An experimentally calibrated model for heat and mass transfer in full-scale direct contact membrane distillation

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ABSTRACT

This paper presents experimental and theoretical results for the performance of direct contact membrane distillation (DCMD). An experimental DCMD unit is used to study the thermal and material behavior of the closed-loop system, investigating the effect of feed flow rate, inlet temperature, and salinity. The results indicate the proportional growth of water production with increasing feed flow rate and inlet temperature. Specifically, the mass flux increases from 0.6 to 1.7 kg/(m²·h) when the inlet temperature rises from 50 to 80°C at 300 L/h feed flow rate. Similarly, the mass flux increases from 0.27 to 1.7 kg/(m²·h) when the feed flow rate increases from 50 to 300 L/h at an inlet temperature of 80°C. A transition region is observed at a feed flow rate of 100 L/h; at higher flow rates, the heat flux saturates causing the exit permeate temperature and recovery ratio to reach saturation. Solution salinity moderately affects the mass flux but only slightly affects the heat flux. A theoretical model based on heat and mass transfer balances is developed, and careful adjustment of the mass transfer coefficient and heat losses improves its accuracy, making it reliable and particularly suitable for energy efficiency analysis of the process.

Keywords: Membrane distillation; Water desalination; Mass and heat transfer; Modeling; Spiral wound membrane

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