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Experimental electrocoagulation installation for pretreatment of natural water and experimental studies of the ion-exchange capacity of new ionites type ASX-64, ASX-64M

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ABSTRACT: The article highlights the state of pre-chemical purification of natural water on the Tashkent thermal power plant using aluminum sulphate and the creation of an experimental unit for producing coagulant, sulfuric acid aluminum, as well as a block diagram of the proposed electrocoagulation unit for preliminary purification and clarification of water. The use of new ion exchangers of the type ASX-64 and ASX-64M synthesized by scientists of the Tashkent National University.

KEYWORDS: Water treatment plant, thermal power plant, the electrochemical method, circulating water supply systems, purification, clarification of water.

I. INTRODUCTION

Among the most important technological processes of modern thermal power plants is a complex of processes for the preparation of deeply desalinated water, providing the normalized composition of impurities in steam and boiler feed water. To do this, each thermal power plant (TPP) has a system of preparatory installations (SPI). The SPI system includes an installation for the chemical treatment of the source water of steam and condensate, as well as the preparation of additional water and the cleaning of turbine condensate using ion exchangers at thermal power plants. In the TashTPP water treatment plant (WTP), it is often important to pre-purify water from sludge and various organic impurities. Preliminary purification consists in clarifying the source water (Boz-Su canal) by removing coarse and colloidal impurities from it.

So far, water clarification has been carried out by coagulation by introducing a special coagulant into the water being treated (in the case of TashTPP, this is aluminium sulphate $Al_2(SO_4)_3$).

We have developed electrocoagulation technology for the production of aluminium hydroxide with preliminary purification and water clarification for steam boilers of the TashTPP.

It is established that aluminium hydroxide obtained by the electrochemical method has a much higher sorption capacity than aluminium hydroxide formed because of the hydrolysis of its salts. The latter can be explained by the special conditions of the formation of coagulation structures in electrolysis, as well as by the much smaller influence of anions of strong acids, the concentration of which in this case is much lower than with the introduction of chemical reagents into water [1].

Initially, a pilot plant was created and commissioned to produce a coagulant at the TashTES, the scheme of the pilot plant is shown in Figure 1.

