Desalınatıon of Salt Water by Chemıcal Method

Gulnar Feyziyeva and Olena Stepova

Abstract Ways to improve the efficiency of chemical methods of water desalination process by analyzing anion was determined that the first step to further expand the scope of application of this method anionit filter regeneration NaOH instead of cyanide, which is much cheaper than the Ca (OH)2 will need to use cyanide. As it is known, when the highly acid cationites regenerate with acid, the best regeneration is Na, the good regeneration is Mg and the worst regeneration is Ca ions. The results of the raw water composition show that by using filters operating with the reverse flow principle, the first stage H-cationite filters at stoichiometric value or regenerating with an acid close to it and can achieve high exchange capacity. An effective technology for regeneration of anionite filters with lime solution has been developed and studied in AUAC. In this technology, wastewater is not produced and regeneration products are removed from the system in the form of a calcium sulfate suspension. Anionit filters waste with lime and H-cationite 3–5% solution of sulfuric acid regeneration technology developed filters. Alkali and acid regeneration technologies have been proposed stexiometrik private consumption is equal to the price.

Keywords Reverse osmosis · Salinity · Regeneration · İon exchange · Exchange capacity · Filter · Lime suspension · Desalination technology

1 Introduction

The production of desalinated water for thermal power plants (TPPs) can be carried out using either chemical, reverse osmosis or thermal methods. The question of which of the above methods to desalinate raw water for these TPPs depends on mainly the salinity of the raw water, ionic composition and the required quality of desalinated water. When the salinity of raw water is up to 0.6–0.7 g/dm^3, according

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to current norms, economically, the chemical method is used. If the concentration of salts in the primary water is higher than the above value, reverse osmosis or thermal methods are used. The amount of acid and alkali used by the traditional method to purify water from chemical salt is 2–3 and 1.8–2.5 times higher than stoichiometric amounts, respectively. Although the consumption of reagents is much higher than the theoretical amount for the regeneration of ion exchangers, only some of their total exchange capacities are used. For example, although the total exchange capacity of strongly acidic KU-2–8 cationites is 1700 (g-eq)/m^3, the working exchange capacity in the H-cationization process is on average 450–500 (g-eq)/m^3, that is, this value covers 25–30% of the total exchange capacity [1, 2].

The chemical desalination technology of the water discussed in the article allows reducing the amount of acid and alkali used for regeneration of ionites up to a stoichiometric value, which means an average reduction of reagent consumption by 2–2.5 times. Also, due to the 1.5–2.5 times increase in the exchange capacity of ion exchangers, the decrease in ionite consumption in the considered productivity, as well as the number of filters used in the device, is significantly reduced. As a result, capital investment in the construction of a water treatment plant is sharply decreasing.

From the above, we can observe that it is possible to desalinate water with higher salinity rate (1500–2000 mg/dm^3) by using the technologies developed at the Azerbaijan University of Architecture and Construction (AUAC), by extending the area of use of chemical desalination. In order to further expand the usage area of chemical desalination of the water, the regeneration of the first stage anionite filters can be carried out with the most common $Ca(OH)_2$ alkali rather than NaOH alkali [1].

First stage anionite filters can be reproduced with a 0.5–1.5% lime suspension or lime solution. The disadvantages of regenerating anionite filters with lime suspension are the complexity of the regeneration process, the low utilization rate of exchange capacity of anionite, the deterioration of the filtrate quality due to contamination with calcium ions and the pollution of water basins with the treated regenerated solution of anionite filters.

The low solubility (44–46 mg-eq/dm^3) of lime in water allows it to effectively regenerated anion filters. When the anion filters are regenerated with lime solution, the water consumption for the preparation of the solution increases, a large amount of wastewater is formed and the water basins are contaminated.

Although the value of Ca(OH)2 is sharply lower than the value of NaOH, it is not used to replenish anionites for the above reasons that have arisen during the regeneration of anionite with Ca(OH)2. In order to regenerated the first stage anionite filters from Ca(OH)2 alkali, a new technology should be developed to overcome the shortcomings mentioned above.

2 Methods

An effective technology for regeneration of anionite filters with lime solution has been developed and studied in AUAC [1, 3]. In this technology, wastewater is not produced and regeneration products are removed from the system in the form of a calcium sulfate suspension.

