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DESALINATION AND DEEP TREATMENT OF MINERALIZED MINE WATER TECHNOLOGIES. -

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ABSTRACT

Most of all saline water of mines industry relates to a class of sodium sulfate water. The application of waters of this class for the drinking purposes is limited most often because the total salinity and the contents of separate ions are in excess of the standards. For desalination of saline waters various methods are used. Among them the membrane methods have a leading part. Considerable progress in manufacture of composite membranes results in lower cost of water desalination. At the same time desalination of saline waters brings about plenty of salt concentrates, which pose essential damage to the environment. Tightening the requirements on ecological safety has resulted in development of a number of projects for utilization of salt concentrates being formed at desalination of saline waters, and providing minimization of volumes of slimes produced. In a number of cases utilization of salt concentrates results in the production of commercial products.

I. INTRODUCTION

Mining usually accompanied by pumping large volumes of mine water. Groundwater, confined to the deposits of minerals, mostly mineralized and enriched with ions of heavy metals and organic impurities.

To use these waters for economic purposes requires cleaning. The processes of purification of saline water containing heavy metals is accompanied by the formation of concentrated waste that can not be discharged into the environment without environmental degradation [1]. Strengthening environmental safety requirements led to the development of a number of projects involving recycling resulting from the desalination of brackish water and salt concentrates that minimize the volume of waste generated. In some cases, when disposing of salt concentrates is possible to obtain a certain number of commercial products. The purpose of original technology of deep processing of mineralized mine water developed by the Mendeleyev University of Chemical Technology of Russia jointly with Suez University, Egypt is to produce maximal amount of water of drinking quality with simultaneous

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minimization of slimes. Developed technology is world leader for mineralized mine water desalination.

II. METHODS AND MATERIAL

There are projects of desalination systems with recycling concentrates developed by a number of companies in the US, Germany and other countries. All these projects, solving the problem of disposal of saline concentrates usually have very high capital costs at a relatively high energy consumption and chemical reagents.

In this technology along with access to drinking water corresponding to the international standards there is provided a certain number of chemical products, which leads to a significant reduction of the environmental load concentrates discharges to the environment and gives a significant increase in the economic effectiveness of the project.

III. RESULTS AND DISCUSSION

The developed technology has been tested in a pilot scale in a particular part of the original mine water, given in Table 1.

Table 1.

Parameter	Standard	Initial Mine Water	Purified Water
Total dissolved solids, mg / L	<1000	3500-5500	150-200
RN	6-9	6-7	5,5-6,0
Suspended solids mg / l	<5	500	<0,5
Total Alkalinity, mg / L	<160	300	20-30
Nitrates and nitrites, mg / l	<1,0	<0.3	<0.3
Calcium, mg / L	<200	350-500	2-4
Chloride, mg / L	<400	100-400	5-10
Fluoride, mg / l	<2,0	<0.5	<0.2
Magnesium, mg / l	<100	150-250	1-2
Potassium, mg / l	<100	20	3-5
Sodium, mg / l	<400	250-400	50-70
Sulfates mg / l	<500	2000-3500	70-110

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Aluminum, mg / L	<0,5	<1.0	<0,3
Iron, mg / l	<1,0	150-400	<0,5
Manganese mg / l	<0,2	8	<0,03
Ni mg / l	<1,0	<0,03	<0,03
Zinc, mg / l	<1,0	<0,1	<0,1

Based on the analysis of the composition of source water, the technology provides for dematerialized water, anhydrous sodium sulfate, mixed oxides of iron, calcium and magnesium carbonates. The technology involves the use of power and chemicals, and the formation of a certain amount of waste water.

For the testing of the technology developed and manufactured pilot plant. The pilot plant comprises a water treatment, desalination unit, the crystallization unit and automatic control system. General view of the pilot plant is given in Figure 1.

Figure 1. General view of the pilot plant.

A block diagram of the pilot plant is shown in Figure 2. Initial water from the mine is fed into the intermediate tank T1. Consumption of raw water is regulated by an automatic water level control in the tank T1.

The water from the intermediate tank T1 is fed to a water treatment. Water treatment unit for clarification and softening of raw water. As part of the water treatment unit used septic

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tanks, clarifiers, mechanical cleaning granular filters, micro-filters and filter presses for dewatering sludge.

