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On the Prospect of Rapid Heating for Inducing Flash Boiling Atomization

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Abstract

Flash-boiling atomization is one of the most efficient means for generating a fine spray, during which a violent phase change occurs. Due to the complexity of such rapid heat and mass transport process, the method's potential has not been fully realized. Traditionally, high superheat conditions are reached through sudden pressure drop in the liquid phase. The present work proposes and theoretically examines a different method for spray generation employing the flash boiling mechanism, where the liquid is subjected to intense volumetric radiation.

We consider a mixed regime where both heterogeneous and homogeneous nucleation may occur and evaluate the bubbles' nucleation rate, the bubbles' growth rate, and their size at burst time as a plausible sign of the droplets' size. The influence of the heating rate, system heterogeneity, and the liquid's thermodynamic properties on the rapid boiling process is studied. We analyze the conditions necessary to induce a large number of tiny droplets and assess the applicability of the proposed mechanism for generating fine spray.

Our results suggest that intensive radiation of the liquid might induce homogeneous nucleation in cases where the liquid is heated such that the heating time is much shorter than the growth time of the heterogeneously nucleated bubbles. An increase in the heating power leads to a significant decrease in the bubbles' mean diameter, thus contributing to the refinement of the generated droplets. The atomization process efficiency shows a complex behavior; it is limited to roughly 0.05% when homogeneous nucleation is dominant, whereas for systems where heterogeneous boiling is the dominant regime it aspires to much smaller values.

Keywords
Flash-Boiling, Intensive Radiation, Atomization

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