RECENT RESULTS ON NONCOALESCING AND NONWETTING SYSTEMS

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Summary Recent results from laboratory and numerical experiments on noncoalescing and nonwetting systems will be presented. Of specific interest are aspects of nonwetting systems of importance to their ultimate use as "frictionless" bearings in low-load applications.

INTRODUCTION

Permanent noncoalescence and nonwetting are driven through the imposition of relative, tangential surface motion between the liquid-liquid or liquid-solid surfaces of interest. This is accomplished either through the forced motion of one of the surfaces or through the use of thermocapillarity to drive the motion. The relative motion serves to drag surrounding air into the gap between the surfaces to form a lubrication layer. We have found through experimentation and theoretical computation that such lubricating films are able to sustain reasonably large loads. Consequently, we have proposed the use of such systems for use as virtually frictionless bearings in low-load applications.

Current efforts are focused on two fronts: 1) quantifying the degree to which nonwetting systems are indeed "frictionless"; and 2) identifying the conditions under which the application of a load causes the lubricating film, and hence the "bearing" to fail. Both of these issues are important to the eventual development of applications for noncoalescing and nonwetting systems.

Measurement of sliding friction of isothermal nonwetting droplets

An apparatus has been built to create an isothermal nonwetting situation and measure the friction in the lubricating film between a drop and the moving solid surface adjacent to it. The surface consists of a rotating disk coated with a transparent metallic coating to permit the surface to be grounded electrically (to prevent static-charge-induced wetting as discussed below). A droplet is suspended from a cantilever and pressed against the rotating disk without wetting it. The deflection of the calibrated cantilever, measured using Michelson interferometry, is used to determine the total load applied to the cantilever/droplet configuration. Figure 1 shows a schematic of the idea.

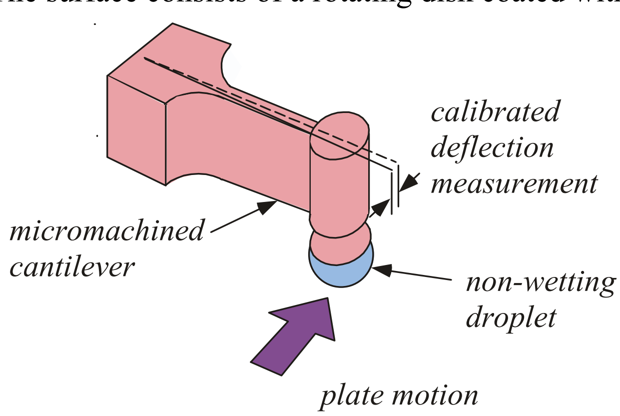

Figure 1. Schematic for non-wetting friction measurement.

One of the difficulties in making this measurement is distinguishing between the frictional force in the lubricating film between the droplet and disk and the aerodynamic drag force exerted upon the droplet/support structure due to the flow dragged by the rotating disk. To minimize this force, the use of shrouds of various shapes is being examined computationally to determine the optimum configuration and positioning to permit the friction measurement. The results of these computation and preliminary results from the experiments will both be discussed during the presentation.

Failure modes for nonwetting droplets

For a nonwetting droplet to function as a bearing, the system must designed in such a manner that the range of operating conditions will avoid conditions known to lead to failure of the lubricating gas film or the contact line holding the droplet to its underlying surface. With respect to film failure, we have observed two types in our experiments with thermocapillary-nonwetting droplets. The first type, with the solid surface electrically grounded, appears to be due to a shape instability of the film that occurs as the droplet is squeezed more firmly against the surface. Failure is initiated at one point on the droplet periphery, where the film is thinnest, and proceeds across the droplet. The second type of failure is seen when the nonwetted surface is electrically charged. In this case, the droplet failure is initiated in the droplet center, where the film is thickest, and proceeds axisymmetrically outward. Both these cases are shown in Figure 2.

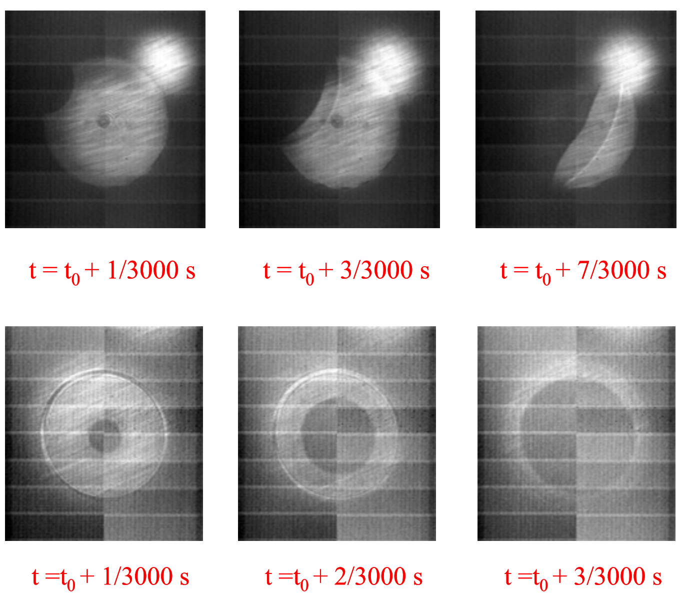

Figure 2. Time sequences of film rupture of thermocapillary nonwetting droplets in the cases of (top) grounded and (bottom) charged surfaces.

The droplets used in our experiments are attached to sharp-edged supports and pinned to this edge by the contact line. Another mode of failure for a nonwetting droplet occurs when this contact line is non longer capable of holding the droplet to its support. Experiments that demonstrate this failure will also be discussed.

Acknowledgment

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