CHAPTER 1 INTRODUCTION

1.1 Rational

Since the depletion of the ozone layer and global warming were discovered, many conventional refrigerants have been phased out from industries. Consequently, the refrigeration industry has switched over to ‘‘ozone-friendly” refrigerants such as R-134a. Therefore, improving the performance of heat transfer equipment which uses R-134a is necessary. The thermal performance of heat transfer equipment can be improved by using heat transfer enhancement techniques. In general, heat transfer enhancement techniques are classified into two groups: active methods and passive methods. Active methods are those that use the addition of external power such as mechanical vibration, injection, and electric field to facilitate the desired flow modification and concomitant improvement in the rate of heat transfer. The second group is passive methods which do not require direct input of external power such as surface modification. The rough surface technique is a passive method that usually involves surface modification to promote turbulent flow and increases the heat transfer surface area. Normally, smooth tubes are replaced by corrugated tubes in many heat exchangers to increase the heat transfer rate by mixing and also limiting the fluid boundary layers close to the heat transfer surfaces. Moreover, they can promote two-phase heat transfer enhancement.

1.2 Literature review

Over the years, the heat transfer and flow characteristics of refrigerants have been studied by a large number of researchers, both experimentally and analytically, mostly in horizontal straight tubes (Goldstein et al. 2005). Study of the heat transfer and pressure drop of refrigerant in vertical tubes has received comparatively little attention in the literature. Publications on the heat transfer and flow characteristics of refrigerant flow in vertical tubes are summarized as follows.

Shah (1979) presented a simple dimensionless correlation for predicting heat-transfer coefficients during film condensation inside pipes. It has been verified by comparison with a wide variety of experimental data. These include water, R-11, R-12, R-22, R-113, methanol, ethanol, benzene, toluene, and trichloroethylene condensing in horizontal, vertical, and inclined pipes of diameters ranging from 7 to 40 mm. Shah (1982) proposed equations to fit his chart correlation which use for the estimation of heat transfer coefficients during saturated boiling of water, R-11, R-12, R-22, R-113 and cyclohexanein in tubes and annuli. The correlation was shown to be applicable to both horizontal and vertical tubes. Gungor and Winterton (1986) presented a new general correlation for forced convection boiling that has been developed with the large data bank. This data bank consists of over 4300 data points for water, refrigerants and ethylene glycol, covering seven fluids and 28 authors, mostly for saturated boiling in vertical and horizontal tubes. Kandlikar (1990) proposed the correlation for predicting saturated flow boiling heat transfer coefficients inside horizontal and vertical tubes. The correlation has been developed with 5246 data points for water, refrigerants and cryogenic fluids from 24 experimental investigations. Briggs et al. (1998) studied the condensation of CFC-113 with downflow inside enhanced microfin tubes and tubes containing twisted-wire inserts. One plain tube, nine microfin tubes (with different fin heights, helix angles, and number of fins), and four twisted-wire inserts (with different wire densities) were tested. Cheung et al. (1999) studied the EHD-assisted external condensation of R-134a in vertical and horizontal smooth tubes. Experimental results demonstrate a remarkable potential in utilizing EHD to enhance external condensation heat transfer. Ma et al. (2004) experimentally studied the heat transfer and pressure drop characteristics for condensation of downward flow of R113 in vertical smooth and micro-fin tubes. Lee and Chang (2008) investigated the heat transfer characteristics in the post-dryout region for the boiling of up-flow of R-134a in vertical smooth tubes and rifled tubes. Among all these studies, extensive studies concerning the condensation of R-134a in vertical smooth tubes have been continually performed by Dalkilic et al. (2008a). The two-phase pressure drop during condensation of R-134a was studied. A new correlation for the two-phase friction factor was presented by means of the equivalent Reynolds number. In a series of studies, Dalkilic et al. (2008b, 2009a) presented the effect of void fraction models on the two-phase friction factor and film thickness during condensation of R-134a. The friction factors and film thickness values obtained from various void fraction models and correlations were compared with each other. Dalkilic et al. (2009b, 2009c) studied the heat transfer coefficient, film thickness, and condensation rate during downward condensing of film. A new correlation for the heat transfer coefficient was proposed for practical applications.

Most of the experimental investigations described above focused on the heat transfer and flow characteristics of refrigerant flow inside vertical smooth tubes, particularly during condensation. There have been very few works dealing with the flow in vertical enhanced tubes. However, it can be noted that the heat transfer and flow characteristics of refrigerant flowing downward during evaporation and condensation in corrugated tubes remain unstudied despite their possible importance in many refrigeration applications. Therefore the main concern of this work is to study the heat transfer and flow characteristics of R-134a during downward evaporation and condensation inside vertical corrugated tube. Experimental data that have never been seen before on heat transfer and pressure drop are presented.

1.3 Objectives

The objective of this work is to study the heat transfer and flow characteristics of HFC-134a during condensation and evaporation inside vertical corrugated tubes. The effects of various relevant parameters on the heat transfer and pressure drop characteristics are also investigated.

1.4 Scopes

1. Only HFC-134a refrigerant will be used.

2. Heat transfer coefficient and pressure drop during condensation and evaporation will be determined.

3. Smooth and corrugated copper tubes will be tested.