Comparison of oscillating flow and slip velocity mass transfer enhancement in spacer-filled membrane channels : CFD analysis and validation

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ABSTRACT

Unsteady shear methods have the potential to generate flow perturbations near the membrane surface, which play an important role in reducing concentration polarisation and fouling tendency. In general, there are two main approaches for generating time-varying flow perturbations: 1) generating oscillations in the bulk flow; or 2) forcing a slip velocity near the membrane surface. This paper presents a detailed comparison study of both approaches by means of two-dimensional computational fluid dynamics (CFD) simulations. The results show that both approaches result in significant increases in flux and maximum wall shear at the same disturbance resonant frequency and Reynolds number. This suggests that the mechanism by which the flow perturbations are generated is not as important as the perturbation frequency, in terms of increasing wall shear and permeate flux. However, it is more important to perturb flow near the membrane surface because it reduces energy consumption compared to oscillating flow approach. In addition, this paper confirms that a white noise perturbation can be used to simplify the approach for maximising vortex-shedding-induced mass transfer enhancement, without the need to identify the peak/resonant frequency for the flow in spacer-filled membrane channels at the expense of a higher pressure loss.

KEYWORDS

CFD; Flow perturbation; Slip velocity; Oscillating flow; White noise perturbation

ACKNOWLEDGEMENTS

The authors acknowledge the Sydney Informatics Hub and the University of Sydney's high performance computing cluster Artemis for providing the high performance computing resources that have contributed to the research results reported within this paper. Funding support by Universiti Malaysia Pahang research grants (Project numbers RDU 160342, RDU 170324 and PGRS 170341), CONACYT (PDCPN 2015-1221 and Cátedras Project 2338) and by the Instituto Tecnológico de Sonora (PROFAPI fund Project 2018-0029) is also acknowledged. Thanks are extended to Ismael Murillo Verduzco for assisting with the fabrication of the oscillating valve, and to José Luis Robles Magdaleno for support in obtaining the experimental data.