The Dynamics of Three-Dimensional Liquid Bridges with Pinned and Moving Contact Lines

S. Dodds*, M. S. Carvalho+, and S. Kumar*
*Department of Chemical Engineering & Materials Science,
University of Minnesota, Minneapolis, MN 55455;
+Department of Mechanical Engineering, PUC-Rio, Rio de Janeiro, 22453-900, Brazil

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

Liquid bridges with moving contact lines are relevant in a variety of natural and industrial settings, ranging from printing processes to the feeding of birds. While it is often assumed that the liquid bridge is two-dimensional in nature, there are many applications where either the stretching motion or the presence of a feature on a bounding surface lead to three-dimensional effects. To investigate this we solve Stokes equations using the finite element method for the stretching of a three-dimensional liquid bridge between two flat surfaces, one stationary and one moving. We first consider an initially cylindrical liquid bridge that is stretched using either a combination of extension and shear or extension and rotation, while keeping the contact lines pinned in place. We find that whereas a shearing motion does not alter the distribution of liquid between the two plates, rotation leads to an increase in the amount of liquid resting on the stationary plate as breakup is approached. This suggests that a relative rotation of one surface can be used to improve liquid transfer to the other surface. We then consider the extension of non-cylindrical bridges with moving contact lines. We find that dynamic wetting, characterized through a contact line friction parameter, plays a key role in preventing the contact line from deviating significantly from its original shape as breakup is approached. By adjusting the friction on both plates it is possible to drastically improve the amount of liquid transferred to one surface while maintaining the fidelity of the liquid pattern.

[1] Unpublished. ISCST shall not be responsible for statements or opinions contained in papers or printed in its publications.