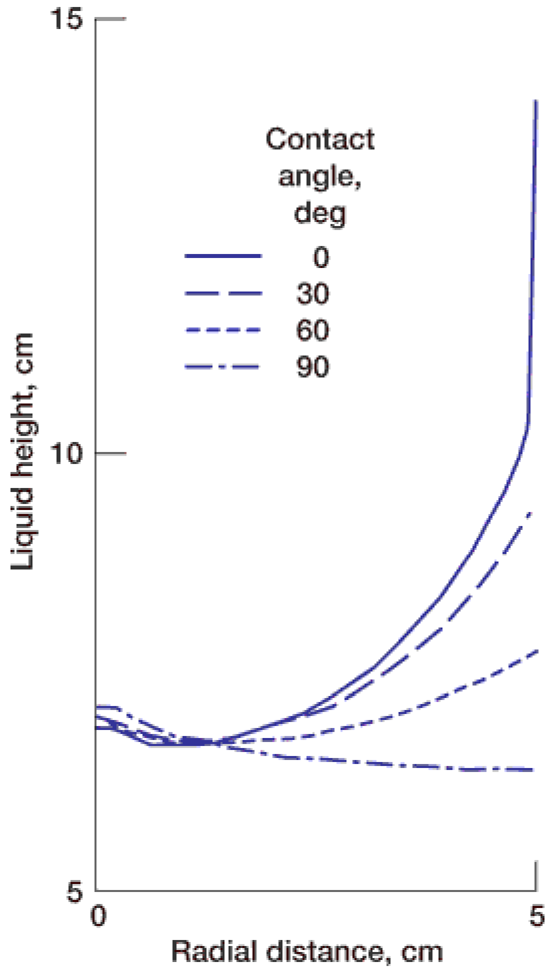
Contact Angle Influence on Geysering Jets in Microgravity Investigated

Microgravity poses many challenges to the designer of spacecraft tanks. Chief among these are the lack of phase separation and the need to supply vapor-free liquid or liquid-free vapor to the spacecraft processes that require fluid. One of the principal problems of phase separation is the creation of liquid jets. A jet can be created by liquid filling, settling of the fluid to one end of the tank, or even closing a valve to stop the liquid flow. Anyone who has seen a fountain knows that jets occur in normal gravity also. However, in normal gravity, the gravity controls and restricts the jet flow. In microgravity, with gravity largely absent, surface tension forces must be used to contain jets.

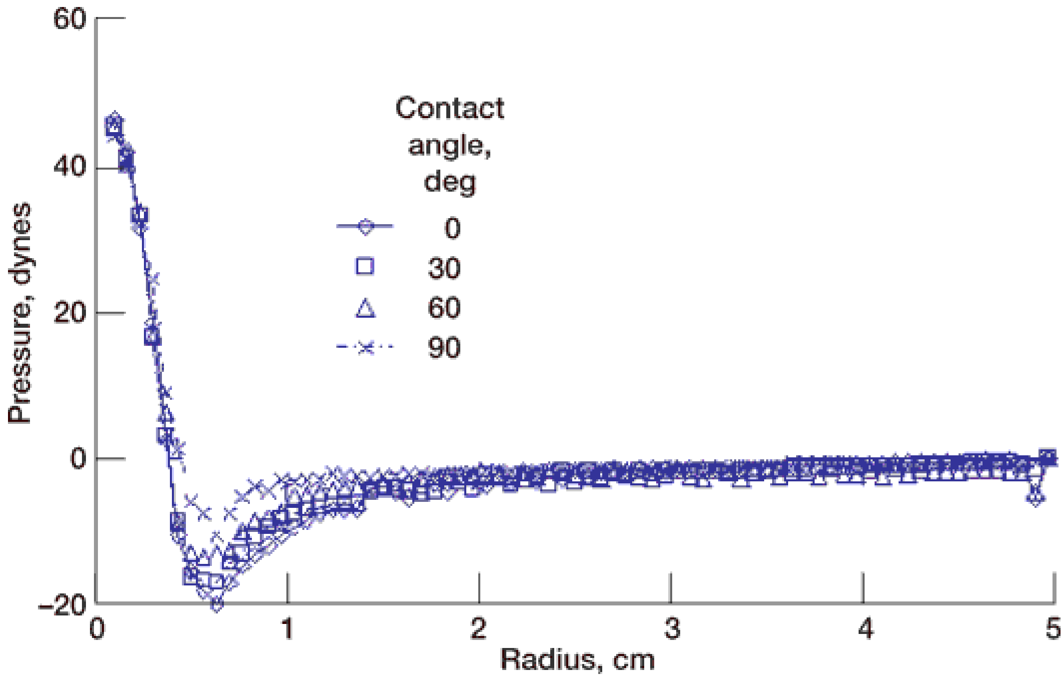
To model this phenomenon, a numerical method that tracks the fluid motion and the surface tension forces is required. Jacqmin (ref. 1) has developed a phase model that converts the discrete surface tension force into a barrier function that peaks at the free surface and decays rapidly away. Previous attempts at this formulation were criticized for smearing the interface. This can be overcome by sharpening the phase function, double gridding the fluid function, and using a higher-order solution for the fluid function. The solution of this equation can be rewritten as two coupled Poisson equations that also include the velocity.



Comparison of free surface shape as a function of contact angle.

Long description. Free surface shapes caused by a 17cm/sec liquid jet striking the free surface for wall contact angles ranging from 0° to 90° in a 5-cm-diameter flat-ended cylinder for a liquid assumed to have all the properties of ethanol except its contact angle.

Using this code, researchers at the NASA Glenn Research Center investigated the effect of changing the wall contact angle. This value can be changed with a single input into the code. It is of interest because it varies greatly in the liquids used in spacecraft (water, 60°; cryogens, 0°). It also gives a range of free-surface forces (90°, no force, 0°, maximum force.) This change enables us to study how changes in the equilibrium shape, without changes in the jet, influence the final geyser shape. The preceding graph compares the shapes. The following graph shows the free-surface pressures for each of these runs. Although the preceding graph shows that the free-surface shapes are different, the forces acting from the free surface seem to be quite similar.



Pressure at the free surface as a function of contact angle.

Long description. Pressure forces at the free surface from the free surface shapes shown in the preceding graph.

Reference

1. Jacqmin, David: Calculation of Two-Phase Navier-Stokes Flows Using Phase-Field Modeling. J. Comput. Phys., vol. 155, no. 1, 1999, pp. 96-127.

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