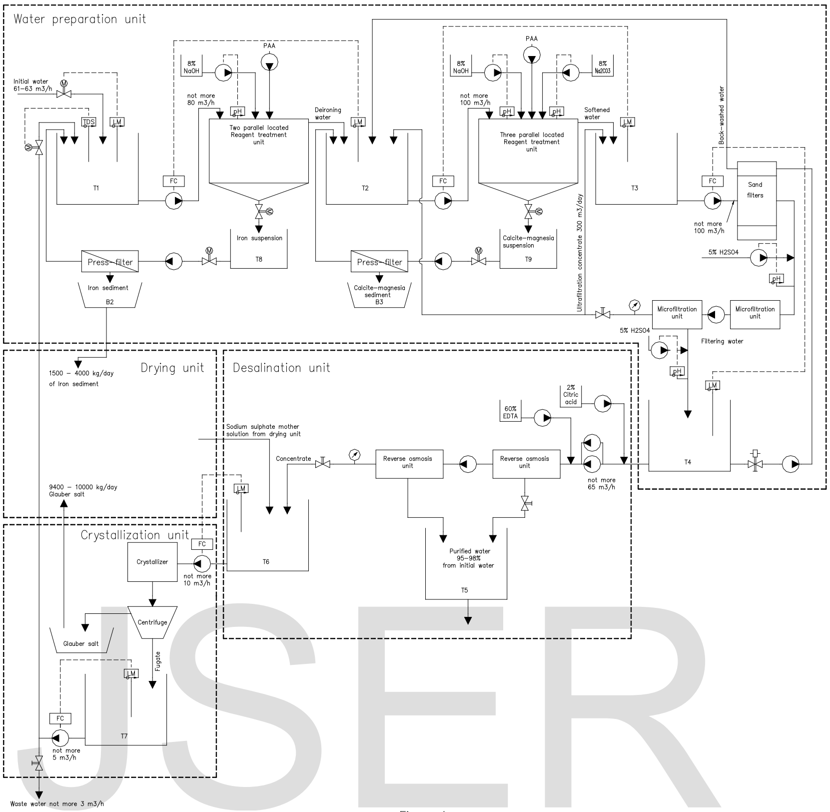

Figure 2. A block diagram of the pilot plant

The water flow from tank T1 is regulated by an automatic control of the level of water in tank T2. Since the raw water contains a large quantity of bivalent iron, it is necessary to carry out oxidation by means of forced supply of air into the water. For this purpose an air compressor. For better mixing flows of water and air entering the first settler-clarifier installed water-air ejector. Water-air ejector to create a fine mixture of water and gas bubbles and thereby to intensify the process of iron oxidation.

Sediment-brighteners combines his design of the reactor, a mixing chamber, clarifier sludge, and seal. This allows a single device to carry out the processes of mixing of the reactants with water, chemical interaction, sedimentation, gravity separation of the precipitate from the water discharge of sludge from the clarification zone and its subsequent sealing. Moreover, reactants can be supplied to different zones of the installation, which allows to control chemical reactions. In this case fed to the iron precipitation solution sodium hydroxide or milk of lime until pH = 8.

Between the first and second settler-clarifier tank T2 is an intermediate. The water flow from tank T2 is regulated by an automatic control of the level of water in tank T3.

The solutions of sodium hydroxide, sodium carbonate and flocculent are added to second clarifier where the water softening. pH = 10 in the lower part of the apparatus and pH = 11.5 in the upper part of the apparatus are supported. This regime is determined by the ratio metering of calcium and magnesium in the composition of mine water. Numerous experimental studies on the kinetics of extraction and precipitation of calcium and magnesium from the mine water allowed developing this system and implementing it in practice water softener.

Between the second clarifier and mechanical filters located intermediate container T3. The water flow from tank T3 is regulated by an automatic control system for the water level in the tank T4.

From the tank T3 clarified and softened water pump to the discharge granular filters mechanical treatment. The filters can be loaded filter materials such as quartz sand, anthracite, crushed zeolite, foam beads of polystyrene, activated alumina and others. Selection of filter material depends on the composition and the treated water quality requirements for purification. In this case, a loading of foamed polystyrene granules. Unlike other materials, this type of boot is not subject to the carbonate clogged after delays petroleum products, it has a large dirt holding capacity. Loading works as a floating layer of granules with a given particle size distribution. Size distribution of the granules in the filter layer increases the degree of purification and allows working with large filtration rate.

After purification from suspended particles on mechanical filters the flow is moving under residual pressure filtered through a microfilter unit. The pilot plant was used microfilters polypropylene yarn wound on a perforated frame. These microfilters are volumetric and after a certain period of validity need to be replaced. It is very promising the use of microfilters film made in the form of rolling elements. The use of roll film microfilters enables to reduce the area under installation microfiltration, does not require frequent replacement of the filter elements.

To stabilize of the water relative to the calcium salts the water after the microfilters is acidified with sulfuric acid. Acidification is carried out to pH = 6.4.

Mechanical filters are periodically rinsed with water from the tank T4. The frequency of flushing regulated by a system of automatic control. Concentrate after mikrofiltrovtsionnyh and water from the filter back wash mechanical input to a second clarifier.

The thickened sludge generated in the first and second clarifiers periodically diverted to the intermediate storage volume T8 and T9. The frequency of feeding the suspension in the tank T8 and T9 is governed by an automatic control.

