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A numerical study on longitudinal vortex induced enhancement of mass transfer in a membrane channel

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Concentration polarization phenomenon often occurs in membrane separation, it acts to deteriorate the transmembrane mass transfer, so measures should be taken to suppress it. The present work simulates the flow and mass transfer in narrow membrane channels with and without flow disturbers. The channel is composed of an impermeable solid wall and a membrane. The flow disturbers include the rectangular and delta winglets, which are generally used as longitudinal vortex generators to enhance heat transfer in heat exchanger applications, and the square and triangular prisms and circular cylinder, which are employed here to simulate the traditional spacer filaments for comparison purpose. Calculations were made to investigate and compare the effects of various flow disturbers, which are attached to the solid wall surface to enhance the mass transfer near the membrane surface to reduce the concentration polarization. The disturber performance was evaluated in terms of concentration polarization factor versus consumed pumping power and pressure drop, with a larger factor meaning a more serious concentration polarization. Calculations were done for NaCl solution flow in membrane channels having a 2.0 mm height for Reynolds numbers of 400-1000. The results show that the concentration polarization occurs mainly in a very narrow range near the membrane surface and the degree of concentration polarization increases along the fluid flow direction but decreases with Reynolds number. The traditional prism- and cylinder-type disturbers can considerably reduce the concentration polarization factor, but they simultaneously cause substantially increased pressure drop and pumping power, while the novel winglet-type disturbers can effectively enhance the mass transfer with much less pressure drop penalty. Overall performance comparison of the abovementioned various disturbers suggests that under equal pressure drop and equal pump power conditions, the delta winglets yield the best mass transfer enhancement effect while the tri-prism gives the worst mass transfer enhancement effect.

Biography

Jingchun Min is an Associate Professor of Engineering Thermophysics at the Department of Engineering Mechanics in the Tsinghua University, China. He has received his Bachelor's degree from the Dalian University of Technology, China, Master's and PhD degrees from the Hiroshima University, Japan. He currently serves as an Editor for *Journal of Enhanced Heat Transfer* and an Editorial Board Member for *Energy and Power Engineering*. His current research interests include membrane transport, transport phenomena in porous media, aircraft icing, aero-engine cooling, enhanced heat and heat exchanger technology.

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