The schematic diagram of the developed technology is shown in Fig. 1. The processed regeneration solution of (1) anionite filter operating in the sulfate ion capture mode accumulates into (2) tank and is drawn from there with (3) pump and passed through a lime suspension loaded device such as (4) saturator. Here, calcium sulfate collapses and the solution is saturated with calcium hydroxide. Then a solution of lime containing a certain amount of calcium sulfate is released from anionite at a speed of 10–15 m/h, where hydroxide ions turn into sulfate ions, that is, the regeneration of the anionite's filter takes place and the solution of calcium sulfate is obtained from the anionite. The same solution is discharged again from a lime suspension loaded device, where calcium sulfate precipitates and the solution saturates with calcium hydroxide, after that the solution sends to the anionite filter. Thus, the same solution circulates between the anionite filter and the lime suspension loaded device. In this case, sulfate ions are transferred from the anionite filter to the device loaded with lime suspension and separated in the form of calcium sulfate, OH-ions are transferred from the apparatus loaded with the lime suspension to the anionite filter and regenerate it. It is also possible to repair the circulating regeneration solution in ordinary clarifier [4].

Anionite filter (1) is washed with the water of the 1st stage H-cationite filter and the solid part and the diluted part are collected in the processed (2) regeneration tank of the anionite's filter and (5) tank, respectively. From there, it is transmitted to the primary water clarifier with the help of (6) pump.

The first stage anionite filter which is loaded with weak-based anionite can work in two modes. In the first case of the first stage anionite filter, mainly SO_4 ions are retained, and in the second case, both SO_4 and Cl ions are retained in the filter.

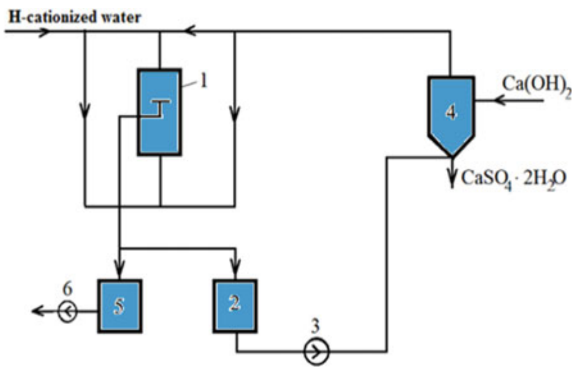

Fig. 1 Scheme of regeneration of anionite filters with lime solution

Since the SO_4 ions are primarily kept in the first stage anionite filter, Cl ions are retained in the second stage anionite filter which is loaded with high-base anionite. Since Silicate and CO_2 ions are also retained in the second stage anionite filters, it must be regenerated with NaOH alkali. As a result, NaOH alkali consumption for the regeneration of the second stage anionite's filter will be several times higher than regeneration of only silicate and CO_2 ions. In addition, due to the specific consumption of NaOH alkali for regeneration of the second stage anionite filter is several times higher than the stoichiometric amount, the processed regeneration product consists primarily of alkaline solution, which is sufficient for regenerating the first stage anionite filter for many types of water.

In case of keeping SO_4 and Cl ions together in the first stage anionite filter loaded with weak base anionite, it is necessary to release the sulfate salt solution from it and to be converted to SO_4 before regenerating it with the lime solution. As a sulfate salt solution, a neutral sulfate salt solution can be used, which is arisen by the regeneration of cationite filters with a sulfuric acid solution. Depending on the ionic types of salts in primary water and the regeneration regime of cationites, the processed regeneration solution cannot consist of a mixture of sodium and coarse salts.

The scheme of the proposed device (in "Shimal" Steam Power Plants) for the desalination of brine with a total salinity of 1702 mg/dm3 and ion content of Ca = 5,2; Mg = 11,6; Na = 9,36; Cl = 5,35; SO4 = 16,56; HCO3 = 4,25 mq-eq/dm3 is shown in Fig. 2.

