High-Speed Internal Nozzle Flow Visualization of Flashing Jets

Henry Vu and Guillermo Aguilar*
Department of Mechanical Engineering
University of California-Riverside
Riverside, CA 92521 USA

Abstract

Flashing or thermodynamic breakup of a liquid jets occurs when a pressurized, subcooled or saturated liquid is released to a lower pressure, resulting in violent vapor nucleation, expansion, and breakup of the liquid phase. Flashing is known to produce very fine droplet atomization, often not possible by other means. Despite its usefulness as an atomization method, the fundamental processes involved in flashing remain poorly understood. This has limited its applicability due to a lack of control of spray characteristics. In a previous study, several new flashing breakup modes emanating from vertically downward-oriented long tube nozzles were discovered through high-speed imaging and depended on the level of superheat. Breakup mode and frequency appeared to be highly dependent on the state of two-phase internal flow within the nozzle.

In this study, internal flow phenomena during flashing were observed using transparent glass tube nozzles of 0.6 mm and 1.2 mm ID. These nozzles allowed for imaging of the developing internal two-phase flow with a high-speed video camera set at 25000 fps. Water was used as the working fluid and was preheated and pressurized at saturation conditions within a sample cylinder prior to release through the nozzle to the atmosphere. Gravitational effects were also studied by orienting the nozzle vertically upward, vertically downward, and horizontally. Internal flow phenomena were then related to observed external jet breakup characteristics emanating from stainless steel tube nozzles with similar surface roughness.

Results reveal that the bubble nucleation process is often unstable and unpredictable. Nucleation tends to occur near the nozzle exit due to the superheat required from wall frictional pressure drop. Due to wall confinement effects, narrower nozzles require higher superheat to initiate boiling. Buoyancy effects also appear to influence nucleation characteristics, as downward facing nozzles exhibit the most unstable behavior.

Key words: flashing sprays, atomization, internal flow

*Corresponding author, gaguilar@engr.ucr.edu