DEVELOPMENT AND DESIGN OF A CLOSED WATER USE CYCLE

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ABSTRACT

The organization of a closed cycle of water use is one of the priorities for both recycling water supply systems and wastewater treatment systems of industrial enterprises. Water cooling systems are considered and the possibility of closed water cycle organization is estimated. For cooling systems of circulating water supply of industrial enterprises, depending on the water content, the cooling scheme can be: running, open (evaporative cooling) and close.

The technological scheme of water treatment based on the complex approach is offered. This approach allows to create a closed cycle of water use with high quality of purified water and allows the use of ferrous sediment. Water-treatment technologies are considered.

Membranes are used at 2 stages of aeration process:

* directly at the stage of aeration: it is possible to obtain air bubbles of 350 – 450 micrometers with the help of ceramic membranes;

* at the last stage of filtration: in addition to the removal of iron, the content of manganese, microorganisms in the water is reduced, the content of chlorine and heavy metals is reduced. Also produced partial softening of water, while maintaining 80-110 mg / l of salts necessary for the human body. The water is transparent and increase its flavor.

Iron-containing slurries can be used as additives to raw materials for the production of cement clinker. The inclusion of small amounts of these additives in the raw material mixtures for the production of cement clinker essentially does not change the firing technologies used in cement enterprises and does not affect the quality of the clinker produced. Also, iron-containing slurries can be used in the ingredients of various functional purposes: fillers, promoters of adhesion of rubber to metals, vulcanization activators

The conducted research on the study of bubbling showed the effectiveness of the use of ceramic tubular membranes as a dispersing material.

This technical solution allows:

* Reduce water intake and related charges by 5-10%;

* Create a closed circuit with no liquid waste and charges for their discharge into water bodies;

* Reduce the amount of solid waste and dispose of it;

* Reduce the need for production facilities;

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* To reduce operating costs for chemical reagents and replaceable elements;
* Increase the capacity of the washing water recycling system due to the modularity of the equipment, without replacing the existing equipment.

Keywords: closed water use cycle, water-treatment, membranes

INTRODUCTION

Of particular concern about the growing shortage of drinking water in almost all regions of the Earth is associated with both the effects of climate change and diverse human activities, leading to a decrease in available water resources due to pollution of freshwater ecosystems. It is the sewage of industrial enterprises that pollutes water with heavy metals, toxic compounds, toxic chemicals and other harmful substances. Today, one of the main problems associated with water purification is a multiple excess of iron and manganese in it. Natural water is a complex dispersion system containing a wide variety of mineral and organic impurities. These impurities are divided according to the phase-dispersed state, depending on which the most suitable methods of purification of such water are chosen.

The organization of a closed cycle of water use is one of the priorities, both for circulating water supply systems and for wastewater treatment systems of industrial enterprises.

For cooling systems of circulating water supply of industrial enterprises, depending on the water content, the cooling scheme can be flow, open (evaporative cooling), closed.

The largest systems are used in power plants, steel mills and industrial enterprises of the petrochemical complex [1].

In the flow-through method of cooling, water is taken, as a rule, from a water intake (river, canal, lake), is conducted through heat exchangers, and already warm returns to the water source. Since the use of flowing water requires a large amount of water, it is advisable to use low-cost water treatment methods. Water treatment is usually limited by filtration through sand filters. Chemical treatment of water is usually not performed; fine cleaning methods are also not used, which causes problems in the cooling system, such as corrosion, sedimentation or microbiology growth [2].

In order to save water in open circulating cooling systems (evaporative cooling), warm cooling water can be reused in a further cooling process, at which higher temperatures are acceptable. The circulating cooling system will briefly look as follows: the required amount of cooling water is taken from the cooling tower bowl and carried out through refrigeration units with the help of water pumps. The cooling water heated there returns to the cooling tower. Water losses due to evaporation and desalting occur there, these losses should be compensated by make-up water. Heating in heat exchangers corresponds to cooling in a cooling tower. A significant difference from flow-through cooling is the need to replenish evaporative losses, which simultaneously thickens the salts dissolved in water (an increase in the salt concentration). As a result, mechanical and / or chemical treatment of make-up water often becomes unavoidable [3].