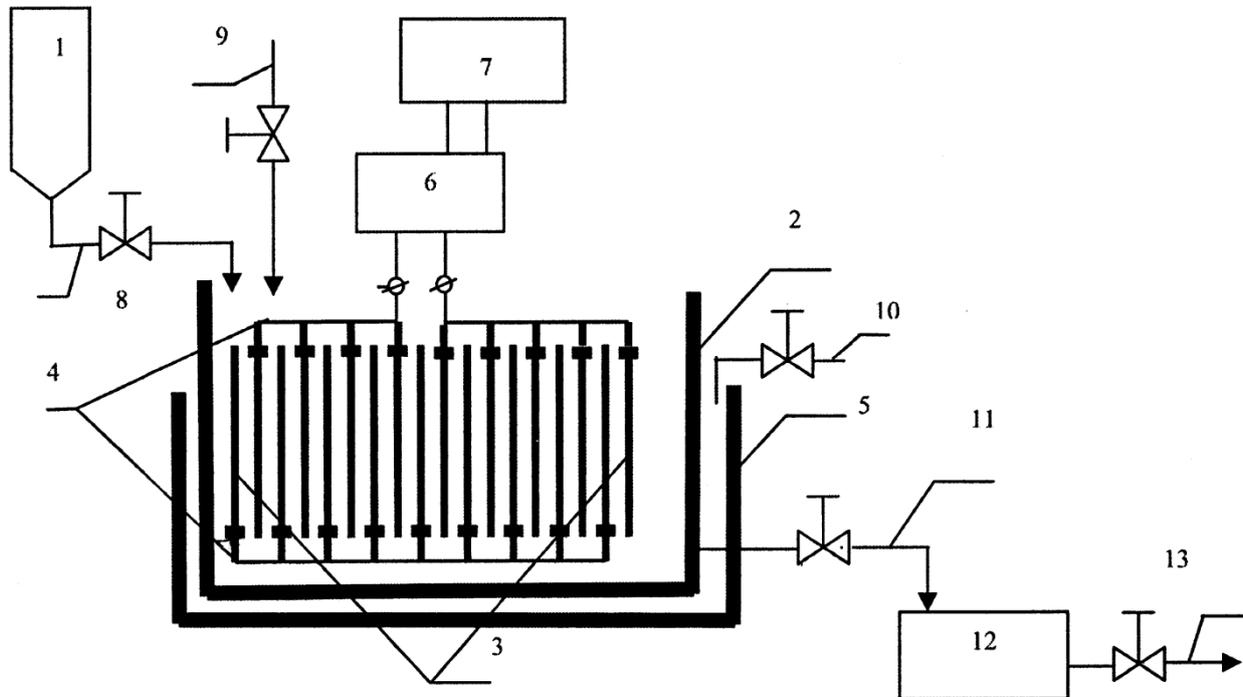


Figure 1. Diagram of the experimental unit for coagulant production at the TashTPP. 1-dimensional acid tank; 2-tank coagulator; 3- aluminium plates; 4-connecting tires; 5-tank for cooling; 6-ballast resistance; 7-power supply; 8-pipe acid supply; 9-water supply pipe; 10-piped cooling water supply; 11-pipeline draining the finished coagulant; 12-capacity for the finished coagulant; 13-coagulant supply to the technical water purification line.

II. SIGNIFICANCE OF THE SYSTEM

The essence of the method of electrocoagulation is the anodic dissolution of metals under the influence of electric current with the subsequent formation of colloidal impurities.

In the developed technology, it is proposed to use aluminium and duralumin waste. The method provides high efficiency of water purification and has significant advantages over reagent methods, first, the compactness of the installation, the absence of bulky reagent facilities, ease of maintenance, and the ability to fully automate and save currency.

In connection with the impossibility of providing the TashTPP with the necessary reagent - aluminium sulphate aluminium - we carried out studies to obtain the necessary reagent with electrocoagulation using aluminium scrap as a soluble electrode.

III. LITERATURE SURVEY

To carry out the tasks we have carried out literary analysis and research on the illuminated materials. The greatest contribution to the study of problems of treatment of water was made by the following scientists and experts: Zenin S.V., Mosin O., Kurik M.V., Martin Ch., Ignatov I., Emoto M., and other. Thousands of papers by both theorists and experimenters are devoted to the study of the properties of water. But they are all fragmented, not coordinated. The problem of water is an extremely important fundamental problem of the 21st century that should be solved by a wide range of specialists.

IV. METHODOLOGY

The removal of colloidal substances and water clarification at the Tash TPP is carried out by introducing into the treated water the technical coagulant of aluminium sulphate $Al_2(SO_4)_3$. In connection with the impossibility of regularly providing the TUHP of TashTPES with the necessary $Al_2(SO_4)_3$ reagent. We have conducted studies to obtain a solution of this reagent in industrial conditions.

In the Republic of Uzbekistan, various ion exchangers are used for deep water desalination at TPP, such as KU-1, KU-2, AN-17, AV-18 and others. Such ionites in the Republic of Uzbekistan are imported from foreign countries and Russia.

A block diagram of the proposed electrocoagulative pre-treatment and water clarification unit is shown in Figure 2.

