IOWA STATE UNIVERSITY
Department of Mechanical Engineering

Early Spray Development at High Pressure: Hole, Ligament, and Bridge Formations

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in Alliant Energy-Lee Liu Auditorium, Howe Hall
Seminar host: Song-Charng Kong

Abstract

Three-dimensional temporal instabilities, leading to spray formation, of a round liquid jet segment with co-axial gas flow at high pressure are studied by Navier-Stokes and level-set computations. Post-processing demonstrates a strong relation between surface wave dynamics and vorticity dynamics; in fact, a duality of the character is found. Liquid-surface shape shows the development of smaller structures on the conical wave crests, i.e., lobes, holes, bridges, and ligaments. The gas-to-liquid density ratio, liquid Reynolds number (Re), and liquid Weber number range between 0.05 to 0.9, 320 to 5000, and 2000 to 230,000, respectively. At higher Re, lobes are longer and curve more at the crest edge with a regular formation of holes. The crest rims eventually tear, transforming the crest rims to ligaments. At higher gas densities throughout the Re range, the lobes are regular but shorter. The holes merge before the rims break to form ligaments. Consequently, liquid formations with both rim bridges and middle bridges are more common in this domain. In cases where both gas density and Re are lower, the well-ordered lobes are replaced by a more irregular corrugation with more wrinkles along the conical wave crest edge. Ligaments stretch from the lobes before holes form. The more viscous crests are thicker here explaining a delay in hole formation; still, the ligament extension is driven by pressure gradient rather than shear at the gas-liquid interface. In all cases, hole formation is correlated with hairpin and helical vortices; the perforations correlate with resulting fluid motion. Qualitative agreements with experiments are very good.

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