METHODS OF INDUSTRIAL WASTEWATER TREATMENT AT OIL REFINING AND GAS PROCESSING ENTERPRISES

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Abstract*. The article considers the process of formation and composition of industrial wastewater of oil refining enterprises. Methods of industrial wastewater treatment formed in the technological process are briefly analysed. Many traditional and common technological methods such as biological, physico-chemical and chemical approaches are used in industrial wastewater treatment. Methods of treatment of industrial wastewater from oil refineries were studied based on the analysis of works carried out by foreign researchers.*

Keywords*: industrial wastewater, oil products, filtration, flotation, electrocoagulation, membrane bioreactor, membrane ultrafiltration.*

Introduction. Environmental protection from pollution and rational use of natural resources is one of the main problems of our time. As a result of technological processes at oil refineries and gas processing plants, a large amount of wastewater is generated. The average specific amount of wastewater generated during the processing of one tonne of oil can vary from 0.4 to 2.38 m3 depending on the type of oil products produced, profile and production technology. Refinery wastewater will contain large quantities of oil in the form of petroleum, petroleum products and oil emulsion, suspended solids, light and heavy hydrocarbons, phenol and other dissolved organic and inorganic substances. Petroleum hydrocarbons in wastewater are the main cause of environmental pollution.

Materials and research methodology. The composition and quantity of wastewater generated in the technological processes of oil refining were studied as a result of analysing scientific and methodological literature devoted to this field. Methods and techniques of industrial wastewater treatment of oil refineries were studied as a result of analysing scientific works of foreign researchers who conducted research in this field.

Analysis of literature on the quantity and quality of wastewater. Wastewater from oil refineries is generated in the technological processes of obtaining various petroleum products from crude oil and converting them into petrochemical intermediates by further processing.

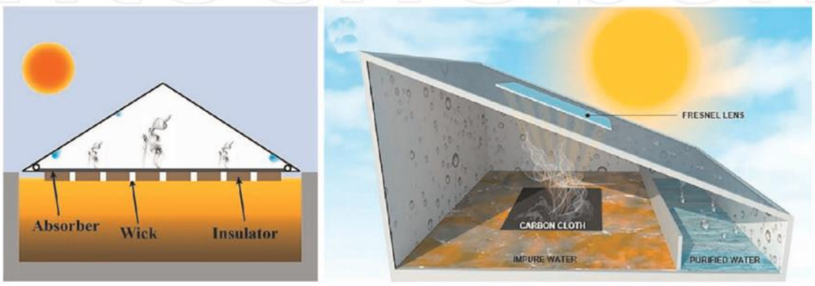
Desalination of crude oil in desalination plants produces large quantities of brine together with the oil. These effluents pose a serious environmental problem because of their unique quantitative and qualitative characteristics. They contain soluble salts, petroleum substances, volatile and non-volatile organic matter and other hazardous pollutants [1]. Such waters, containing over-wetted soluble salts and solid particles of pollutants, as well as super active corrosion-causing substances, are prohibited to be discharged into them for the purpose of filling oil or gas wells without treatment. This is because they may cause clogging of the flow path in underground flow lines or well openings due to wastewater leaking to the surface or corrosion of flow lines. Refineries, as one of the complex process industries, consume large volumes of water (65 to 90 gallons per barrel of crude oil) depending on the volume and configuration of the process flowing for several operations and consequently generate large volumes of wastewater of different categories [2].

The amount of wastewater generated will be 4 times greater than the amount of crude oil processed. After treatment at oil refineries based on quality standards, treated water can be distributed to the cooling systems of technological units, irrigation and fire-fighting water supply systems, as well as for reuse in production [3]. Technological maps will be developed for the efficient use of water at refineries, application of advanced water treatment methods, modernisation and improvement of management and creation of a water management complex [4]. These approaches include the study and implementation of traditional methods such as distillation, evaporation, activated carbon filtration, sand filtration and chemical oxidation, as well as more advanced states such as pressurised membrane separation, electrodialysis, ion exchange and advanced oxidation processes [5].

Analysis of wastewater treatment methods. Many traditional and common technological processes such as biological, physico-chemical and chemical approaches are used in refinery wastewater treatment. There are gravity separation-flotation, filtration based separation method and biological treatment methods [3].

Solar evaporation method. The solar evaporation method of wastewater from crude oil desalination is appropriate for treating waters containing more than 50 grams per litre of soluble salts, oily substances, volatile and non-volatile organic substances and other hazardous pollutants. Currently, this wastewater is typically discharged back into production wells or abandoned wells to increase well capacity or protect the environment without or after initial treatment, including removal of solids and major petroleum substances. Also from an environmental perspective, wastewater generated after degreasing crude oil desalination plants is discharged into evaporation basins. In this case, over time, their quantity is reduced by solar evaporation and the volume of the evaporation basin is released for the discharge of production effluents. Given the sufficient temperature and high intensity of radiation on most days of the year, the use of solar energy seems reasonable. Solar distillation is a relatively simple solution for salt water sources. In the solar distillation method, solar evaporated water and pure water vapour after condensation can be used as pure water. Having the ability to be built at low capacity, no or minimal need for fuel and electricity, no environmental pollution due to fuel combustion, using this system in areas with renewable energy potential and at the same time with difficulties in transmission of electricity and fuel, has great advantages and is feasible. The building of this device consists of a wooden pool darkened with safety pigments. The solar evaporation pool can be divided into two groups according to the sloping surface with one-sided slope and two-sided slope (Fig.1).

