3D CFD study of the effect of multi-layer spacers on membrane performance under steady flow

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ABSTRACT

Multi-layer feed channel spacers have shown superior mass transfer enhancement than conventional dual-layer spacers used in reverse osmosis (RO) spiral wound membrane modules. However, mass transfer indicators do not directly address the economic advantages of multi-layer spacers. To allow for a direct economic comparison of spacer designs, a simplified multi-scale techno-economic model is proposed which can provide useful cost trends. A total of 8 feed spacer geometries with different attack angles (α = 0–60°) and filament sizes (df/hch = 0.4–0.6) are first investigated using 3D-CFD. Multi-layer spacers typically increase both Sherwood number (~12%) and friction factor (~140%). The techno-economic model is then used to assess the impact of these changes on the total processing cost for RO. The latter analysis found that larger pressure drops associated with multi-layer spacers in long channels have little impact on total water processing cost for RO, with multi-layer spacers showing lower total processing costs (by 2–4%) than the dual-layer spacer for both seawater and brackish water RO. Novel spacer designs should therefore emphasise flux enhancement. The importance of including energy recovery for a more accurate economic analysis is highlighted, especially for systems with low recovery ratio.

KEYWORDS

CFD; Spiral wound module; Multi-layer spacer; Mass transfer enhancement; Economic analysis