Modeling and simulation of polymer melt spinning

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Accurate modeling of polymer melt spinning is of great importance for better design and optimization of fiber-spinning processes. This paper focus on the development of a transient numerical technique for the modeling of non-isothermal melt spinning with and without crystallization. The model equations include familiar mass, momentum and energy balance, non-isothermal Giesekus constitutive equation for viscoelastic stress contribution and Schneider equations [1] for crystallization kinetics. The set of non-linear governing equations is solved by using the DEVSS-G/SUPG finite element method.
The solution technique is built upon previously developed operator splitting and time integration techniques of isothermal die-swell flow [2]. This technique decouples at each time-step the update of the velocity and pressure fields which is given by the solution of a generalized Stokes problem and calculation of polymer microstructure and evolution of the fluid free-surface calculated from the surface kinematics and represented using the elliptic mapping equations developed by Christodoulou and Scriven [3]. We have modified the analysis to include the calculation of temperature field by solution of energy equation and crystallization by solution of Schneider rate equations.

The simulation results are compared with the prediction of previously developed steady-state code [4]. The results to be presented include effect of operating conditions on melt spinning. Also included are the results on the prediction of fiber crystallinity due to both thermal and stress induced crystallization

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