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Flow boiling heat transfer of R134a in the multiport minichannel heat exchangers

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ABSTRACT

The flow boiling heat transfer characteristics of R134a in the multiport minichannel heat exchangers are presented. The heat exchanger was designed as the counter flow tube-in-tube heat exchanger with refrigerant flowing in the inner tube and hot water in the gap between the outer and inner tubes. Two inner tubes were made from extruded multiport aluminium with the internal hydraulic diameter of 1.1 mm for 14 numbers of channels and 1.2 mm for eight numbers of channels. The outer surface areas of two inner test sections are 5979 mm^2 and 6171 m^2, while the inner surface areas are 13,545 mm^2 and 8856 mm^2 for 14 and eight numbers of channels, respectively. The outer tube of heat exchanger was made from circular acrylic tube with an internal hydraulic diameter of 25.4 mm. The experiments were performed at the heat fluxes between 15 and 65 kW/m^2, mass flux of refrigerant between 300 and 800 kg/m^2 s and saturation pressure ranging from 4 to 6 bar. For instance the boiling curve, average heat transfer coefficients are discussed. The comparison results of two test sections with different the number of channels are investigated. The results are also compared with nine existing correlations. The new correlation for predicting the heat transfer coefficient was also proposed.

1. Introduction

Multiport minichannels have been considered to be of great interest in compact evaporator applications in both automotive air conditioning and heat pump systems. There are many advantages over both the conventional tube and the single channel such as more compact size, low refrigerant charge, light weight, and reduced pressure drop. Thus, designs of multiport minichannels used as evaporators in air conditioning or heat pumps need to overcome the practical obstructions related to flow boiling in small channels. However, the heat transfer and flow characteristics of refrigerant in small channels have been studied by a number of researchers, mostly in single ports. The heat transfer and flow characteristics of refrigerant in multiport minichannels have received little attention in the open literature.

State-of-the-art and some examples of the most productive studies of single ports and multiports are summarized and described below.

Yan and Lin [1] determined the evaporation heat transfer coefficient and pressure drop of R134a in a tube with an inner diameter of 2 mm. The test section consisted of 28 parallel pipes with outer diameter of 3 mm and length of 0.2 m. They found that the heat transfer coefficients were quite different from those of larger pipes. The heat transfer coefficient increased with increases in the wall heat flux except in high quality regions. However, reverse results were obtained in the case of the high vapour quality region for high wall heat flux. Moreover, their results indicated that the heat transfer coefficients in small tubes are higher than that of conventional tubes (d_i > 8 mm) by around 30–80%. In the case of pressure drop, the experimental results showed that the measured pressure drop increased with increases in the mass flux as well as the imposed heat flux. Finally, they also proposed empirical correlations to predict the evaporation heat transfer coefficient and friction factors.

Owhaib et al. [2] presented new experimental results on saturated flow boiling of R134a in vertical circular tubes with internal diameters of 1.7, 1.224, and 0.826 mm. From their results, they concluded that wall heat flux and system pressure have more significant effects on the heat transfer coefficients, while mass flux and vapour quality had no significant effect on the heat transfer coefficient. They also strongly recommended that the heat transfer coefficients were dominated by nucleate boiling.

In 2004, Huai et al. [3] performed an experimental study of boiling heat transfer and pressure drop of CO_2 flowing through a multiport extruded aluminium tube with 10 circular channels, each with an inner diameter of 1.31 mm. The heating effect was obtained by hot water flowing inside copper blocks attached on both sides of the test section. The experiments were performed for either subcooled liquid or two-phase of CO_2 being fed to the inlet of the test section. They found that both a larger mass flux and a higher heat flux led to larger heat transfer coefficients.

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