

Membrane bioreactors for treatment of galvanic wastewater

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Abstract. The article speaks about the membrane methods applied for treatment of galvanic sewage. It reveals the main features and peculiarities, which determine the maintenance of various types of membranes for industrial wastewater treatment. Ultrafiltration is a method that uses a membrane to separate by size ions of heavy metals, petroleum products, macromolecules and suspended solids. Application of ceramic membranes in ultrafiltration plants allows implementing of various technological processes with resource-saving opportunities, such as treatment of galvanic workshops sewage with efficiency of 99% and entire restoration of the worked out solutions. Nanofiltration is a process of membrane filtration of wastewater, which ensures the removal of multi-charged ions from water, depending on the size. Reverse osmosis is a process that is used to desalinate the bulk of dissolved salts in wastewater of various industries. In addition, this process is used to ensure the purification of effluents from organic and inorganic compounds, suspended solids and high molecular weight compounds.

1 Introduction

At present, electroplating enterprises have to invent significant changes both in manufacturing process and, subsequently, in sewage treatment methods. In this sense, special attention is focused on up-to-date wastewater treatment technologies, such as membrane technologies.

Membrane systems are one of the most efficient and methods of wastewater treatment that ensure its wider implementation in industrial production. Efficiency of membrane methods means high quality of treatment, minimal use of chemical reagents, versatility and compactness of wastewater treatment plants. In some cases, membrane systems remain as the only possible option for the treatment of industrial wastewater [1-3].

There is a large number of various papers available now that describe the researches carried out in that field world-wide and can give details of membranes' application in various processes. However, some of the statements and conclusions are in permanent renewal due to the constant progress and improvement of technology.

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2 Ultrafiltration in treatment of galvanic sewage

Membrane methods are base on removal of dissolved and undissolved impurities out of wastewater is made at the molecular level. Depending on the size of the particles, the following types of membrane processes are used for wastewater treatment (table 1).

Table 1. Control indicators for WWTP

Type of process	Pore size [μm]	Pressure [bar]	Membrane elements	
			Material	Configuration
Microfiltration (MF)	0,2-4,0	< 2	PP, PVDF, lavsan, Teflon, ceramics	Spiral-wound hollow-fiber tubular
Ultrafiltration (UF)	0,02-0,2	1-10	PP, PVDF, polysulfone, ceramics	
Nanofiltration (NF)	0,001-0,01	5-35	Cellulose acetate, polysulfone, ceramics	
Reverse osmosis (RO)	0,0001-0,001	10-70	Cellulose acetate, polysulfone	Spiral-wound, hollow-fiber, flat sheet

Ultrafiltration is a method that uses a membrane to separate by size ions of heavy metals, petroleum products, macromolecules and suspended solids. Ultrafiltration is the boundary between microfiltration and nanofiltration, combining technological solutions of boundary processes. Ultrafiltration membranes have a wide range of applications in various industries. They are successfully applied in the processes of sewage treatment of machinery building, metallurgy and petroleum industries [2,3].



Fig. 1. Ultrafiltration membrane modules

Ultrafiltration is considered as the most promising technology of post-treatment of industrial wastewater. Ceramic membranes are often used in the process of post-treatment of wastewater ultrafiltration. Ceramic membranes are in fact spongy ceramic filters. They are manufactured by sintering of metal-ceramic materials, such as aluminum compounds, titanium dioxide or zirconium under ultra-high temperatures. According to the texture, the membranes are asymmetric and held by the active membrane layer. Macroporous materials give the stability, while a number of membranes ensures even distribution [4-6].

Filters generally operate in the order of tangential filtration with suitable hydrodynamic modes. The dirty mixture flows through the membrane row from inside the single-channel or multi-channel shell at a considerable speed. Under the influence of transmembrane pressure, moisture flows vertically through the membrane layer, creating a filtrate flow. Suspended solids and high-molecular compounds remain inside the membrane and form the

concentrate flow to perform purification of sludge-containing liquids. A research was held in laboratory conditions to estimate possible efficiency of ultrafiltration facility to treat galvanic wastewater. Tables 2 and 3 show parameters and average efficiency of galvanic sewage treatment by means of ceramic membranes throughout laboratory research.

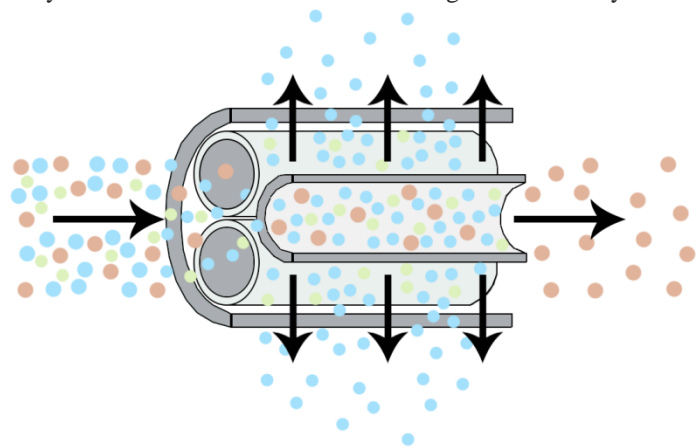


Fig. 2. Filtration through ceramic membrane module

Table 2. Research facility parameters

Parameter	Value
Flow capacity [m ³ /h]	0,25 - 0,4 (depended on solids concentration)
Membrane surface [sq.m.]	1,4
number of single-channel tubular elements	56
Pore size [µm]	0,07-0,2
Filtration scheme	dead-end, cross-flow
Pressure [bar]	3-5
Operation temperature [°C]	5-90
Material of the casing	Stainless steel
Dimensions of ultrafiltration module [mm]	920x113
Weight [kg]	11,2
Regeneration	Reverse purge by compressed air in the automatic mode and chemical CIP (cleaning in place) washing
The frequency of regeneration	depended on solid particles concentration
Operation time [year]	>10