The heated cooling water is irrigated in a cooling tower using special built-in elements. The water is cooled by close contact with air in two stages:

1. Heat transfer by direct contact of cooling water with colder air is approximately 15-25% of the total heat exchange.

2. Due to the evaporation of part of the water, most of the heat removal occurs.

At power plants, cooling towers of high-rise construction with natural draft are usually used, which represent the most economical type of cooling tower with a very large need for cooling water. Industrial installations, on the other hand, operate predominantly using forced-draft sectional cooling towers of low design, with numerous cells often connecting into larger units.

In order to maintain a constant volume of water in the cooling circuit, the water evaporated in the cooling tower must be replenished. Since the evaporation of water does not evaporate its constituent parts, the remaining amount of water is saturated with these substances. Such an increase in concentration cannot continue arbitrarily, since the dissolved multitude of salts will inevitably increase its solubility. In order to avoid high salt concentrations, some of the water must be continuously or intermittently discharged from the system. This process is called salt removal or purging. The amount of make-up water and purge (removal of salts) can be calculated, knowing the constant composition of water in the cooling circuit [2, 3].

Unlike the first two cooling systems in closed systems, water is cooled using a heat exchanger. Cooling of the heat exchanger can be done both through the second open cooling system (secondary system), and with the help of air in air coolers. Water losses in closed cooling systems are naturally much less. Make-up is produced mainly with softened or completely desalinated water. Regarding water treatment, these systems require a bit of care.

MATERIALS AND METHODS

The above disadvantages of traditional industrial water recycling systems of industrial enterprises can be successfully solved through the use of an integrated approach. Complex water purification includes its sequential processing by various methods. Consequently, a complex system for purifying water from iron will consist of purification modules in which the necessary purification stage will be carried out.

The proposed technological scheme of water treatment, allows you to create a closed cycle of water use with high quality of purified water and allows the use of ferruginous fluoromash. In this paper, tubular ceramic membranes are proposed for use as a dispersing material. They can be used both to disperse air oxygen in a liquid, and to remove the formed insoluble iron compounds [4]. Fine-porous ceramic membranes are made by sintering metal-ceramic materials at ultrahigh temperatures. The result is a substrate - a porous structure, already capable of retaining some pollution. At the next stage, a special mineral membrane is applied to the surface. The total pore size is from 0.5 to 0.05 microns. Such membranes are capable of retaining virtually all contaminants and microorganisms [4,5].

The study showed the effectiveness of the use of such material, which will intensify the process of bubbling and reduce the cost of installation, repair and replacement of aeration elements [6-8].

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This water purification technology is based on the use of ceramic tubular membranes for water deferrization and electroflotation for utilization and reuse of wash water.

This technology has the following advantages:

- is non-reagent (uses only air, instead of toxic Cl_2 and O_3);
- has a high rate of iron removal process (10-15 minutes);
- easy to maintain;
- compact;
- does not require large capital expenditures;
- minimizes wastewater and sludge;
- does not require consumables for the process;
- flow membrane assembly has a lifetime without clogging and clogging of membranes up to 5 years.

Membranes are used in 2 stages of the process:

- directly at the stage of aeration: it is possible to obtain air bubbles of 350–450 micrometers in size with the help of ceramic membranes;
- at the last stage of filtration: in addition to the removal of iron, there is a decrease in the content of manganese in water, microorganisms, the content of chlorine and heavy metals decreases. Partial water softening is also performed, while maintaining 80-110 mg / l of salts necessary for the human body. At the same time, the water becomes transparent and its taste qualities increase [6,8].

The technological scheme of the complex method of deferrization with the use of aeration, ultrafiltration and electroflotation is presented in fig. 1.

