Flow Separation at a Free Surface: Scenarios that Promote Liquid Jetting

Alberto Goenaga and Brian G. Higgins
Department of Chemical Engineering and Materials Science
University of California
Davis CA 95616, USA

Presented at the 16th International Coating Science and Technology Symposium,
September 9-12, 2012, Midtown Atlanta, GA[1]

Coating flows are known to develop regions of high curvature when the interface is subject to a combination of viscous/pressure and capillary forces that produce large surface deformations locally. A well-known example is the cusp-like interface that develops when a liquid film on a rotating cylinder is dragged into a reservoir of similar liquid. At a critical capillary number air is entrained or "jetted" into the liquid at the cusp location. In this presentation we examine the possible mechanisms for "liquid jetting" at a gas-liquid or liquid-liquid interfaces.

In our analysis we exploit the principle that the global streamline pattern of a flow can be deduced from a local analysis of the flow behavior at a stagnation point. We use normal form transformations to construct a polynomial expansion of the stream function in the proximity of degenerate critical points, and thereby study how streamline patterns and their bifurcations evolve as flow parameters are varied. In this way we construct possible flow scenarios that show the onset of liquid jetting at the gas-liquid or liquid-liquid interfaces. The implication for coating flows is discussed.