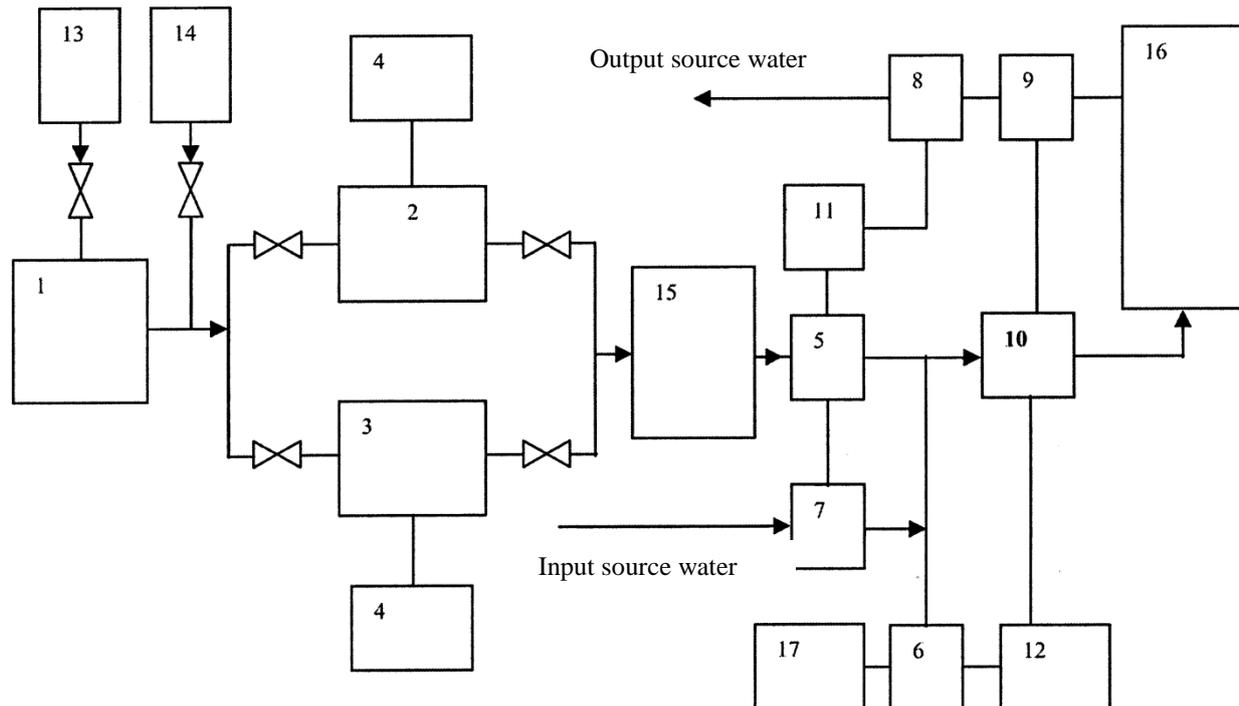


Fig. 2. The block diagram of the electrocoagulation unit: 1-tank electrolyte preparation; 2 and 3 electro coagulators; 4-power supply; 5-coagulant dispenser; 6-acid dispenser; 7 sensor lightness of the source water; 8 light water sensor; 9 pH sensor clarified water; 10 - pH sensor of the source water; 11 and 12 control circuits dispensers; 13-mer acid tank; 14-tank prepared salt; 15- coagulant filling tank; 16 column clarifier; 17-tank of sulphuric acid.

According to the calculations of electro coagulator tanks should be chosen with a capacity of 2 m³, dissolving electrodes can be used in the form of pressed plates or sheets prepared from waste, or block-bulk. In the tanks with electrodes electrolyte flows from the tank, in which the electrolyte of the required density is prepared.

Energy consumption can be minimized by selecting the interelectrode spacing and the switching time of the electrodes. Calculations based on the experience of working on an experimental installation for obtaining a coagulant by an electrochemical method showed that the capacity of the installation with a current density on the electrodes of 50 A/m² and an electrolyte temperature of 20 °C is 20 l/h. The plant capacity can be regulated by the current density, as well as the temperature of the electrolyte.

The accumulated coagulant with the necessary composition is accumulated in the coagulant accumulation tank (available at TashTPP. From this coagulant tank through the dispenser it mixes with the source water (water from Boz-Su) is fed to the input of the clarifier columns.

To improve the cleaning process and clarify the purified water is added acid to obtain the required pH. The pH sensor installed at the inlet and outlet of the clarifier columns, and the metering control circuit regulate the flow of the required amount of acid through the metering unit.

It is planned to introduce control from the quality and clarified water quality sensors into the automation scheme. This will allow to regulate the intake of coagulant when the source water is highly contaminated and to monitor the quality of the clarified water during the day.

The feasibility of the proposed project is confirmed experimentally by an electro coagulator, which has shown its working capacity, and a coagulant was obtained on it that fully meets the requirements of cleaning and clarification of the source water. Calculations based on the experience on the experimental installation for obtaining a coagulant by



electrochemical method showed that the performance of the proposed installation with a current density on the electrodes of 50 A / m² and a temperature of electrolyte 20°C is 20 l/h of a coagulant with a chemical composition: density of 1.3 g /cm³; aluminium oxide Al₂O₃ -7.6%; in terms of aluminium sulphate Al₂(SO₄)₃-25.5%. The plant capacity can be regulated by the current density, as well as the temperature of the electrolyte.

As is well known, one of the reliable methods of preparing deeply desalinated water for powering steam generators of TPPs is ion-exchange water treatment, therefore, a large amount of ion exchangers is needed when preparing additional water and cleaning turbine condensate at TPPs. [1,2].

Due to the lack of technology for the synthesis and production of such ion exchange materials, in the Republic of Uzbekistan for use at TPPs they are imported from foreign countries.

At this time, researchers of the National University of Uzbekistan proposed technological regulations for the production of new ion-exchange materials based on polyacrylonitrile, polyacrylamide, produced at the Navoi chemical plant, and they successfully completed the synthesis of an experimental batch of samples of ion-exchange materials ASX-64 and ASX-64M. [2]

These ion exchangers are obtained by modifying polyacrylonitrile produced at the Navoi chemical plant by polymerization.