Precipitation dewatered in filter presses to a moisture content of 50-60%. After the filter press filtrate under residual pressure is directed to the input of the corresponding clarifier.

After the water treatment unit water by gravity is directed into the intermediate storage container T4. From an intermediate storage tank T4 water is directed to the desalination unit. Desalting unit is designed to produce the maximum amount of purified water.

In desalination unit the water is supplied to the input of the reverse osmosis installation of low pressure. To prevent the formation of deposits on the surface of the membranes precipitation inhibitor is dosed.

Reverse osmosis installation of low pressure are assembly of the cylindrical body, wherein the membrane elements are inserted roll. Number of bodies and membrane elements designed using of the developed special mathematical program. The calculation results are often tested in practice.

After low-pressure reverse osmosis installation the concentrate by the pump is directed t to the high-pressure reverse osmosis installation. The design of the installation is similar to installing a low-pressure, with the difference that it uses sea membrane elements and housing, pipes and fittings designed for the higher pressure.

The chemical cleaning of reverse osmosis plants with special washing solution is periodically performed. The wash water is sent to the drainage system.

After desalination unit purified water is sent to the storage capacity of treated water T5. Concentrate under its own pressure is supplied to the intermediate tank T6.

From the intermediate tank T6 the concentrate is sent to the crystallization unit. The unit is intended for crystallization of sodium sulfate from the concentrate after the desalination unit.

The crystallization of Glauber's salt followed by the withdrawal of sulfate improves the yield of desalinated water and reduces the volume of discharge. is The treatment of the high costs of the concentrate with the initial content of sodium sulfate and 60 g is a feature of the technology [2]. From industrial processes of sulfates receiving method of isobar hydrate

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crystallization at cooling the solution has greatest interest [1]. For ensure a continuous process a heat exchanger of the "tube in tube" is the optimal equipment. The design should take into account a residual concentration of sodium sulfate, the heat of crystallization of Glauber's salt, the kinetics of the formation and growth of crystals. A common process engineering of anhydrous sodium sulfate receiving [3] has higher capital and operating costs.

According polythermal curve of ternary system NaCl - Na_2SO4 - H_2O, the area of crystallization is determined by the initial concentration of sodium sulfate (6%) and the freezing point of the filtrate (about 0 °C). The presence of sodium chloride in the concentrate is expanding the range of crystallization and increases the output of Glauber's salt. Taking into account the possibility of the formation of ice jams in the crystallization zone, the maximum temperature of the cooling of the concentrate in the heat exchanger should not be lower 2-3 °C. The residual concentration of sodium sulfate is not less than 42 g / l.

Crystallization zone in the volume of the heat exchanger is disposed between a section where the temperature of the solution corresponds to the state of saturation, and the output of the solution heat exchanger. The residence time of the solution in the crystallization zone is determined by its volume and volumetric flow of the solution. Because the area aligned crystallization processes of heat removal and crystallization, the residence time of the solution in the zone exceed the time determined by the kinetics of formation and growth of crystals. In the [4] is shown in a flow-type heat exchanger "tube in tube", this condition is fulfilled: the combined processes of crystallization of Glauber's salt, and cooling the solution to the above initial concentration of sodium sulfate in the heat exchanger of the "tube in tube" is limited only by heat transfer from the mother liquor to the coolant.

The findings were used in the design of an industrial plant with high environmental requirements [5]. To increase the stability of the process and adjusting the size of the crystals is provided in the return zone crystallization portion of the solution from the settler - slurry separator installed between the heat exchanger and a centrifuge. The filtrate from the centrifuge is used to pre-cool the incoming concentrate, whereupon a portion of the filtrate is discharged and the remainder is sent to the mixing water to be desalination.

REFERENCES

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[1] Alaa M. Younis, Artem V. Kolesnikov, Andrei V. Desyatov. 2014. Efficient Removal of La(III) and Nd(III) from Aqueous Solutions Using Carbon Nanoparticles. American Journal of Analytical Chemistry,5, 1273-1284.

[2] Shikheeva L.V., Zyryanov V.V. Sodium sulfate. Properties and production. Chemistry, Leningrad, 1978.

[3] Bujakow D.V. et al. Investigation of influence of the concentration of the aqueous solution of sodium sulfate in the emergence of the field of impaired heat transfer in the evaporator and Steam Converters. Heat power, № 4, 2000, p. 4-7.

[4] Moshkin V.I., Desyatov A.V., Egorov A.V., Kakurkin N.P. The crystallization of salts from concentrates desalination plants. Coll. scientific papers MUCTR. D.I. Mendeleev, Moscow, 2002, p. 230-239.

[5] Desyatov A.V., Isvolsky I.M. A method of reverse osmosis separation of crystals from the brine. The patent of the Russian Federation № 2142329. BI, 1999, 34.