Spray Formation from Homogeneous Flash-Boiling Liquid Jets

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Abstract

Systems including flow injection processes that use a variety of injection methods are currently in use in many fields. These systems are widespread in internal combustion engines, painting and coating processes, cooling processes, and more. The injection methods are based upon breaking up the jet stream by creating or increasing the forces that destabilize it and allow it to become a spray containing tiny drops. The spray may be characterized by such criteria as angle, distance necessary to break up the jet stream of the liquid, average drop size and size distribution. Different applications require different spray criteria. One of the most common current injection methods is breaking up the liquid jet by dissolving an additional material into the injected material so that the vapor pressure from the added material is higher than that of the liquid. This propellant undergoes an extremely rapid boiling process (flash-boiling) during injection, due to a sudden drop in pressure. As a result of the boiling process, a large amount vapor nucleons forms and develops into bubbles within the liquid; these bubbles destabilize the liquid jet and cause its relatively rapid and even break-up into tiny drops. Most of the studies carried out in this field to date have used a system that consists of an inlet orifice, an expansion chamber and a discharge orifice. Nucleation occurs on the walls of the inlet orifice (heterogeneous nucleation) and the bubbles grow in the expansion chamber. The aim of this study is to experimentally examine the characteristics of an emerging jet that undergoes homogeneous nucleation when it emerges through a single orifice. In this study, we first explored the border between heterogeneous and homogeneous regimes of boiling by conducting a series of experiments using water. The water was heated to nearly critical temperatures, under high enough pressure so that the water remained in a liquid state. The heated water was injected through an orifice into the surrounding area. By observing the different flow regimes resulting from a range of temperatures and injection pressures, the borderline between the different boiling regimes was determined. After analyzing the borderline, we conducted an additional series of experiments, with the aim of characterizing the break-up of the jet using the homogeneous boiling regime. Here, too, by changing temperatures and injection pressures in the range appropriate for homogeneous boiling, we observed the influence of these parameters on the angle of the spray and the distance required to break up the jet. Our observations indicate significant differences in the characteristics of the emerging jet between the two boiling regimes, and the factors that affect the spray angle and the break-up distance in water jets undergoing homogeneous nucleation have been identified.

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