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Membrane morphology and topology: Fouling control in filtration systems

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Reverse Osmosis Membrane (ROM) filtration systems are widely utilized in waste-water recovery, seawater desalination, landfill water treatment, etc. During filtration, the system performance is dramatically affected by membrane fouling which causes a significant decrease in permeate flux as well as an increase in the energy input required to operate the system. Design and optimization of ROM filtration systems aim at reducing membrane fouling by studying the coupling between membrane structure, local flow field and foulant adsorption patterns. Yet, current studies focus exclusively on oversimplified steady-state models that ignore any dynamic coupling between fluid flow and transport through the membrane. In this work, we develop a customized solver (SUMs) under OpenFOAM to solve the transient equations. The simulation results not only predict macroscopic quantities (e.g. permeate flux, pressure drop, etc.) but also show an excellent agreement with the fouling patterns observed in experiments. It is observed that foulant deposition is strongly controlled by the local shear stress on the membrane, and channel morphology or membrane topology can be modified to control the shear stress distribution and reduce fouling. We demonstrate how channel morphology and membrane topology can be jointly optimized in order to increase the efficiency of the system. Finally, we identify optimal regimes for morphological and topological modifications in different operation conditions.

References

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