Computational fluid dynamics simulation of spacer-filled channels in reverse osmosis modules

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Reverse osmosis desalination is a separation process widely used in both potable and industrial water production where dissolved salts are removed from seawater using a semi-permeable membrane. Out of different RO modules, the spiral-wound module (SWM) for nanofiltration (NF) and RO membranes is the most widely used module due to its advantages in terms of moderate fouling tendency and high packing density. Spacers are fiber-like structures in RO modules and it is essential that spacers are designed and optimized in a way that balances the mixing effect and pressure drop, which is correlated with permeation performance and energy consumption, respectively. In this research, we present CFD simulations where user defined functions (UDF) are applied to simulate water flux across the membrane more realistically for various spacer designs. Several parameters are altered to observe the performance of the module, including membrane properties and membrane configuration. Simulation results allow us to investigate the interplay of spacer designs and membrane properties on average water fluxes and pressure drops, indicative of the overall module performance and energy consumption.