Experimental Evaluation of a Film Separation Criterion

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Abstract

The dynamics of thin liquid films that develop on a solid surface and are driven by an adjacent gas flow have many engineering applications including liquid atomizer systems, refrigerant flows in evaporators, internal combustion engines, and demisters. However, details of the interaction between inertial, surface tension, and gravitational forces that affect the behavior of these shear-driven thin liquid films at a sharp, expanding corner are not clear. Recent work analyzed these forces to propose a film separation criterion in the form of a force ratio, which predicts the onset of film separation from the surface at the corner. The force ratio is calculated using the gas phase and liquid film flow conditions, including the average film thickness and velocity at the corner. In this study, the force ratio separation criterion is evaluated using experimental film separation measurements for a wide range of flow conditions. The experimental facility is described in detail, including the method for measuring the mass percent of separated film, and the laser focus displacement (LFD) instrument used for measuring film thickness. The advantages and limitations of using the LFD instrument are discussed, including the maximum measurable film surface angle when using this technique. Results are presented for film thickness and velocity, where film thickness is measured across the width of the film located at the corner, and average film velocities are inferred from liquid mass conservation. The force ratio is then calculated using the experimentally determined flow parameters, and the film separation criterion is evaluated by comparing the calculated force ratio to the measured mass fraction of film separation. In addition, the experiments are performed for several fluids in order to investigate the effects of viscosity and surface tension on the film separation process. The force ratio separation criterion successfully predicts the onset of separation and provides a good correlation to the fraction of film mass separated at higher separated fractions for fluids with varying surface tension and film viscosity.

Key words: shear-driven film, film separation, laser focus displacement instrument

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