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Steady State Modeling of Highly Rotating and Viscous Flow using VOF Method for Rotary Glass Fiberization Process

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Abstract **–** Fiberglass is a very commonly used insulation and filtration media material that is manufactured using the rotary glass fiberization process. The spinner used for fiberglass manufacturing is the heart of the manufacturing process and the spinner is subjected to extreme temperatures and centrifugal stresses. It requires usage of special alloys and high precision manufacturing processes as the spinner has thousands of orifice holes. Experimental methods are very expensive, energy-intensive, and unsafe, hence the use of CFD based design and process optimization is very desirable. Numerical modelling involves the resolution of complex multiphase flow physics in a rotating domain having length scales varying from 500 microns to a few meters. The modelling challenges are further augmented due to the high viscosity of the molten glass in the range of 1000 [Poise] at 2000[F], and large centrifugal accelerations in the order of 1000-1500g.

A steady-state, CFD solution methodology is developed for efficiently simulating this process using the Volume-of-Fluid method. The solution developed for this application uses the pseudo-transient method along with several other numerical recipes to increase the solution accuracy and robustness with aggressive pseudo-time step sizes. The proposed modelling approach allows significantly faster solution as compared to a full transient approach. The case studies in this work are presented systematically following a step by step approach by decomposing the complex problem into sub-problems. In the first case study, a two-phase Poiseuille flow is validated for highly viscous fluids. The second case study involves validation of highly rotating and viscous flows in a closed domain. In the final case study, an analytical and numerical analysis is carried out for a representative fiberization spinner model. The free surface profiles, glass film thickness, mass flow rate, and pressure distribution are validated against the analytical solution in the final case study.

Keywords**:** Glass Fiberization, High Viscous Flow, High Rotational Flow, Rotary Spinner, VOF, Pseudo-Transient