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Modeling air-driven flow of a viscous film coating the interior of a rigid, vertical tube[1] REED OGROSKY, University of Wisconsin, ROBERTO CAMASSA, GREG FOREST, JEFFREY OLANDER, University of North Carolina — The upwards, air-driven flow of a viscous fluid film coating the interior of a rigid, vertical tube is studied theoretically and numerically. The free surface of the film develops instabilities due to the interplay between interfacial stress from the airflow and surface tension from azimuthal curvature. Simple closure models for turbulent airflow coupled to long-wave asymptotic models for the liquid film have been shown to reproduce qualitatively the dynamics of the instabilities past initial transients observed in experiments. However, quantitative agreement requires improving the turbulent airflow modeling beyond leading order theories of free surface stress. An attempt in this direction is described here; the resulting model is compared with others in the literature and with experiments, for the case where the free surface is replaced by a rigid, wavy wall. This comparison is made for both wavy pipe and wavy channel flows, and the mean stress is seen to be out of phase with the wavy wall itself by a phase shift dependent on both the Reynolds number and the amplitude of the wall modulations. The free surface model is then studied through linear stability analysis and numerical solutions, both of which show improved agreement with experiments.

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