A Photographic Study on Flow Boiling of R-134a in a Vertical Channel

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Abstract

The behavior of near-wall bubbles in subcooled flow boiling has been investigated photographically for R134a flow in vertical, one-side heated and rectangular channels at mass fluxes of 0, 190, 1000 and 2000 kg/m^2s and inlet subcooling condition of 8 °C under 7 bar(Tsat 27 °C). Digital photographic techniques and high-speed camera are used for the visualization, which have significantly advanced for recent decades. Primary attention is given to the bubble coalescence phenomena and the structure of the near-wall bubble layer. At subcooled and low-quality conditions, discrete attached bubbles, sliding bubbles, small coalesced bubbles and large coalesced bubbles or vapor clots are observed on the heated surface as the heat flux is increased from a low value. Particularly in beginning of vapor formation, vapor remnants below discrete bubble on the heating surface are clearly observed. Nucleation site density increases with the increases in heat flux and channel-averaged enthalpy, while discrete bubbles coalesce and form large bubbles, resulting in large vapor clots. Waves formed on the surface of the vapor clots are closely related to Helmholtz instability. At CHF occurrence it is also observed that wall bubble layer beneath large vapor clots is removed and large film boiling occurs. Through the present visual test, it is observed that wall bubble layer begins to develop with the onset of nucleate boiling(ONB) and to extinguish with the occurrence of the CHF. It could be considered that this layer made an important role of CHF mechanism macroscopically. However, there may be another structure beneath wall bubbles which supplies specific information on CHF from viewpoint of microstructure based upon the observation of the liquid sublayer beneath coalesced bubbles. Through this microscopic visualization, it may be suggested that the following flow structures characterize the flow boiling phenomena : (a) vapor remnants as a continuous source of bubbles, (b) liquid sublayer depleted with bubble formation if there is not new supply of liquid, and (c) vapor clot as an obstructer blanketing liquid supply to sublayer in high heat flux.