# Newtonian and non-Newtonian Films Coating the Outside of a Rotating Cylinder

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A rotating horizontal cylinder partially submerged in a reservoir of fluid pulls out a thin coating film. The pull-out of an axially uniform Newtonian film has been studied analytically and experimentally, and weak elastic effects have been shown analytically to give rise to normal stresses which decrease the film thickness (Ro and Homsy, JNNFM, 1995). Previously, for the partially immersed cylinder, studies of the non-Newtonian strongly elastic case have been limited to experiments only. Following de Ryck and Quéré (Langmuir, 1998) who studied coating of a fiber, we obtain an analytic description of the pull-out of a non-Newtonian fluid subject to strong elastic effects. A nonlinear equation, derived using the lubrication approximation, describes the thickness of the free surface and asymptotic analysis is used to derive an analytic expression for the film thickness. In the strongly elastic case, normal stresses result in a thickening of the film, in agreement with experimental observations but in contrast to their effect in weakly elastic flows.

Elastic instabilities have been studied both experimentally and theoretically in bounded Taylor-Couette flows and in gravity-driven free surface flows. We consider the instability of the free surface in this rotating cylinder flow. A local linear temporal stability analysis using axially sinusoidal perturbations is performed accounting for weak elastic effects at zero Reynolds number. In the Newtonian limit, the film is neutrally stable to small wavenumber perturbations and is stable otherwise. We show that weak elastic effects create an instability to small wavenumber perturbations. The instability is stationary and arises purely as a result of elastic effects.