Abstract Submitted
for the DFD06 Meeting of
The American Physical Society

Stability of creeping Couette flow of a power-law fluid past a deformable solid SCOTT A. ROBERTS, SATISH KUMAR, University of Minnesota — The stability of plane Couette flow of a power-law fluid past a deformable solid of finite thickness is considered in this work. The solid is a neo-Hookean or linear elastic material which is incompressible and impermeable to the fluid, and linear stability analysis is applied in the creeping-flow limit. Four key dimensionless parameters govern the problem: an imposed shear rate, a solid-to-fluid thickness ratio, an interfacial tension, and a power-law index. The neo-Hookean solid exhibits a first normal stress difference, not present in linear elastic solids, which is strongly coupled to the imposed shear rate and the power-law index. For large thickness ratios, $H \gg 1$, the shear rate necessary to induce an instability, γ_{c}, scales as $\gamma_{\mathrm{c}} \sim H^{-1/n}$, where n is the power-law index. This scaling can be understood in terms of a simple balance between viscous shear stresses in the fluid and elastic shear stresses in the solid. For small thickness ratios, shear-thinning has a stabilizing effect, in contrast to what is observed for thick solids. Whereas a shortwave instability is always observed with Newtonian fluids and neo-Hookean solids when interfacial tension is absent, it can be suppressed with power-law fluids for certain values of n. These results are potentially of interest for enhancing mixing in microfluidic devices and understanding the rheology of worm-like micelle solutions.

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Date submitted: 19 Jul 2006 Electronic form version 1.4