Geometric scaling of purely elastic instabilities in viscoelastic Taylor-Couette flow

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The behavior of viscoelastic Taylor-Couette flow, i.e., the flow of, for example, a polymeric liquid between two concentric, rotating cylinders, has been extensively investigated for many years in experiments as well as in theory - not to mention the Newtonian case. In the most simple case of an outer cylinder at rest and a rotating inner cylinder with radii R_1 and R_2, respectively, even at vanishing Taylor number $\mathrm{Ta} = 2\mathrm{Re}^2(R_2 - R_1)/R_1$, the circular Couette (base) flow gets unstable at a critical Weissenberg number $\mathrm{Wi} = \lambda\dot{\gamma}$, the product of polymer relaxation time λ and (critical) shear rate $\dot{\gamma}$. This non-inertial transition to complex, non-trivial flow patterns is purely elastic in its nature. The dimensionless criterion of Pakdel and McKinley [1] characterizes the critical condition for the onset of elastic instabilities and pictures the competition between viscous and (elastic) normal stresses as well as the influence of polymer relaxation length and curvature of the streamlines. We present, to our knowledge, the first experimental, quantitative investigation of the explicit curvature scaling in Taylor-Couette flow by varying the radii of both inner and outer cylinder, while keeping the gap $d = R_2 - R_1$ constant.

Références

1. Gareth H. McKinley, Peyman Pakdel, Alparslan Öztekin, Rheological and geometric scaling of purely elastic flow instabilities, *Journal of Non-Newtonian Fluid Mechanics*, **67**, 19-47 (1996).