of the implementation of the grant Russian Federation’s President, a heat and power complex is being developed for the highly efficient use of secondary and renewable energy resources. In the offered research the problem of complex use of renewable and secondary energy sources is solved. Accounting of internal overflows of energy in the consumer when heating, conditioning and hot water supply, will allow to minimize use of fuel in the energy balance of the building. Works are based on results of the previous researches of collective with assistance of council for the Russian President's grants. The complex contains the multilevel high performance accumulator of thermal and refrigerating energies and also the cascade heatpumping plant [1]. In this article the emphasis is placed on a water treatment problem as the used water in a heat power complex can create conditions for deterioration in work of radiator surfaces the heat accumulators and also cascades evaporators and condensers of the heatpumping plant. Thus, in article perfecting of drinking and technical system water supply to the level of the heat power complex ensuring no-failure operation for high performance use of secondary and renewable energy resources is described.
For drinking and technical water supply in civil engineering use the waters of the surface reservoirs experiencing rather strong anthropogenic influence now. At the surface reservoirs there are natural impurities, the main ions, microimpurity, gases in solution and organic compounds. Up to 80% of these connections contain in the surface reservoirs and make the humic substances presented humic and fulvic acids. Also there are impurity of anthropogenic origin capable it is essential to complicate operation of clearing devices of water treatment.

Fulvic acids possess higher, in comparison with humic acids, solubility and can reach concentration (during the adverse flood periods) over 100 mg/l. Also high oxidation level and the considerable maintenance of oxygen-containing functional groups - carboxylic and carbonyl and also phenolic and alcoholic hydroxyls, quinoid, lactone and radio groups is characteristic of fulvic acids. Carboxyl and phenolic oxygroups of humic acids promote formation of strength complex connections with organic and inorganic substances of anthropogenous origin. These are ions of metals, the pesticides coming to surface reservoirs together with insufficiently purified household and production drain waters and surface drain. Also the increased salinity, low value рН waters, the increased concentration of phosphates and nitrogen-containing groups (nitrogen-containing substances in the oxidized and recovered forms), biologically resistant organic compounds are characteristic of surface reservoirs. Also increased salinity of oil products and superficially active agents exceeding of threshold limit values of which calls into question possibility of functioning as full-fledged biological system even of large reservoirs.

2. Experimental part
Now by preparation of water of drinking quality, and also preparation of water baromembranny technologies are more and more applied to open networks of hot water supply. It is caused by steady decline in water quality of surface reservoirs, demanding use of new technologies of water purification. It allows to provide even at poor quality of initial water compliance a quality of the purified water to the accepted international standards in the field of drinking and process water supply [2-6]. One more advantage of baromembranny technologies - their environmental friendliness. It allows to minimize the impact on the environment due to the complete absence of secondary pollution.

Application of methods of nanofiltering or low pressure reverse osmosis is more acceptable for preparation of drinking quality water. These methods provide optimum chemical and bacteriological compositions of the prepared water. By preparation of water for heating and hot water supply are more acceptable one or two-level reverse osmosis depending on salinity of initial water.

Anyway baromembranny installations are finishing stage of water treatment, demanding the careful preliminary water purification ensuring safety of membranes. Considering availability surface reservoirs of high concentration of the weighed impurity and colloid connections, requirements to quality of preliminary cleaning very high.

Optimization of the technology scheme was performed for natural water of the characteristic which are provided in table. The approved technology scheme provides supply microdoses of coagulant in the pipeline of initial water supply in front of mechanical filters in proportion to water discharge. And two options of coagulant dosing are provided: contact coagulation and coagulation in flow with removal of the received suspension on the ultrafiltration unit. In front of the ultrafiltration unit water treatment on self-washing automatic filters is provided.

The possibility of preliminary water purification of this initial structure on the macrodepth anion-exchange filters was in vitro studied. This option of pre-treatment showed very good results - steadily high quality of filtrate throughout all filter run. However, use of the macroporous anion-exchange materials assumes unsatisfactory ecological indicators at the expense of regeneration stage the fulfilled ion exchange resins [7-10]. Therefore the technology of ultrafiltration is more preferable despite the high cost of expendables [11-13].

After preliminary cleaning, the ultrafiltered water is directed to a nanofiltration unit whose permeate is divided into two streams. One stream is directed to the purposes of domestic and drinking
water supply, the second stream is sent to the subsequent treatment for the purpose of final desalination and subsequent supply to the heat supply system.

