

SEMINÁRIO DE MECÂNICA

On the multiple solutions of coating and rimming flows on rotating cylinders

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Abstract.

We consider steady solutions of the Stokes equations for the flow of a film of fluid on the outer or inner surface of a cylinder that rotates with its axis perpendicular to the direction of gravity. We find that previously unobserved stable and unstable steady solutions coexist over an intermediate range of rotation rates for sufficiently high values of the Bond number (ratio of gravitational forces relative to surface tension). Furthermore, we compare the results of the Stokes calculations to the classic lubrication models of Pukhnachev (J. Appl. Mech. Tech. Phys., vol 18, 1977, pp. 344–351) and Reisfeld & Bankoff (J. Fluid Mech., vol. 236, 1992, pp. 167–196); an extended lubrication model of Benilov & O'Brien (Phys. Fluids, vol. 17, 2005, 052106) and Evans et al. (Phys. Fluids, vol. 16, 2004, pp. 2742–2756); and a new lubrication approximation formulated using gradient dynamics. We quantify the range of validity of each model and confirm that the gradient-dynamics model is most accurate over the widest range of parameters, but that the new steady solutions are not captured using any of the simplified models because they contain features that can only be described by the full Stokes equations.