Abstract

Masters of Engineering Degree (Mechanical)

Project Title: Liquid Drop Falling Through a Quiescent Gas at Terminal Velocity

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Abstract:

The multiphase phenomenon of a liquid droplet falling through a quiescent gas (e.g., modeling the behavior of rain droplets) was investigated using a volume of fluid (VOF) numerical model with a geometric transport modification. Specifically, the computational code NGA, developed by Prof. Desjardins' lab, was implemented to validate the code's ability to predict drop behavior. Generally, discrete liquid droplets falling in a continuous gas can range in diameter from 1 μm to 7 mm. A significant challenge when simulating this type of flow, particularly for larger drops undergoing break-up, is tracking the phase interface accurately. The transient behavior of a 0.5 mm droplet, characterized by dimensionless Reynolds and Weber numbers of 10 and 0.01, respectively, was investigated. Two and three-dimensional simulations were completed of the drop falling within a moving reference frame; a steady wake developed and the droplet showed no significant deformation, as was expected. The terminal velocity of the three-dimensional droplet model agreed fairly well with experimental predictions. It was determined that for this VOF model to be able to compute the drop's behavior accurately, the following requirements must be met. First, the curvature of the liquid/gaseous interface should be computed robustly at all cells containing the interface, particularly for those cells that contain liquid with interface normal misaligned with respect to the mesh coordinate axes. Additionally, the time-step should be selected such that viscous CFL values are relatively low, ensuring the viscous dynamics have adequate temporal accuracy. Finally, fully three-dimensional simulations are required to capture the "three-dimensional relieving effect" and prevent the velocity fluctuations observed in two dimensions. This relieving effect is due to permissibility of lateral flow in three dimensions, which relieves the 2D constraints.