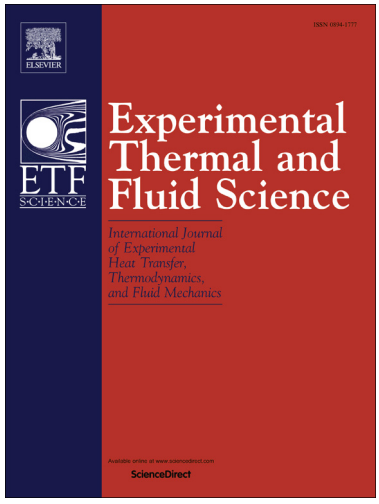

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Transition between nucleate and film boiling in rapid transient heating

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Abstract

This article presents an experimental study of rapid transient boiling regimes of distilled water at saturation on a thin tungsten wire of 50 μm diameter. The heating rate varied from $\sim$0.5 to 5 10^5 K/s. Heat supply was obtained by periodic pulses of constant voltage with a period large enough to avoid response overlap . Rapid video recording (14000 fps) was associated with electrical measurements. Two transient phenomena were studied: pulse heating and thermal relaxation . During pulse heating, it was observed that, depending on heating rate, three kinds of behavior exist: (i) only nucleate boiling appears for small heating rates ($\lesssim 10^5$ K/s), (ii) transition from nucleate boiling to film boiling by bubble coalescence at intermediate heating rates ($\lesssim 2.10^5$ K/s), and (iii), at higher heating rates, transition to film boiling by vapor wave propagation (speed $\sim$20 m/s). This last mechanism is interpreted as homogeneous nucleation process and is qualitatively similar to an autowave process. In the relaxation stage, it is observed that film collapse is characterized by two mechanisms: film break up into nucleate boiling regime or continuous vapor receding. This second mechanism is compared to a conduction model of a temperature traveling wave in the wire. The time variation of the vapor film length predicted by the model is in the range of the experimental data.

Keywords: Transient boiling, Critical Heat Flux, Film boiling, Nucleation, Rewetting

1. Introduction

Boiling heat transfer is widely encountered in industrial and energy processes. It is generally considered as a benefit, as it leads to much higher heat transfer coefficient than in case of single-phase; its main drawback concerns what is called the boiling crisis, as it can lead to severe damages in heat exchangers. Abundant literature exists concerning the case of steady boiling conditions.

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