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ANALYSIS ON EFFECT OF SURFACTANT CONCENTRATION ON SATURATED FLOW BOILING AND POOL & FLOW BOILING IN NARROW GAPS

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Analysis on Effect of Surfactant Concentration on Saturated Flow Boiling and Pool & Flow Boiling In Narrow Gaps

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Abstract – This paper presents the effects of superheat based on heat transfer models in a narrow gap. At low superheat conditions, heat flux in a narrow gap is higher than heat flux in .33/0 8 pool nucleate boiling due to the restricted flow area and a high disturbance, approaches the nucleate boiling heat flux as superheat increasing, and reaches a critical value due to CCFL (counter-current flow limiting). Saturated flow boiling of environmentally acceptable nonionic surfactant solutions of Alkyl (8–16) was compared to that of pure water. The concentration of surfactant solutions was in the range of 100–1000 ppm. The liquid flowed in an annular gap of 2.5 and 4.4 mm between two vertical tubes.

Keywords: Saturated Flow, Pool & Flow Boiling In Narrow Gaps

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INTRODUCTION

In course of the TMI-2 accident [1], high temperature core debris drained into the RPV lower plenum and the lower plenum wall was heated to about 1400 K. At this time, the lower plenum wall cooled down rapidly and the vessel integrity was preserved. At a severe accident in a LWR such as the TMI-2 accident, heat transfer models in a narrow annular gap between the overheated core debris and the RPV wall are important to evaluate integrity of the RPV and emergency procedures. Many experiments on gap cooling have been performed [2-7] and heat transfer models were proposed as gap cooling CHF. However, these experiments were performed at low superheat conditions and the CHF correlation did not include effects of superheat because CHF greatly depends on counter-current flow limiting (CCFL) at the top end of the narrow gap. Ohtake et al. [8] measured heat fluxes vs. superheat without CCFL conditions (large gap), and Henry & Hammersley [9] measured temperature trends under CCFL conditions at high superheat in quenching tests at high surface temperature. In these studies, however, local heat transfer and CHF correlations were not derived.

REVIEW OF LITERATURE:

Heat transfer studies of single miniature channels, as well as the analysis and inverse calculation of IR images of a heated microgap channel wall, are used to identify the existence of a characteristic M-shaped heat transfer coefficient variation with quality (or superficial velocity), with inflection points corresponding to transitions in the two-phase cooling modalities. For the high-quality, Annular flow conditions, the venerable Chen correlation is shown to yield predictive agreement for microgap channels that is comparable to that attained for macro channels and to provide a mechanistic context for the thermal transport rates attained in microgap channels. Results obtained from infrared imaging, revealing previously undetected, large surface temperature variations in annular flow, are also reviewed and related to the termination of the favorable thin-film evaporation mode in such channels.

Consequences of surfactant attentiveness on saturated flow boiling:

Kaminaga et al. (2000) [11] conducted an experiment on boiling heat transfer in small tubes of 1.45 and 2.8 mm with water under natural circulation condition. They observed that when the tube diameter was less than the Laplace constant the heat transfer coefficient was much higher than the conventional pool boiling. Sumith et al. (2003) [12]studied the characteristics of flow boiling heat transfer in a vertical tube of 1.45 mm diameter, which is less than the Laplace constant. Heat transfer coefficients were measured in the range of mass fluxes from 23.4 to 152.7 kg/m2 s, heat fluxes from 10 to 715 kW/m2. Large heat transfer enhancement was observed. The dominant flow pattern in the tube was a slug-annular or an annular flow, and then liquid film evaporation was found to dominate the heat transfer. Jacobi and Thome (2002) demonstrate that transient evaporation of the thin liquid films surrounding elongated bubbles is the dominant heat transfer mechanism in micro channels, not nucleate boiling. Thome et al. (2004) [13] cited the following classification of the transition from macro scale to micro scale based on the hydraulic diameter: microchannels (1–100 lm), mesochannels (100 lm–1 mm), macro channels (1–6 mm) and conventional channels (>6 mm). They noted that such transition criteria do not reflect the influence of channel size on the physical heat transfer mechanism. Therefore the authors suggest that the best threshold criterion is that the bubble growth is confined by the channel, such the bubbles grow in length rather than in diameter.

Resemblance and dissimilarity flanked by flow Boiling in Micro channels and Pool Boiling:

The heat transfer mechanism in the two processes has much similarity through transient conduction, micro convection, and micro layer evaporation playing similar roles in both. The necessary difference between the two processes appears from the presence of strong inactivity forces in the bulk flow and the large shear stress present at the wall. These forces affect the nucleation and other flow distinctiveness directly. Heat transfer processes are also affected [15].

CONCLUSION:

In this paper we found that saturated water flow boiling the mass flux did not affect the behavior of the boiling curve. Addition of small amount of surfactant to water changes the boiling curve drastically. At the same value of heat flux the temperature difference (Tw TS) for boiling of surfactant solution is significantly smaller than that for pure water while pool boiling has been widely investigated in nuclear power plants for potential application to the design of new passive heat removal systems employed in Advanced Light Water Reactors (ALWRs) designs [14]

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