The process of obtaining these ion exchangers consists of the following operations:

1. Amine + catalyst + stabilizer
2. Polyacrylonitrile + stabilizer +
drying
3. Ion-rinse +
drying.

The synthesized ion exchangers ASX-64 and ASX-64M are resistant to effects of 4% hydrochloric acid solution and fully retain their sorption capacity in the range of 6-60°C and above.

To study the ion-exchange capacity and duration of operation of these ion exchangers, we manufactured a laboratory setup equipped with columns with a diameter of 50 mm and a height of 500 mm. For the study, each column is filled with 15-20 grams of ion exchanger, the speed of passing water through the columns is 15-18 m/h.

V. EXPERIMENTAL RESULTS

The table shows the results of experimental studies of ion-exchange capacity of ion exchangers ASX-64 and ASX-64M with respect to chlorine ions. [2]

Determination of chlorine in purified water was carried out by titration of the filter 0.1 sodium hydroxide solutions (NaOH).

The results of the study of the ion-exchange capacity of the ion exchanger ACX-64, water with a chlorine ion content of 36 mg/l.

Table 1.

The amount water ml.	The amount of NaOH consumed for titration, ml	The residual content of chlorine ions in the filtrate where the initial chlorine content, mg/l	Residual equivalent chlorine ion content, mg.eq/l.
200	0	0	0
400	0	0	0
1500	0	0	0
2500	0	0	0
5000	0	0	0
6300	0	0	0
6350	0,1	0,8	0,02
6400	0,15	0,18	0,06
6450	0,20	2,7	0,07
6500	0,30	4,7	0,12
6550	0,35	5,4	0,15
6000	0,40	6,3	0,17

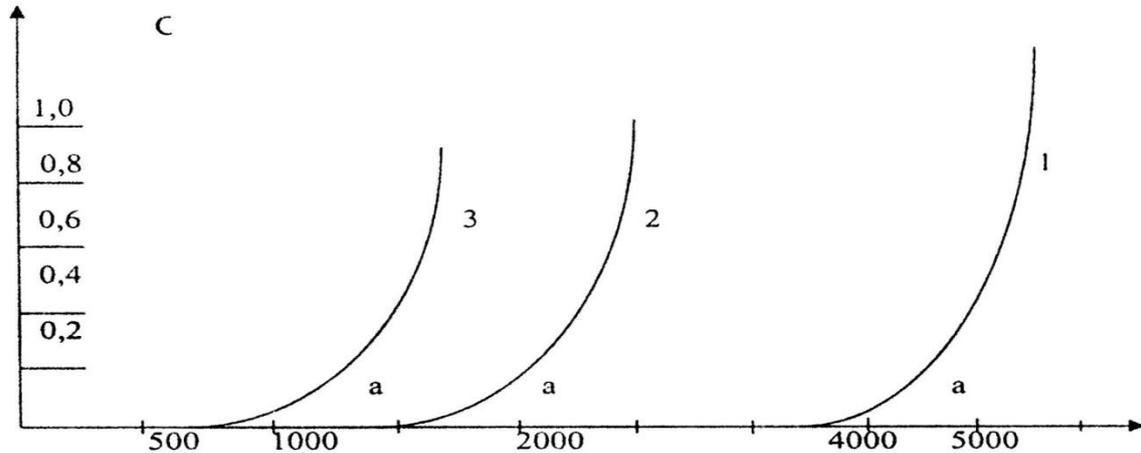
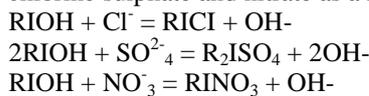


Fig.1.The absorption of chlorine ions by ion exchanger ASX-64 and ASX-64M with chlorine content in the studied water.

Preliminary experimental studies have shown that ionites like ASX-64 and ASX-64M successfully purify water from ionites of chlorine sulphate and nitrate as a result of the following reactions:



In the process of anionizing water on these anion exchangers, the salinity of water decreases to 10 mg.eq/l.

The results of the study of the ion-exchange capacity of the ion exchanger ASX-64M in water with a chlorine ion content of mg/l.

Table 2.

