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Application of membrane technologies in industrial enterprises

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Abstract: The membranes classification and membrane methods of water treatment on various grounds, the membrane separation methods and their application analysis for wastewater treatment chemicals and oil refineries, containing biologically recalcitrant pollutants (oil, phenol and derivatives).Advances in membrane technology related to the membranes and membrane-purpose vehicles development of new generation allow us to solvethe actual problem – the local systems, mobile and stationary applications creation that combine traditional and membrane liquid separation processes.

Keywords: membranes; classification; membrane apparatus; membrane technology; metal ceramic membrane;

Introduction

Recently, membrane technologies have begun to be used in industrial wastewater treatment. They are used to remove dissolved and colloidal particles, bacteria, viruses and to recover valuable or toxic (mercury) and radioactive substances. Membranes are used for desalting and clarification. Membranes can be neutral or electrically charged. Charged membranes - cation exchange resins that allow only cations to pass through and anionic membranes that only allow anions to pass through are used in electrodialysis processes, for example, in water demineralization. The particles size retained during membrane separation depends on the membrane pore size.

By separation thresholds (pore sizes), membranes are distinguished:

- reverse osmosis (hyperfiltration) HF, allowing water to pass through and retaining all salts;

- nanofiltration (NF) is a reverse osmosis membrane that traps polyvalent ions and organic substances (molecular weight ~ 300 g/mol) with pore sizes of more than 1 nm (10^{-3} microns);

- ultrafiltration (UV), with pores from 1 to 50 nm, they retain only macromolecules;

- microfiltration (MF), pore sizes, which are from 100 nm (0.1 μm) to 10 μm; they allow all soluble forms to pass through and retain only insoluble solids. As can be seen from Fig. 52, desalting membranes are subdivided into reverse osmosis membranes and nano-filtration membranes, and clarification membranes are subdivided into ultrafiltration and microfiltration membranes. The ultrafiltration membranes pores are 1000 times smaller than the human skin pores. Membrane separation processes use the semipermeability properties of membranes. They are permeable to water and some solutes, but not permeable to other solutes and suspended discrete particles. So, if during conventional filtration through sand particles layer can be completely retained up to 5 microns, then during microfiltration smaller particles are released, and ultrafiltration, depending on the membrane type, provides the release of even smaller particles with a molar mass of 10 100 g/mol.

- Hyperfiltration separates particles with a molecular weight of several hundred grams / mol (10 100 times less than UV).

Membranes are flat or tubular plastic products. Their designs are very diverse.

Membranes are distinguished:

- by material (cellulose acetate, polyamide, ceramic);

- specific productivity;

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- durability, which depends on the pH of the medium, temperature, membrane material;

- working pressure (demineralization membranes 2.58 MPa, clarification membranes <0.2 MPa)

- selective ability (salt permeability), i.e. varying degrees of certain contaminants recovery.

The main characteristic of the membrane unit is the filtrate (permeate) yield coefficient:

$$K_{\phi} = \frac{Q_{\phi}}{Q} \cdot 100\%$$

here Q_{ϕ} unit filtrate flow; Q flow rate of supplied water; K_{ϕ} filtrate yield factor, K_{ϕ}=10 90 %.

The impurities concentration occurs up to the membrane. This concentration must be controlled to prevent deposits and membrane plugging. It is related to the coefficient K_{ϕ}, and the initial concentration of impurities C_c

$$C_{\kappa} = \frac{100 \cdot C_E}{100 - K_{\phi}}$$

If Кф = 75%, then Cк = 4CE

If you want to get Кф>20...30 %, then raw water is subjected to processing: clarification or filtration. To regenerate the membrane, flush is carried out. With membrane methods of water purification, it is believed that the membrane is a porous medium that retains all substances larger than the pore size. The filtrate concentration in front of the membrane depends on both the water flow rate QF and the concentration Cm of the liquid in contact with the membrane. In turn, Cm depends on the initial CE concentration

Here V - coefficient of concentration polarization of the membrane, V=Cm/Ce the salt concentration in the liquid in contact with the membrane; C_E — the salt concentration in the original liquid entering the treatment.