The raw brine is mixed with the wash water from the regeneration solutions of the first and second stage anionite filters and passed through (1) mechanical filter, (2) first stage cationite and (3) anionite filters in top-down direction order to (4)

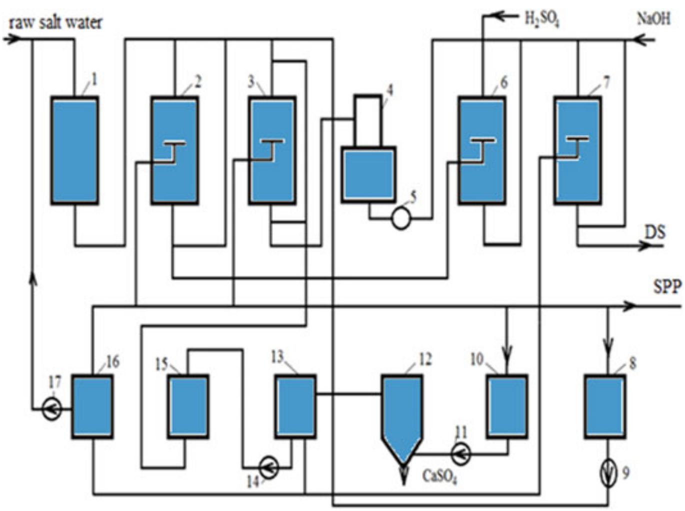

Fig. 2 The scheme of the desalination unit of saltwater by regenerating the first stage anionite filter with the lime solution

decarbonizer. Decarburized water is desalinated from by passing through (6) second stage cationite and (7) anionite filters in top-down direction with the help of (5) pump. Desalinated water (DW) is supplied to consumers. The first stage continues in accordance with the operating conditions of cationite and anionite filters until the Na- and Cl ions begin to pass to the filtrate [5].

As it is known, when the highly acid cationites regenerate with acid, the best regeneration is Na, the good regeneration is Mg and the worst regeneration is Ca ions [1]. Ca cations in the water whose ionic content is shown above make up only 20% of the total cations. Na- and Mg cations are 4 times more than Ca-cations and approximately 2 times more than Na cations.

The results of the raw water composition show that by using filters operating with the reverse flow principle, the first stage H-cationite filters" at stoichiometric value or regenerating with an acid close to it and can achieve high exchange capacity.

H-cationite filters are regenerated as shown below. Firstly, 2–3% sulfuric acid is taken from the middle drainage by releasing from above and below the second stage H-cationite filter, then it is also released from the first stage H-cationite filter in the same way. The solid portion of the processed regeneration product (SPP) is collected in (8) tank. In the next regenerations, the cationite layer, which is in the upper part of the middle drainage system of the first stage H-cationite filter, is regenerated with SPP taken from (8) tank and SPP is discarded. After that, H_2 and H_1-cationite filters are regenerated with 3–5% sulfuric acid solution as before.

Since calcium ions are kept with cationite, which is mainly located in the upper part of the middle drainage system during H-cationization and its contents are taken from (8) tank are almost completely transformed into Na and Mg form when it is regenerated with SPP as its content consists mainly of sodium and magnesium salts. In this case, the concentration of sulfuric acid solution can be increased by 4–5% or more. As a result, the metabolic capacity of cationite can be sharply increased.

To convert SO_4 and Cl ions held in the first stage anionite filter to SO_4 form completely it is necessary to be passed the salt solution which is accumulated in the tank (8) and which is the SPP of the first stage cationite filter consisting mainly of sodium and magnesium salts [6–9].

The first stage anionite filter is regenerated with lime solution in a straight reverse flow scheme. The solid part of the SPP is taken from the medium drainage system and collected into (10) tank by filtering through (12) device loaded with lime solution with the help of (11) SPP pump collected in (13) tank. Calcium sulfate collapses in the unit (12) and the solution is saturated with calcium hydroxide. Then, the lime solution containing some calcium sulfate is passed through (15) mechanical filter with the help of (14) pump and passed through it to regenerate the first stage anionite filter, so the cycle is repeated.

The second stage anionite filter is regenerated with NaOH alkali in a straight reverse flow scheme, the solid portion of the TPP is collected in (13) tank and the liquid portion in (16) tank and mixed with raw brine before mechanical filtration with the help of (17) pumps.

Thus, the area of usage of desalination by chemical method can be significantly extended using the scheme as shown in Fig. 2.

3 Conclusions

By analyzing the ways to increase the efficiency of anionization in the chemical desalination process of water, it was determined that the regeneration of the first stage anionite filter should be done by using $Ca(OH)_2$ alkali instead of NaOH alkali to further expand the area of usage of this method. Regeneration technologies have been developed with lime solution of anionite filters waste-free, and 3–5% sulfuric acid of H-cationite filters. In the proposed regeneration technologies, specific alkali and acid consumption are equal to stoichiometric values.

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