The amount water ml.	The amount of NaOH consumed for titration, ml	The residual content of chlorine ions in the filtrate where the initial chlorine content, mg/l	Residual equivalent chlorine ion content, mg.eq/l.
200	0	0	0
400	0	0	0
600	0	0	0
750	0	0	0
800	0.3	4,5	0,12
850	0,4	6,3	0,17
900	0,5	8,1	0,22
950	0,6	9,9	0,27
1000	0,8	13,5	0,36
1050	1,1	18,5	0,51
1100	1,7	29,7	0,81
1150	2,1	36,9	1,01

As can be seen from the results of the study, the ions are very well absorbed on the ion exchangers ASX-64 and ASX-64M; however, with an increase in the content of ions in the water being purified, the volume of the leaked water decreases to chlorine leakage. This is due to the magnitude of the exchange capacity of ion exchangers.

The magnitude of the working exchange capacity of these ion exchangers mainly depends on the number of functional groups injected, as primary (-NH₂). Secondary (= NH) and tertiary (= N) amino groups, the more connected such amino groups in the resulting ion exchangers, the greater the magnitude of the ion-exchange capacity (E).

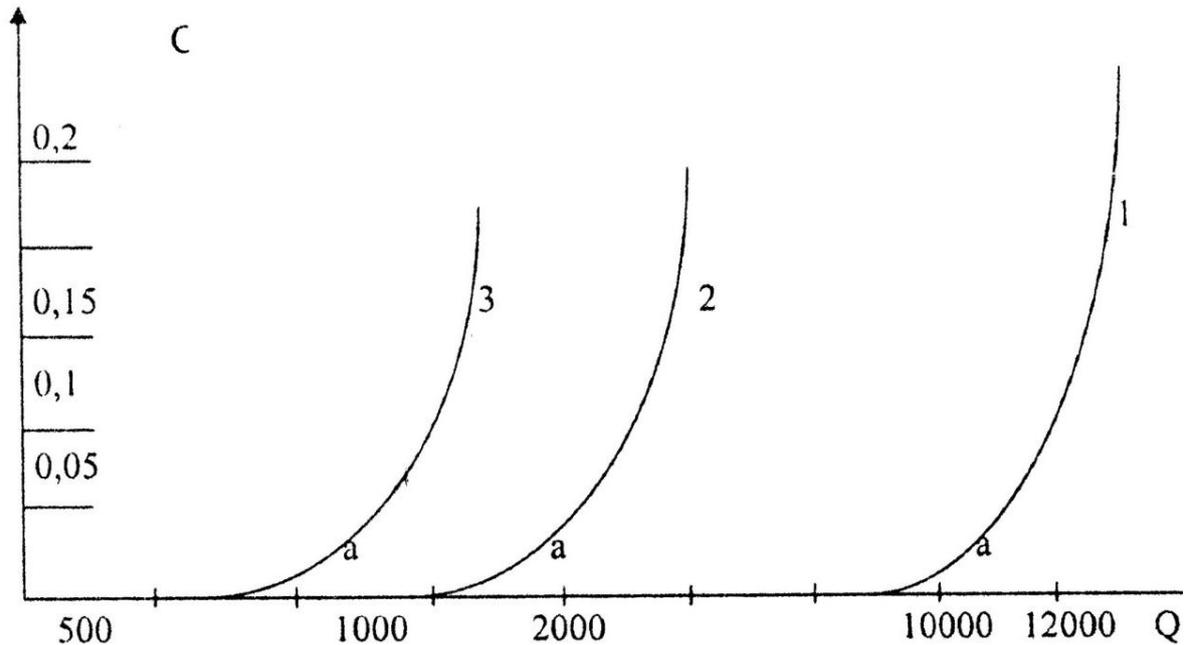


Fig.2. Absorption of ion ions of ion exchangers ASX-64 with chlorine content in the studied water 1-10mg/l, 3-36mg / l, a - the beginning of the leakage of chlorine ions, m-is the mass of the loaded ion exchanger, gr.

The value of EP in relation to the chlorine ion is determined by the formula:

$$E_p = (S_{ysh} - S_f) * Q/m, \text{ mg.eq/m.}$$

Where S_{ysh} - concentration of chlorine ions in the source water, mg/l.

S_f - concentrations of chlorine ions in the filtrate, mg/l.

Q - is the volume of filtered water before the leakage of chlorine ions.

m - consumption of NaOH solution, ml.

Thus, experimental studies of the absorptive capacity of ASH-64 and ASH-64M have shown that these ion exchangers can be used in the purification of water with anions of strong acids, such as chlorine, sulphate and nitrate in water treatment plants of TPP. [3]

VI. CONCLUSION AND FUTURE WORK

The article highlights the production of aluminium hydroxide by the electro dialysis method for coagulation of water at the TashTPP and presents experimental studies of the ion-exchange capacity of new ion exchangers, and showed that the ion exchangers under study can be used to purify water with strong acid anions.

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