According to research, a solar evaporation basin with one-sided sloping surface has higher efficiency due to more incoming light. The main problem of this type of desalination plant is the low production capacity of the plant. Another disadvantage of solar distillation desalination is the low absorption of solar energy by plants located far from the equator.



(a) (b)

Figure 1: Solar evaporation basin

Membrane bioreactor method. Wastewater treatment in the oil industry by the membrane bioreactor method refers to the technologies of biological wastewater treatment with subsequent separation of the resulting biomass from the mixed liquid by membrane processes. All these processes are carried out in one bioreactor (Fig.2).

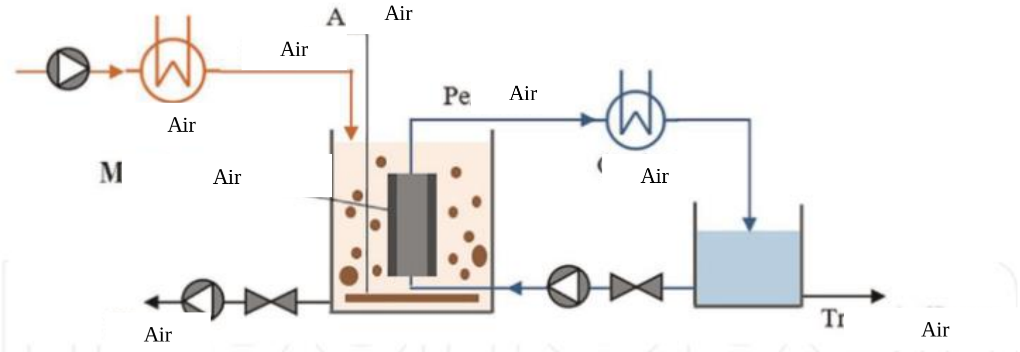


Figure 2: Membrane bioreactor

Hence, in this method, secondary sediment pool will not be present in the system. Other advantages of this system include the fact that the unit does not take up much space and the quality of the treated water is high. This system is now widely used for the treatment of domestic wastewater as well as wastewater from the food, pharmaceutical, petroleum and petrochemical industries.

Electrocoagulation method. The separation of water and oil into two important substances was proposed by researchers in the treatment of oil industry wastewater by electrocoagulation [6]. The electrocoagulation method is one of the ways of effective separation of fat from emulsion. It is technically and economically acceptable and inexpensive method. In this method, the cleaning process is carried out in three steps as shown in Figure 3.

The electrocoagulation method has several advantages, including no chemical reagents, simple equipment design, low cost, short process time, and high cleaning efficiency [12].

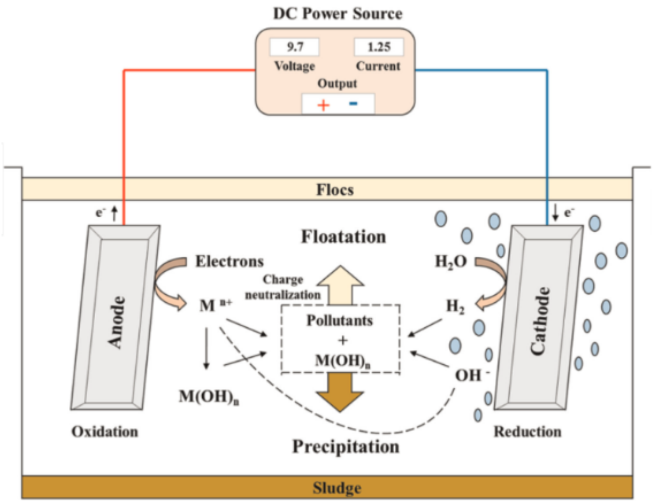


Figure 3: Image of water treatment by electrocoagulation method

Membrane Ultrafiltration Method. In the treatment of oil industry wastewater by membrane filtration method, several separation processes including ultrafiltration, nanofiltration and reverse osmosis are used to separate oil water. Membrane ultrafiltration is one of the most important separation processes in the field of oil industry wastewater treatment [7].

In refineries, large volumes of petroleum products are in the form of emulsions in water, which is treated in their extraction, transport and refining processes [8]. Methods based on membrane separation include dewatering of oil emulsion by reverse osmosis, microfiltration, membrane distillation and ultrafiltration. The advantages of membrane technology are low cost, no need for chemical reagents and high quality of purification. Ultrafiltration membranes can separate large soluble molecules such as proteins and petroleum products from the solution. In porous membranes, due to coagulation and deposition of fat in the membrane cavities, there is a reduction in the release of fat-in-water emulsions [9].

Conclusion, the text highlights the importance of treating hydrocarbons in oil refinery wastewater before its discharge into the environment. The research analysis indicates that a specific separation method should be used for different types of industrial wastewater based on its physical properties. Petrochemical wastewater typically exists as oily emulsions in water, necessitating an understanding of their physical and chemical composition for emulsion decomposition and oil separation. The choice of treatment methods depends on economic factors and the type and form of oily contaminants in the water. Future studies will focus on analysing industrial wastewater from oil refineries and gas processing plants under real conditions and selecting appropriate treatment methods.

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