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MENISCUS CONSTRAINT-CORRECTED VISCOCAPILLARY MODELS OF ROLL COATING

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Coating flows in forward or reverse roll coaters can be simply and for many purposes accurately modeled by one-dimensional viscocapillary models. The success of these models depends heavily on the boundary conditions where the flow splits or liquid films merge, for these conditions greatly affect film thickness predictions. Appropriate boundary conditions can be extracted from rigorous analysis of two-dimensional viscous free surface flow but this approach spoils the simplicity desired for practical applications. A simple and often-used assumption is to neglect viscous stress and to approximate the virtually static meniscus with an arc of circle, which is the basis of the Landau-Levich equation, for example. With this assumption, viscocapillary models of roll coating are accurate only at low capillary number, Ca>~0.01, and fail beyond Ca~0.1.

With a meniscus constraint correction that takes into account gradients of meniscus curvature, we have derived simple boundary conditions. These were used to model film splitting and film merging in forward roll coating and drag-out flow in reverse roll coating. Film thicknesses predicted in this way agree with solutions of the Navier-Stokes system for Newtonian coating liquids even beyond Ca=1.