CFD study of the effect of SWM feed spacer geometry on mass transfer enhancement driven by forced transient slip velocity

K. Foo[a], *Y.Y. Liang*[a,b,*], *G.A. Fimbres Weihs*[c,d]

[a]Faculty of Chemical and Natural Resources Engineering, Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia

[b]Centre of Excellence for Advanced Research in Fluid Flow (CARIFF), Universiti Malaysia Pahang, Lebuhraya Tun Razak, 26300 Gambang, Kuantan, Pahang, Malaysia

[c]CONACyT–Instituto Tecnológico de Sonora, 5 de Febrero 818 Sur, Cd. Obregón, Sonora, C.P. 85000, Mexico

[d]The University of Sydney, School of Chemical and Biomolecular Engineering, NSW, 2006, Australia

ABSTRACT

Recent studies have shown that the interactions between forced transient flow and eddy inducers (i.e. spacers) in spiral wound membrane modules results in significant mass transfer enhancement and reduction in concentration polarisation (CP). This paper uses CFD to investigate the effect of varying the spacer geometric parameters on the resonant frequency for an unsteady forced-slip, as well as the resulting permeate flux enhancement, for a 2D zig-zag spacer. The analysis shows that the resonant frequency is significantly affected by the interaction of the shear layer with successive downstream spacers. The effectiveness of forced-slip reaches a peak (up to 15.6% flux increase) for a spacer size in the range of $0.5<d_f/h_{ch}<0.6$ because of the trade-off between mixing-induced forced-slip and the CP modulus. In addition, vortex shedding is suppressed for smaller spacer sizes ($d_f/h_{ch}\leq0.4$), because viscous forces dominate over convective forces due to a smaller filament Reynolds number. As the distance between filaments is increased, the increase in flux due to forced-slip is greater (up to 31.5%), albeit the actual flux decreases because the boundary layer is more developed. These results also reinforce the finding that forced-slip is more efficient for spacer designs with poor mixing (i.e. high CP).

Keywords

CFD; Unsteady slip velocity; Spacer geometry; Mass transfer enhancement

DOI: https://doi.org/10.1016/j.memsci.2019.117643

ACKNOWLEDGEMENTS

The authors acknowledge funding support provided by Universiti Malaysia Pahang research grants (Project number RDU170324), CONACYT (PDCPN 2015-1221 and Cátedras Project 2338) and by the Instituto Tecnológico de Sonora through a PROFAPI fund (Project 2019-0054). One of us (K.F) gratefully acknowledges scholarship funding by Universiti Malaysia Pahang (UMP).