Concentration polarization reduces the process efficiency. In an industrial setting, support = 1,05...1,4. The factor can be reduced to a minimum by efficient flushing of the membrane, discarding more fluid concentrate flow.

Treatment plants are assembled from modules that are assembled from separate membranes.

Modules are distinguished depending on the membranes used:

— tubular;

— tubular with hollow fibers;

— lamellar;

— spiral.

For microfiltration and ultrafiltration, hollow fiber modules are used in 95% of all installations, and spiral modules for nanofiltration and reverse osmosis. Tubular modules are assembled from tubular membranes (Fig. 38 *a*), which have an outer diameter of 4 to 25 mm. They are placed in series or parallel in a cylindrical body to form a tubular module.

The liquid circulation speed in it can be taken up to 6 m/s. Such modules do not require preliminary fine water purification and are used for liquids with high suspension content. They are easy to clean by inserting sponge balls. The disadvantages of tubular modules include: large dimensions, high cost of $1m^2$ filtration area.

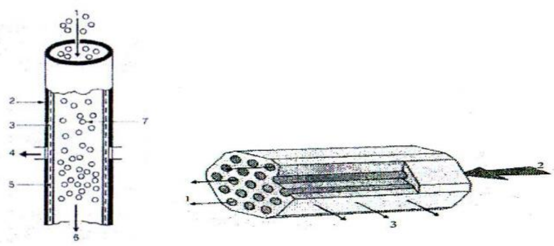

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Fig. 1*a*). tubular membrane: 1 – raw water supply; 2 – trumpet; 3 – membrane holder; 4 – treated waste water; 5 – membrane; 6 – concentrate yield; 7 – suspended solids; b). ceramic membrane: 1 concentrate; 2 – water; 3 – permeate

Hollow fiber modules. Such fibers diameter is from 0.6 to 2 microns. They are made by membrane material extrusion through annular dies. They can withstand significant internal and external working pressures. They are sometimes reinforced with a cloth mesh and are often grouped together from several thousand fibers. The processed liquid flows inside the fibers (internal filter surface) or outside (external filter surface). Such modules can be regularly flushed with reverse water flow after 0.33 2 hours. Moreover, the pressure during flushing is much lower than the maximum allowable for crushing or bursting.

Submersible ultrafiltration modules with an external filtering surface (Fig. 2) are installed directly into the treated water. The filtrate is sucked through the fiber walls by creating a vacuum (0,2 ... 0,6 bar). They consist of reinforced hollow fibers sheets, combined in cassettes containing from 10 to 60 modules, with one power supply, one permeate (filtrate) outlet and one air manifold.

To combat clogging (clogging) of the membranes, an air supply is provided. In addition, all clarification modules (ultrafiltration and microfiltration) must be protected from clogging by large particles, for which it is recommended to install protective microsieves with openings from 150 to 500 microns in front of them.

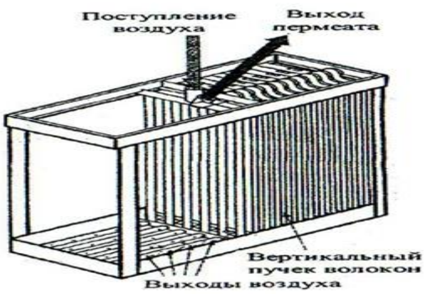

Fig. 2 Submersible ultrafiltration modules

Spiral modules (Fig. 2). Module diameter from 5 to 30 cm, length 0.3 ... 1.5 m, membrane surface from 0,3 to 41 m^2, K_f = 5... 13 %. Several such modules (from 2 to 8) are installed in series in a single cylindrical body. These modules are the most compact and provide the lowest head drop, however, they are very susceptible to clogging and good fluid pre-treatment is required. At present, almost all desalination modules (HF, NF) are manufactured in spiral form.

