Experimental and simulation study of multichannel air gap membrane distillation process with two types of solar collectors

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Abstract

Solar thermal energy for membrane distillation desalination is a green and safe way for areas where water scarcity and solar irradiance are strongly correlated. In this paper, a commercial-scale of desalination plant was installed and tested to study the performance of a multichannel spiral-wound air gap membrane distillation module with an area of 14.4 m_2. Air gap membrane distillation desalination plant at Port Said university was powered by solar energy using flat plate and evacuated tube collectors. The model validation was carried out. The solar desalination systems were numerically

simulated using the program TRNSYS under different weather conditions throughout the year. The influence of the main operating parameters (feed flow rate and inlet temperatures of evaporator and condenser) was investigated. Regression analysis agreed with experimental data fitting using a quadratic polynomial model with coefficients of determination (R_2) values of 0.997, 0.972, and 0.999 for permeate flux, outlet feed temperature, and outlet coolant temperature, respectively. The results showed that the permeate flux of the air gap membrane distillation with the evacuated tube collectors was 18.81%–30.44% higher than flat plate collector, and its cost was 22.48% lower. The specific thermal energy consumption of the air gap membrane distillation system ranged from 158.83 kWh/m_3 to 346.55 kWh/m_3. The maximum gain output ratio reaches 4.4 at 52 °C, depending on the feed inlet temperature. The thermal efficiency of the air gap membrane distillation system is 72%. The proposed air gap membrane distillation system produced 28.78 m_3/year of fresh drinking water at a cost of USD 14.73/m_3 with remarkable reducing in carbon dioxide emissions by 7,274.45 kg/year.