Abstract Submitted
for the DFD09 Meeting of
The American Physical Society

Thermal instabilities in melt spinning of viscoelastic fibers CHUN-FENG ZHOU, SATISH KUMAR, University of Minnesota — Nonisothermal melt spinning of viscoelastic fibers where the viscosity varies in a step-like manner with respect to temperature is studied in this work. A set of one-dimensional equations based on the slender-jet approximation and the upper-convected Maxwell model is used to describe the melt spinning process. The process is characterized by the force required to pull the fiber, the strength of external heating, and the draw ratio, the square of the ratio of the fiber diameter at the spinneret to that at the take-up roller. For low levels of elasticity and sufficiently strong external heating, there can be three pulling forces consistent with the same draw ratio, similar to the Newtonian case studied by Wylie et al. (J. Fluid Mech. 570 (2007) 1-16). For higher levels of elasticity, the process exhibits a draw ratio plateau where the draw ratio hardly changes with the pulling force, reflecting a competition between thermal and elastic effects. As in the Newtonian case, external heating introduces a new instability—termed thermal instability—that is absent in isothermal systems. Linear stability analysis reveals that external heating improves stability for low levels of elasticity, but can worsen stability for higher levels of elasticity, which is again a consequence of the interplay between thermal and elastic effects. The results of the present work demonstrate a possible mechanism through which external heating can stabilize the melt spinning of viscoelastic fibers.

Satish Kumar
University of Minnesota

Date submitted: 03 Aug 2009 Electronic form version 1.4