For clarification membranes used at very low pressures (<2 bar), only parallel connections of all modules are used and a recirculation loop is provided to implement tangential filtration mode, if necessary.

Clarification membranes are gradually replacing traditional structures in the drinking and industrial water preparation without the use of reagents from natural or recycled water of enterprises, as well as in the preliminary treatment of water for desalination systems.

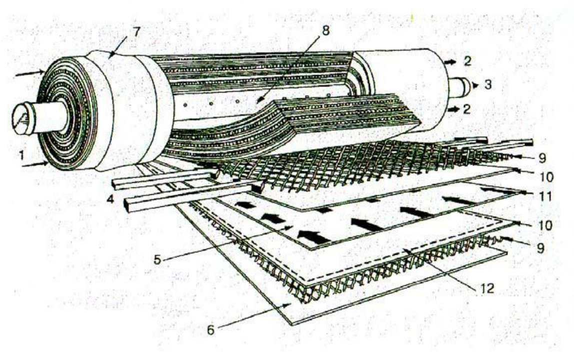

Fig. 3. Spiral module: 1 water intake; 2 concentrate yield: 3 collector tube; 4 direction of source water movement; 5 the direction of permeate movement; 6 protective material: 7 airtight gasket between the module and the case; 8 permeate manifold holes; 9 gasket; 10 membrane; 11 permeate collector; 12 adhesion line of two membranes

Membrane technologies are used for:

— obtaining ultrapure water and demineralization;

— industrial effluent treatment;

— improving the water quality treated in traditional installations;

—water disinfection.

An ultra filtration unit for cleaning wastewater from motor transport enterprises from suspended and colloidal particles, oil products, organic contaminants and heavy metals (Fig. 4) includes blocks:

1. Preliminary cleaning from the main amount of coarse suspended particles and free oil products in a settling tank. The separated oil products and sludge are sent for utilization.

2. Fine filtration on a mechanical filter (removal of suspended particles over 20 microns).

3. Deep cleaning from fine and colloidal particles, emulsified oil products, high molecular weight organic matter and heavy metals on an ultra filtration module. In the ultra filtration process through the membrane, the source water is divided into two streams: ultra filtrate, which is continuously discharged into a tank for purified water and then for reuse, and a concentrate saturated with oil products and mechanical impurities, which is returned to the settling tank.

4. Additional treatment in a sorption filter (in the case of treated wastewater discharge into open water bodies) ensures the removal of dissolved oil products, low molecular weight organic matter, and residual heavy metals.

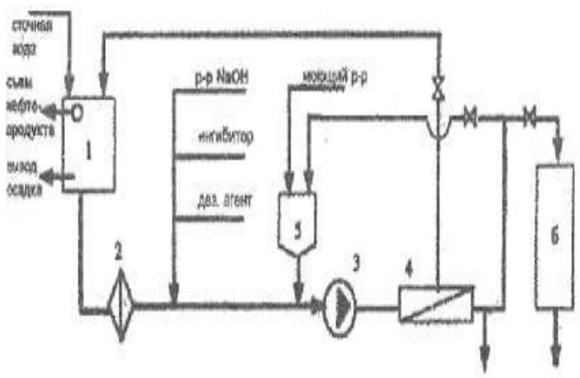

Fig. 4. Technological scheme of an ultra filtration plant for wastewater treatment of motor transport enterprises: 1 – sump; 2 – mechanical filter; 3 – pump; 4 membrane module; 5 – sink unit; 6 – sorption filter

Conclusion. The technology provides for the membrane elements regeneration with a washing solution; adjusting the pH to 9 10 value by dosing NaOH to increase the detergent properties of water; the introduction of an inhibitor to prevent the sediment formation on the pistols that supply water for flushing, and to prevent the streaks and stains formation on the car body surface; periodic introduction of a disinfectant for water disinfection.

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