Pressure Drop CFD Modeling in Spacer-Filled Channels for TFF Ultrafiltration

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Abstract

Membrane-based tangential flow filtration (TFF) cassettes are used for the clarification, concentration and purification of fluid streams containing macromolecules of proteins. In TFF, the protein fluid is pumped tangentially along the surface of the membrane. The feed flow along the length of channel between two membranes causes a pressure drop from the feed to the retentate end of the channel. During concentration of a protein solution, the pressure drop from the feed side to the retentate side of the TFF cassettes increases with the increase of solution viscosity; meanwhile, flux, which is defined by the volume flow normalized for membrane area it passes through, decreases as solution viscosity becomes higher. During concentration of a protein solution, for example, the final concentration is now limited by either the discharge pressure of the pump, or the pressure rating of the cassette or some other component in the system. As a result, it is difficult to obtain high final concentration/viscosity. Channel spacers are commonly used in ultrafiltration to improve mass transfer at the expense of increased pressure drop. In this study, we investigate the pressure drop in spacer-filled channels for TFF ultrafiltration using computational fluid dynamics simulations. Both 2D and 3D models were developed in COMSOL to simulate the effect of screen-like channel spacers. Laminar flow was used in the model and a parametic sweep was performed to simulate the feed channel hydraulics in different concentration/viscosity. A combination of spacer characteristics such as thickness, strand diameter, mesh count etc. was evaluated. In membrane processes such as ultrafiltration, most of the feed are non-newtonian fluids, which have a significant shear thinning effect. The viscous of feed is dependent on temperature, shear rate, etc. A non-newtonian fluid material model was also imported in the simulation to predict the pressure drop along the feed channel.

Figures used in the abstract

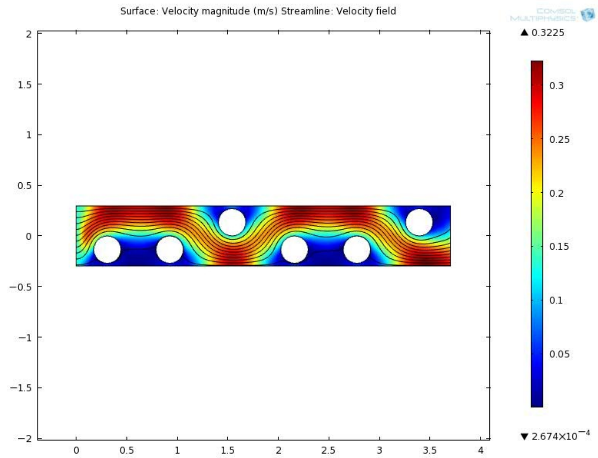

Figure 1: Fluid velocity in feed channel of 2D model.

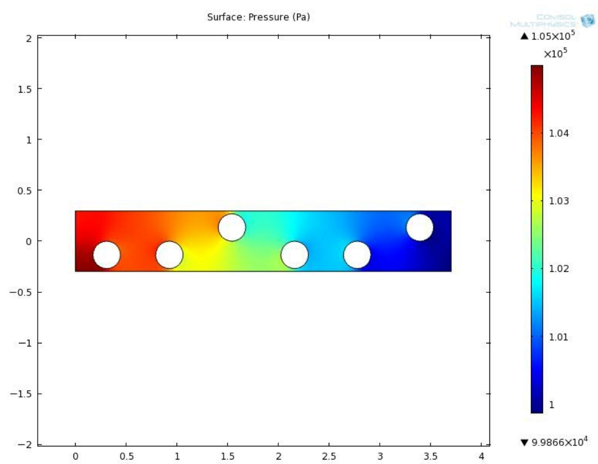

Figure 2: Pressure in feed channel of 2D model.

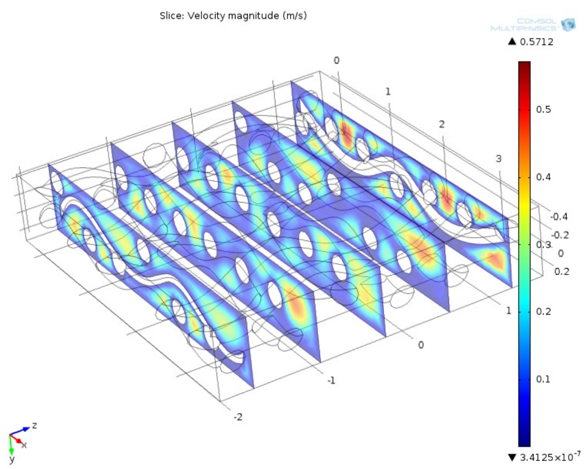

Figure 3: Fluid velocity in feed channel of 3D model.