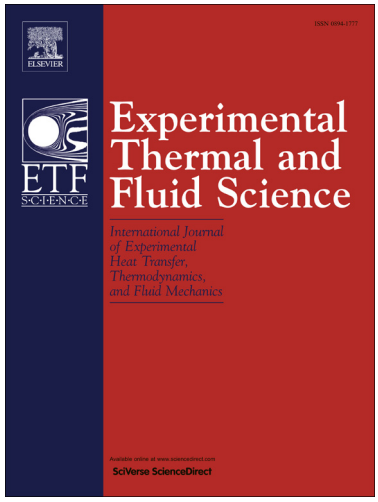

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Visualization study on nucleate pool boiling of ethane, isobutane and their binary mixtures

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Abstract

Visualization experiments were carried out to investigate the nucleate pool boiling heat transfer characteristics of ethane, isobutane and their binary mixtures on a horizontal flat surface. Extensive experimental heat transfer coefficient data were obtained under various pressures of 0.1 MPa, 0.3 MPa and 0.5 MPa for pure substances and 0.3 MPa for mixtures. The measurements were performed under heat fluxes from 20 kW/m^2 to 150 kW/m^2 at a descending heat flux procedure. For binary mixtures, the pool boiling data were measured covering the whole concentration range. Obvious heat transfer coefficient reduction for mixtures was found. Various empirical correlations were screened out for comparison. The accuracy for those correlations varied considerably with mixture concentrations and measurement conditions. The bubble departure diameter and frequency for pure substances and mixtures were also carefully observed. Increasing heat flux can obviously increase the bubble departure diameter and frequency for both pure refrigerants and mixtures. But the mixture effect shows none-linear influence on the bubble size and departure frequency, which varies distinctly with mixture concentrations.

Key words: Nucleate pool boiling; ethane/isobutane; mixtures; visualization; bubble behaviors

1. Introduction

Because of ozone-layer depletion and global warming effects, the synthetic chlorofluorocarbons (CFCs) refrigerants have been phased out, while hydrochlorofluorocarbons (HCFCs) refrigerants have been scheduled to be phased out by the year of 2030. More efforts have been made to seek for the environmental friendly refrigerants in the field of refrigeration and air-conditioning industry in the past years. As a kind of natural substances, hydrocarbons are generally regarded as possible alternatives to such CFCs and HCFCs refrigerants. For instance, isobutane (R600a) is generally accepted for using in the domestic fridges as an alternative to R12, especially in Asia and Europe [1, 2]. Ethane (R170) can be used in the low-temperature stage in a two-stage cascade refrigeration system for applications at temperatures around 190 K to substitute for R13. R170 can also be used as a key component to compose cascade system mixed refrigerants with R116 or R23 [3, 4].