Table 1. A slightly more complex table with a narrow caption

| Index                              | Value  |
|------------------------------------|--------|
| Total stiffness (mg-eq / l)        | 2.6    |
| Total alkalinity (mg-eq / l)       | 1.5    |
| Sodium + potassium (mg-eq / l)     | 0.28   |
| Chlorides (mg-eq / l)              | 0.34   |
| Sulfates (mg-eq / l)               | 0.85   |
| Bicarbonates (mg-eq / l)           | 1.96   |
| Nitrates (mg-eq / l)               | 0.051  |
| Salinity (mg / l)                  | 291.85 |
| Carbonates (mg / l)                | 2.7    |
| Silicic acid – SiO₂ (mg / l)       | 16.5   |
| Iron total (mg / l)                | 1.74   |
| Aluminum (mg / l)                  | 0.08   |
| Oxidizing property, permanganate   |        |
| (mg / l)                           | 3.9    |
| Suspended matters (mg / l)         | 18.2   |
| pH                                 | 7.8    |
| Oil products (mg / l)              | 0.17   |
| Specific conductance (micromho/cm) | 286   |
| Turbidity (mg / l)                 | 18     |

The possibility of operation of installation of reverse osmosis [14-16] according to two technology schemes was investigated. In the first installation of reverse osmosis uses the ultrafiltered water, and on entrance to installation of reverse osmosis the block of dosing of inhibitor (antiskalant) is installed. In the second the ultrafiltered water goes only on the purposes of economic drinking water supply.

For the installation of reverse osmosis, waste water is supplied to the ultrafiltration units that have passed contact coagulation and fine filters with filter elements of cartridge type with dimensions of 5 microns. Dosing of inhibitor is made in proportion to flow [17-20].

Characteristics of installation of reverse osmosis on indicators of desalted water - chlorides and the general salinity are provided on fig. 1 and 2.

On installation of reverse osmosis BW30-440 membranes with selectivity of 99,5% were used.

In need of higher extent of desalting water the possibility of reverse osmosis installation modules according to the cascade scheme was investigated. The scheme works as follows: the ultrafiltered water, arriving in in parallel the installed modules of the first group, it is separated into two flows. Permeate from each module is taken away in the general collector of desalted water where mixes up with permeate of the second group modules, and the concentrate moves on entrance of modules of the second group, being for them initial water. The concentrate which is formed in the course of desalting from the second group of modules is brought out from an installation.

For definition of demineralization water extent in installation of reverse osmosis the concept of installation selectivity which can significantly differ from passport values of selectivity of membrane element was used. Distinction of these two types of selectivity is caused by the fact that the content of salts in water at the movement through the membrane elements located in each module and is consecutive - via the cascade of modules significantly increases. At increase of hydraulic efficiency of installation the content of salts in concentrate increases. Respectively, salinity of the desalted water received in final membrane elements in proportion increases. Salinity of the desalted water produced
on installation is average between received on initial and final membrane elements. Therefore, selectivity of installation appears always below selectivity of one membrane element. And this distinction of subjects is more, than the reached extent of concoction is higher.

Additional bonus when using the cascade two-level scheme of water treatment by method of reverse osmosis is decrease in content of silicon acid to 50 mkg/l. Further reduction in the concentration of this compound is possible only if additional water treatment is used on strongly basic anion exchange filters or when using the electrodionization method.

An additional series of laboratory experiments was devoted to optimization of the pre-cleaning stage using the method of nanofiltration of drinking water quality preparation. It is known that the process of desalination of natural water by the method of nanofiltration is influenced by many factors, including the characteristics of the source water and the conditions for its preliminary preparation before feeding into the baromembrane cell. Therefore, the determination of optimal parameters for carrying out the process of natural water desalination with a high content of natural organic substances was carried out using fractional factorial experiment of type $2^{5-1}$ with the generating ratio $x_5 = x_1 x_2 x_3$.

Variable factors in the experiment were the yield on the filtrate of the baromembrane cell (%) and the indelible residue accumulated on the membrane (mg). The optimization parameter was the value of the passed water total hardness through the nanofiltration membrane, mg-equiv./l. The performed studies showed that the greatest influence on the optimization parameter is provided by the concentration of the cationic flocculant dosed and the speed of passage of the coagulated water through the mechanical filters.

3. Conclusions
The expediency of using a hybrid technological scheme of water treatment for a specific composition of natural water of a surface reservoir is proved. The scheme allows to prepare water of a given quality for the purposes of domestic and drinking water supply and open systems of hot water supply in the buildings of individual housing construction at high environmental performance of the plant in operation and minimization of secondary pollution.

Acknowledgements
Article is executed with financial support of grant of the Russian Federation President for the state support of young Russian scientists - candidates of science MK-3537.2018.8 (Contract №14.Z56.18.3537-MK or 17.01.2018)

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