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Seawater Desalination for Production of Highly Pure Water Using a Hydrophobic PTFE Membrane and Direct Contact Membrane Distillation (DCMD)

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Abstract : Qatar's primary source of fresh water is through seawater desalination. Amongst the major processes that are commercially available on the market, the most common large scale techniques are Multi-Stage Flash distillation (MSF), Multi Effect distillation (MED), and Reverse Osmosis (RO). Although commonly used, these three processes are highly expensive down to high energy input requirements and high operating costs allied with maintenance and stress induced on the systems in harsh alkaline media. Beside that cost, environmental footprint of these desalination techniques are significant; from damaging marine eco-system, to huge land use, to discharge of tons of GHG and huge carbon footprint. Other less energy consuming techniques based on membrane separation are being sought to reduce both the carbon footprint and operating costs is membrane distillation (MD). Emerged in 1960s, MD is an alternative technology for water desalination attracting more attention since 1980s. MD process involves the evaporation of a hot feed, typically below boiling point of brine at standard conditions, by creating a water vapor pressure difference across the porous, hydrophobic membrane. Main advantages of MD compared to other commercially available technologies (MSF and MED) and specially RO are reduction of membrane and module stress due to absence of trans-membrane pressure, less impact of contaminant fouling on distillate due to transfer of only water vapor, utilization of low grade or waste heat from oil and gas industries to heat up the feed up to required temperature difference across the membrane, superior water quality, and relatively lower capital and operating cost. To achieve the objective of this study, state of the art flat-sheet cross-flow DCMD bench scale unit was designed, commissioned, and tested. The objective of this study is to analyze the characteristics and morphology of the membrane suitable for DCMD through SEM imaging and contact angle measurement and to study the water quality of distillate produced by DCMD bench scale unit. Comparison with available literature data is undertaken where appropriate and laboratory data is used to compare a DCMD distillate quality with that of other desalination techniques and standards. Membrane SEM analysis showed that the PTFE membrane used for the study has contact angle of 127º with highly porous surface supported with less porous and bigger pore size PP membrane. Study on the effect of feed solution (salinity) and temperature on water quality of distillate produced from ICP and IC analysis showed that with any salinity and different feed temperature (up to 70ºC) the electric conductivity of distillate is less than 5 µS/cm with 99.99% salt rejection and proved to be feasible and effective process capable of consistently producing high quality distillate from very high feed salinity solution (i.e. 100000 mg/L TDS) even with substantial quality difference compared to other desalination methods such as RO and MSF.

Keywords : membrane distillation, waste heat, seawater desalination, membrane, freshwater, direct contact membrane distillation
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