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Heat transfer and enhancement analyses of flow boiling for R417A and R22

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ABSTRACT

The experimental study on heat transfer of R417A and R22 flow boiling inside a horizontal smooth and two internally grooved tubes with different geometrical parameters was conducted. Based on the experimental results, evaporation heat transfer characteristics of R417A and R22 flowing in different tubes, the influence of micro-fin geometrical parameters, vapor quality and mass flux of refrigerants on heat transfer enhancement factors, and the difference of enhancement factors between R417A and R22 were analyzed and discussed. The result indicates: whether for R22 or for R417A, the enhancement effect of Tube III having the narrower distance between micro-fins excels than Tube II. The influence of vapor qualities and mass fluxes on enhancement factors for R417A is different from R22. And the difference of enhancement factors between R417A and R22 appears different cases at different vapor quality regions.

1. Introduction

In recent years, for the need of substituting for HCFCs, there are many non-azeotropic or near-azeotropic refrigerant mixtures to be developed, the heat transfer performance of refrigerant mixtures is very different from the pure refrigerants during phase change due to a number of factors, such as the variable temperature characteristic, an obvious change in physical properties with composition, the concentration gradient near the interface, and mass transfer resistance. So the phase change heat transfer of refrigerant mixtures has become a research hotspot in refrigeration and air conditioning fields, evaporation heat transfer process occurring in evaporator determines the performance of the whole system directly, so the study on flow boiling heat transfer for refrigerant mixtures is given particular concern.

In contrast with pure and azeotropic refrigerant mixtures, the heat transfer degradation occurs during the flow boiling of non-azeotropic refrigerant mixtures, and many kinds of tubes with enhanced surface have been developed to ameliorate this heat transfer degradation. A comprehensive survey of flow boiling in enhanced tubes was published and the fundamental for the different types of enhancements was discussed by Thome [1]. Special emphasis is laid on micro-fin tubes, which seem to represent the most promising enhancement technique. One of the earliest papers on micro-fin tubes was published by Ito et al. [2], they varied both the spiral angle and the fin height, but kept the same general shape of fins, for R22 they found an optimum spiral angel of 10°. Heat transfer performance during evaporation and condensation of R22 in horizontal tubes with a lot of spiral fins were examined by Ishikawa et al. [3], the relation between the heat transfer performance and the number of fins was discussed in terms of the inner surface area enhancement. Experimental tests using R22 were conducted to measure the condensation and vaporization coefficient inside a given micro-fin tube by Del Col et al. [4], a key objective of this work is to define the contribution made by nucleate boiling to the micro-fin tube evaporation performance. Yoshida et al. [5] experimentally measured local evaporation coefficients of R22 on the top, side and bottom of the tube. They conclude that the narrow grooves carry liquid to the sides and top of the tube by capillary wetting. Thus, thin films are provided around the entire tube circumference. Low heat transfer coefficients exist on the top and sides of the plain tube at low mass velocity, because the tube surface is dry. The in-tube evaporative heat transfer of R134a was examined for a smooth and five micro-fin tubes by Oh et al. [6], the effect of the spiral angle of micro-fin tubes was investigated to determine the optimal spiral angle, and the optimal spiral angle was found to be mainly dependent on the mass flux.

However there are many difficulties in theoretical analysis on heat transfer and its enhancement for refrigerant mixtures because of the complexity of flow boiling heat transfer mechanism, the especial properties of non-azeotropic refrigerant mixtures and the influence of micro-fin parameters, so this problem is basically on a stage of experimental study at present. A number of experimental studies on flow boiling heat transfer and its enhancement for refrigerant mixtures in diversified tubes were conducted, and evaporation heat transfer and its enhancement characteristics for refrigerant mixtures were analyzed and discussed. Lallemand

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