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Investigation of Membrane Distillation Process as a Tertiary Wastewater Treatment of Bandar Abbas Oil Refinery for Reuse in Industry

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INTRODUCTION

Regarding the poor quality of most treated wastewater of refineries for reuse in the industrial sector, the need for completeness treatment is unavoidable. According to the tightening of environmental standards on the one hand and the need for reuse of treated wastewater in the industry on the other hand, the need for feasibility study and research in the field of new membrane technologies is becoming increasingly evident. Membrane distillation (MD) is nowadays considered as a new membrane separation process in the world [1]. The improvement of the membrane distillation process in the world as a substitute for routine separation processes, such as distillation and reverse osmosis, is under investigation by researchers [2-6]. The use of a membrane distillation process for oil refinery treatment was reported by Mecedonio and his colleagues in 2014 [7]. Moreover, membrane distillation was used by Singh and Sirkar to refine simulated oil wastewater [8]. In this research, in order to feasibility study of using refinery wastewater as feed for membrane distillation process, at first, the output water of the refinery of Bandar Abbas Oil Refinery was analyzed during four months, and the values of important output parameters were determined. After construction of the membrane distillation module and the AGMD laboratory scale pilot, the analyzed refinery wastewater fed to the system and the effect of process factors such as changes in the feed temperature, air gap distance, feed concentration and membrane pore size effects on the amount of flux produced for two commercial membranes were studied. Also, the amount of flux reduction due to membrane fouling was studied using a 0.45 micron membrane which was used multiple times compared to the new membrane. Finally, the analysis of the quality of the product obtained from the membrane distillation system was carried out, and comparing the results with the standards values for use in the industrial sector was discussed.

EXPERIMENTAL PROCEDURE

MATERIALS

In experiments, two types of PTFE membranes made by Membrane Solutions Company with trade codes MSPTFE022B and MSPTFE045B with pore sizes of 0.45 and 0.22 µm were used.

MODULE AND LAB-SCALE PILOT DESIGN

The AGMD module is made of Plexiglas and has two hot and cold flow chambers on both sides and an interchangeable air gap. In this module, a thin copper sheet of 0.2 mm thickness was used as a condenser and cooling plate. Figure 1 shows an overview of the designed module and laboratory pilot.

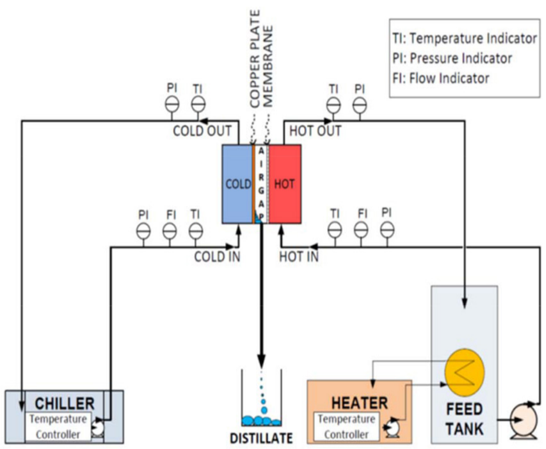

Figure 1: Module and Lab-Scale Pilot Schematic.

In order to measure changes in the amount of flux by the change in the distance between the membrane and the condenser copper plate (Air Gap), feed at various temperatures at 40, 50, 60, 70 and 80 °C entered the module, and the amount of flux in the two possible air gap modes (6 and 12 mm) was calculated. Two membranes with pore sizes of 0.22 and 0.445 µm were used to study the effect of membrane pore size on flux value.

In order to investigate the effect of feed concentration, different effluents with electrical conductivity of 4400, 780, 2100 and 3200 µS/cm were compared to the feed water.

RESULTS AND DISCUSSION

EFFECT OF MEMBRANE PORE SIZE

The amount of flux has increased with increasing the size of membrane pores. At 80 °C, the mean flux for membrane with 0.45 µm pore size was 12.29 kg/m^2.h that decreased to 11.10 for 0.22 µm pore size.

EFFECT OF AIR GAP

In both cases, the air gap of 6 and 12 mm, with increasing feed temperature, also increased the flux. At 80 °C, the mean flux for module with 6mm air gap was 16.44 kg / m^2.h that decreased to 12.29 for 12 mm air gap case.

EFFECT OF FEED CONCENTRATION

Reducing the concentration increased the amount of flux in all feed samples at any temperature. By increasing the feed EC from 4400 to 5200 µS/cm, the amount of flux changed from 12.29 to 11.25 kg/m^2.h.

WATER QUALITY ASSESSMENT

By comparing the quality of distilled water produced from the membrane distillation module with the standard range of industrial water, clearly, the quality of this water is evident at the high est level required by the industrial water standards.

CONCLUSIONS

According to the results of this study, both types of membranes used in tests with pore sizes of 0.22 and 0.45 microns have the required performance to provide minimum flux. However, the maximum flux produced by using a 0.45 µm membrane, with 6 mm air gap, and at 80 °C feed temperature, yielded 16.44 kg / m^2.h which can be acceptable. Increasing the air gap reduces the flux, which results are consistent with the results of other investigations. Also, with a reduction in the electrical conductivity (EC) of the wastewater from 4400 to 780 µS/cm, the flux value has shown a little growth; therefore, it would be hoped that the changes in concentration would not have much effect on the amount of flux.

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