290p Theoretical Observations of Recirculation Regions in the Bore Fluid during Hollow Fiber Spinning

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Hollow fiber membranes are used widely in membrane separation processes because of their high surface area to volume ratio. Several one-dimensional and two-dimensional models have been developed for the hollow fiber spinning processes. However, many details of the process are not well understood.

In this work, the conservation of mass and momentum equations are solved for isothermal, axisymmetric hollow fiber spinning using the commercial computational fluid dynamics package FIDAP. In contrast to past work, the conservation equations are solved for both the bore and clad fluids. The two sets of equations are linked by continuity of velocity and stress across the bore-clad interface. Additionally, the die geometry was selected to correspond to a die used in our laboratory. The bore and clad fluids were assumed to be Newtonian.

Simulation results show an unexpected recirculation region in the bore fluid under certain operating conditions. The presence/absence and size of the recirculation region is dependent on the die geometry, bore-to-clad flow rate ratio, and bore-to-clad viscosity ratio. The bore-to-clad flow rate ratio is the key parameter for fixed die geometry and a bore gas. The appearance of the recirculation region leads to a more rapid decrease of both fiber outer and inner surfaces after die swell. The predicted changes in fiber radii are in better agreement with experimental observations than predictions from the one-dimensional thin filament analysis. The potential impact of bore fluid recirculation on membrane formation is discussed.