Finite Element Study of the Mass Transfer in Annular Reactor

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Abstract

The annular reactor is a very useful design to carry many chemical reactions. Its advantages such the low pressure drop and ease of temperature control renders it more desirable than traditional reactor, for example in the use as a double heat exchanger, a dialyzers or a photo-catalytic reactors, where a UV lamp can be placed in the core of the reactor.

In this study, COMSOL Multiphysics® software was used to study the isothermal mass transfer from the inner side of the outer tube of the annular reactor within a range of flow rates corresponding to 200<Re<12000. The study focuses on the effect of the geometry on the rate of mass transfer in the developing flow zone (section A)and in the fully developed zone (section B). The dissolution of sparingly soluble wall was used to simulate the mass transfer from the wall. The laminar flow and low Reynolds number K-ε turbulence model were used to simulate the flow in the reactor and then the Transport of Diluted Species interface was used to simulate the mass transfer from the saturated wall to the fluid. A very fine mesh was constructed near the wall using the boundary layer mesh option in COMSOL and the results were checked to be mesh independent.

This study results were in good agreement with previous experimental results. The results showed that the surface mass transfer is highest at the entrance and decreases downstream as the flow becomes fully developed. Also, as the difference between the annulus diameters decreases, the rate of mass transfer increases. Moreover, as the inlet spacing between the inlet port of the reactor and the inner tube rounded front decreases, the rate of mass transfer slightly increases.

Reference

1. Mobarak, A.A., H.A. Farag, and G. H.Sedahmed, Mass transfer in smooth and rough annular ducts under developing flow conditions. Journal of Applied Electrochemistry, 1997. 27(2): p. 201-207.

2. Esteban Duran, J., F. Taghipour, and M. Mohseni, CFD modeling of mass transfer in annular reactors. International Journal of Heat and Mass Transfer, 2009. 52(23-24): p. 5390-5401.

Figures used in the abstract

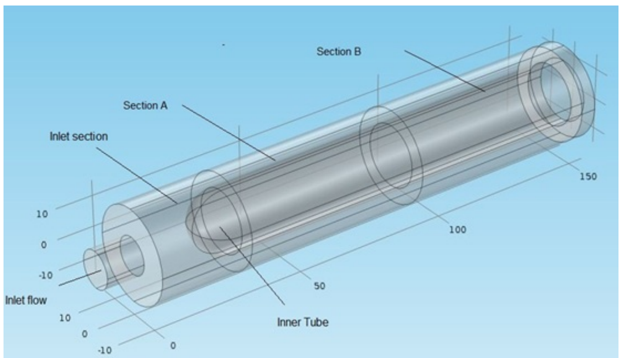

Figure 1: Schematic diagram of the 3D annular reactor model.

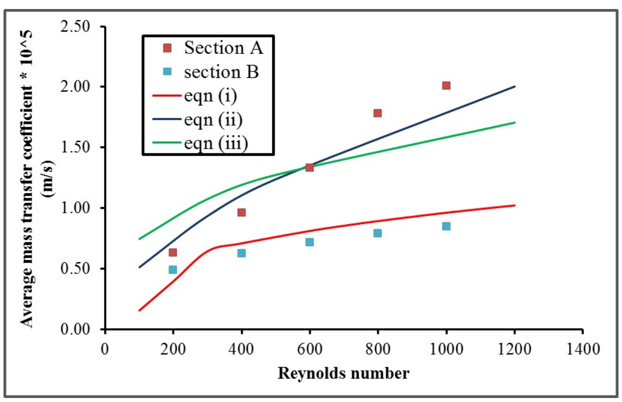

Figure 2: Comparison of the CFD predicted average mass transfer coefficients for laminar flow with the ones estimated using different correlations reported in the literature.

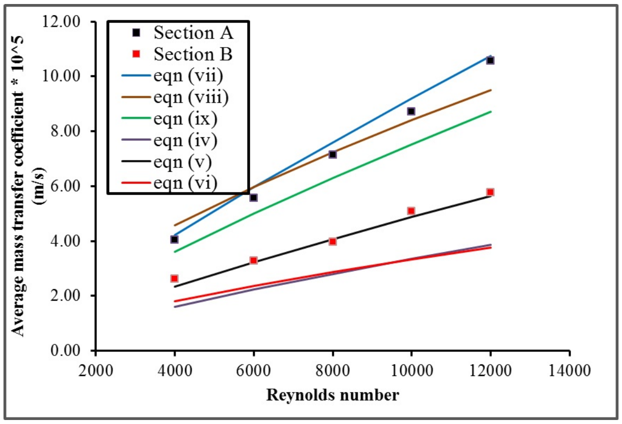

Figure 3: Comparison of the CFD predicted average mass transfer coefficients for transitional and turbulent flows with the ones estimated using different correlations reported in the literature.

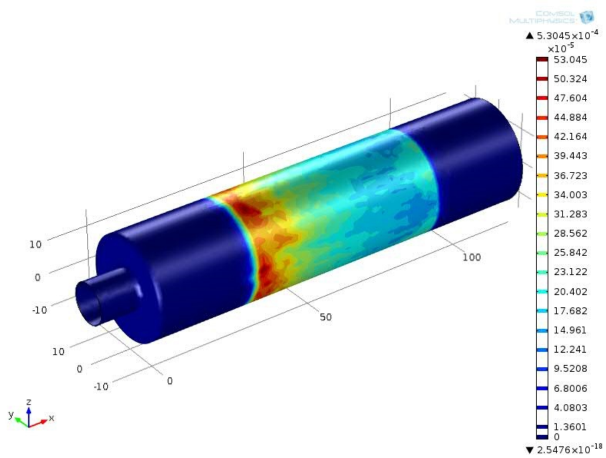

Figure 4: Local mole flux magnitude in section A for Re=500.