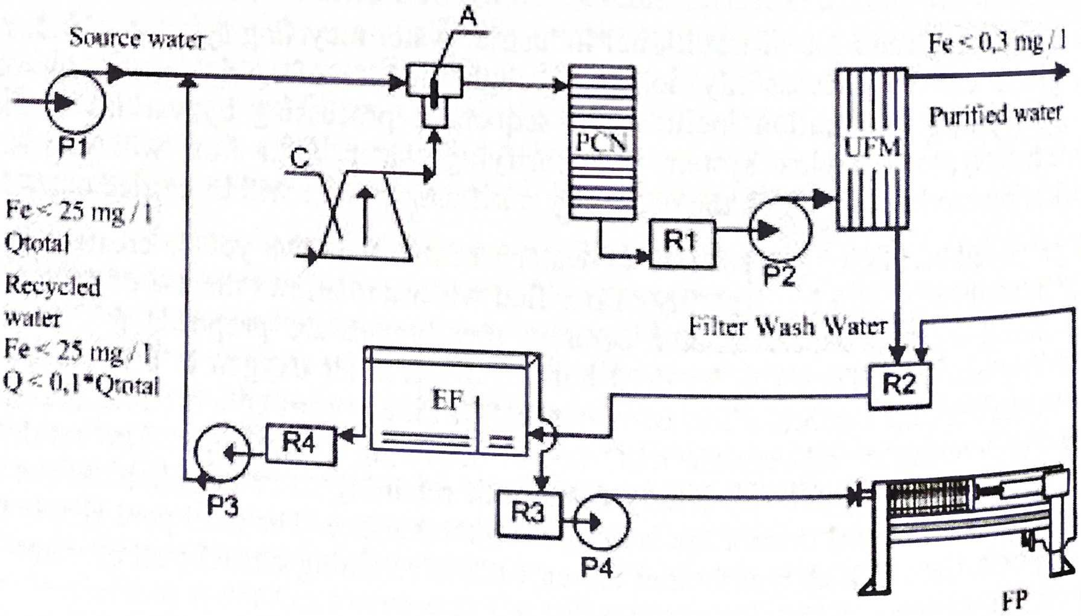

Fig.1. Technological scheme of the complex method of deferrization.
P - pumps; K - compressor; A - aerator; PCN - phase contact node (coil); UFM - ultrafiltration module; R - accumulative capacities and averagers; EF - Electroflotation module (electrofloater); FP - filter press; Q - water consumption.

Source water is pumped by pump P1 to aerator A. Also air is fed to aerator A by compressor K. Aeration is carried out through ceramic tubular membranes. Next, water is supplied to the contact node of the PCN phases, which works according to the model of a plug flow reactor. Next, water is supplied to the ultrafiltration module of UFM, where oxidized impurities are separated in the "dead end" mode [9]. The following periodic regeneration of UFM is also provided [10]. It is carried out by reverse air blowing with simultaneous water supply; for this purpose, air is supplied by compressor K through the filtrate line and simultaneously a small amount of water is fed along the membrane surface. The water-air mixture enters the R1 storage tank, where air separation and quantitative averaging and homogenization of the composition are performed. For the organization of free flow, R1 is set below the UFM level. From R1, the washings flow into the electrofloater EF. In the EF, microbubbles of electrolytic gases are released. Microbubbles capture the flakes of the dispersed phase $Fe(OH)_3$ and transport them to the surface of the water, where the latter accumulate in the foam layer of the flotation concentrate. The flotation concentrate is periodically removed with an automatic foam collector into the container R2. The residual content of iron ions in purified water after electroflotation is 2-10 mg / l.

The purified water from the EF by gravity flows into the intermediate tank R3, from where the pump P1 is fed into the feedwater pipeline of the water deferrization station, thus forming a closed loop.

The flotation concentrate from R2 is pumped by P2 to the filter press FP for dehydration up to 70%. Dehydrated flotation concentrate can be used both for the preparation of various coagulants, and as a secondary raw material.

RESULTS AND DISCUSSION

The proposed technological scheme of water treatment can be applied to the purification of ferrous wastewater of enterprises with the subsequent application of electroflotation for disposal.

Iron-containing sludge can be used as an additive to raw materials for the production of cement clinker. The inclusion of small quantities of these additives in the raw material mixtures for the production of cement clinker essentially does not alter the burning technologies used at cement enterprises and does not affect the quality of the clinker produced. Also, iron-containing sludge can be used as part of ingredients for various functional purposes: fillers, promoters of rubber adhesion to metals, vulcanization activators [11].