Table 3. Treatment efficiency

Indicator	Efficiency
Heavy metals	95-99%
Petrochemicals	85-99%
Solid	94-99%
Surfactants	50-75%
Maximum flow of 0,4 m3/h if	Suspended solids - < 25 mg/l Petrochemicals < 200 mg/l

Application of ceramic membranes in ultrafiltration plants allows implementing of various technological processes with resource-saving opportunities, such as treatment of galvanic workshops sewage with efficiency of 99% and entire restoration of the worked out solutions. In addition, it is likely to purify and restore the coolants, different types of oils, cleaning solutions and non-reagent iron removal.

Application of ceramic membranes in Russia is not wide-spread now. They were considered to be of limited application. At the same time, in many other countries (in Europe and Asia, for instance) ceramic membranes have been actively used both for wastewater treatment and galvanic production. In Europe, ultrafiltration is used in more than 80 plants with galvanic shops.



Fig. 3. Ultrafiltration facility for treatment of galvanic sewage

The use of ultrafiltration in the processes of electroplating on the part allows reducing the loss of paint by 15-30% and improving the quality of products. It also helps to completely eliminate the discharge of waste water, which are formed during washing products and reduce the consumption of fresh water. In the process of ultrafiltration, a closed water cycle should mainly be carried out, in which the product to be extracted from the wash water will be returned to production and the treated water will be reused for washing.

3 Nanofiltration in treatment of galvanic sewage

Nanofiltration is a process of membrane filtration of wastewater, which ensures the removal of multi-charged ions from water, depending on the size.



Fig.4. Nanofiltration facility for treatment of galvanic sewage

Selectivity in the process of water purification from heavy metal ions and hardness salts is 98-99%, and when removing single-charge ions about 50%. Nanofiltration combines some features of ultrafiltration and reverse osmosis. In the processes of nanofiltration and reverse osmosis separation is promoted at the molecular level. Hydration, adsorption, hydraulic resistance of membranes and osmotic effect have a huge impact on the separation. Concentration polarization causes an increase in the concentration of pollutants directly near the surface of the membranes, while there is a decrease in the performance of the membrane installation and an increase in the operating pressure is required [6,7].

In the author proved the prospects of simultaneous application of reverse osmosis and nanofiltration technologies for wastewater treatment from heavy metal ions. According to the results, the combination of technologies can achieve effective removal of heavy metal ions from wastewater (98% and 99% for copper and cadmium).

4 Reverse osmosis in treatment of galvanic sewage

Reverse osmosis is a process used to desalinate the bulk of dissolved salts in wastewater of various industries. Also, this process is used to ensure the purification of effluents from organic and inorganic compounds, suspended solids and high molecular weight compounds [8, 9].

Reverse osmosis is carried out on installations that operate on the principle of squeezing water under high pressure through special semipermeable reverse osmosis membranes. Depending on the salt content in the solution, the working pressure is in a range from 10 to 70 bar. Membranes are used with minimal pore size, which are correlated with the size of single ions. Thanks to the reverse osmosis method, it is possible to remove up to 99.9% of impurities from wastewater.

The main working element is a semipermeable membrane. Cellulose acetate or polyamide materials are most often used as membrane material. To ensure operation, it consists in a housing providing connection of the input water supply line, permeate and concentrate lines.



Fig. 5. Reverse osmosis module for industrial wastewater treatment

Filtration modules by design can be made by two technologies: hollow-fiber and spiral-wound. In the first embodiment, the working element is a bundle of hollow fibers into

which the purified water enters. In the second case, the performance of the filter module involves winding filter bags and drainage layers on a hollow tube. The input stream is fed to the open end of the roll. Flowing around the drainage grid, part of the flow passes through the membrane and enters the central tube. From the dead-end of the spiral-wound membrane, the concentrate flow is diverted.

In the engineering industry reverse osmosis is widely used, especially in the electroplating industry, because there are quite high requirements for the degree and quality of water purification. The use of reverse osmosis units allows obtaining high quality water for washing operations and preparation of electrolyte solutions in the creation of water recycling systems of galvanic production and production of printed circuit boards.

It is recommended to use the reverse osmosis process at a certain concentration of effluents: for monovalent salts not more than 5-10 %; for bivalent: 10-15 %; for multivalent 15-20 %. In order to further reduce the content of residual salts, another stage of purification is introduced - the installation of complete desalting (most often mixed-action filters). As an effective method of wastewater treatment, reverse osmosis used in continuous processes. Water after desalination enters the tank, which is made of non-corrodable material. From this tank, desalinated water is supplied to the consumer by a pump, which is made of high quality steel [10-12].

Reverse osmosis plants are implemented in many enterprises of machine-building and galvanic production. Purification is often represented by two stages: ultrafiltration and reverse osmosis. This method does not require large costs, the installation takes up little space, but it requires constant monitoring. Employees supervising the operation of the unit must undergo prior training.

5 Conclusions

1. Membrane methods proved to be among on the most efficient for the treatment of wastewater of different origin.
2. Treatment of galvanic wastewater can provide the efficiency at the level of 95-99% if membrane methods are applied: ultrafiltration, nanofiltration, reverse osmosis.
3. Each of membranes' types has certain advantages and due to that its' own scope of application for treatment of galvanic wastewater.

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