This solution allows:

- Reduce water intake and related fees by 5-10%;
- Create a closed loop with the absence of liquid waste and payment for their discharge into water bodies;
- Reduce solid waste and recycle it;
- Reduce the need for production space;
- Reduce the operating costs of chemical reagents and replaceable elements (the life of insoluble electroflotter electrodes is at least 5 years, polypropylene filter cloth press filter is at least 1 year);

• Increase the performance of the flushing water disposal system due to the modularity of the equipment, without replacing the existing equipment.

In addition to iron, toxic and carcinogenic metal compounds are more dangerous. In this article, the proposed technological scheme of water treatment, allows you to create a closed cycle of water use with the neutralization of wastewater from one of the electroplating plants. Galvanic production is one of the largest consumers of fresh water among the enterprises of the chemical complex and, due to the formation of large volumes of wastewater, one of the most dangerous sources of environmental pollution, mainly surface and underground water bodies. Wastewater from electroplating industry contains harmful impurities of heavy metals, inorganic acids and alkalis, surface-active substances and other highly toxic compounds that cause great economic and environmental damage. Especially dangerous contaminating components of wastewater are soluble hexavalent chromium compounds with allergic, mutagenic and carcinogenic effects. About 40% of galvanic production effluents are chrome-containing wastewater. The source of Cr (VI) intake is washing waters of chromium plating baths, chromate plating, copper and brass pickling, aluminum anodizing. In addition to chromium compounds, simple and complex heavy metal cyanides are particularly hazardous pollutants from wastewater. In many enterprises, cyanogen-containing waste waters with high toxicity are formed due to the presence of free cyan, hydrocyanic acid, and cyanic metal complexes. Therefore, the organization of a closed cycle of water use in such industries will give a noticeable result.

In addition to electroplating processes, chromium compounds are used in woodworking, metallurgical, glass, paint and varnish and other industries, and cyanides are mainly used in organic synthesis, in the extraction of precious metals, in pests from pests and other fields. Often these productions are small, technological workshops which, as a rule, are not equipped with areas for wastewater treatment. But even at the more successful Russian enterprises, outdated solutions and electrolytes are mainly used, which do not meet modern environmental and technological standards. In order to save money, a number of enterprises do not take wastewater disposal measures at all. As a result, a situation has been created when part of the industrial effluent enters the sewage networks of populated areas in an insufficiently cleaned form or without any treatment at all [12-14].

The review of scientific and technical information and practical experience in the area under study allows us to develop a set of organizational and technical measures to improve chemical safety using the example of electroplating and the organization of a closed cycle of water use.

CONCLUSION

The created complex system is based on the following materials, developments and technological processes:

• application of the aeration stage using ceramic membranes to intensify the process of oxidation of ferrous ions contained in water;

• the use of electroflotation in the treated medium for the utilization and reuse of wash water;

• stages of ultrafiltration, where, in addition to the removal of iron, there is a decrease in the content of manganese in water, microorganisms, the content of chlorine and heavy metals is reduced. Partial water softening is also performed, while maintaining 80-110 mg / l of salts necessary for the human body. These membrane filter elements, providing a long-lasting effect of fine water purification.

• The application of this approach allowed the development of a set of organizational and technical measures to improve chemical safety on the example of electroplating. Thus, the reagent method of purification from these compounds is quite simple to implement and operate. Allows with a small consumption of reagents to provide a high degree of purification and simplify the separation of sediment from treated effluent.

The power consumption of the COP does not exceed 5 kW with a capacity of 2 m^3 / h.

Proposed in this work, the technological scheme of water treatment, allows you to create a closed cycle of water use with the use of ceramic membranes is almost universal and can be used with different iron content, different pH, as well as in a wide range of side impurities. The technology is characterized by the efficiency of extraction of iron ions - 99.5–99.8% reduction in water content of manganese, microorganisms, a decrease in the content of salts of heavy metals.

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