CHAPTER 6 CONCLUSION AND RECOMMENDATIONS FOR FUTURE WORK

This chapter presents the conclusion and recommendations for future work. In the part of conclusion, the important conclusions of this thesis are categorized into subsections as follows:

6.1 Conclusion

6.1.1 Heat transfer and flow characteristics of HFC-134a during evaporation inside vertical corrugated tube.

1. For smooth tube and corrugated tubes, the average heat transfer coefficient tends to increase with average quality, mass flux, and heat flux. At low or moderate quality, the heat transfer enhancement is more remarkable than at high quality. As the evaporation temperature is increased, the heat transfer coefficient is changed by a relatively small amount.

2. For smooth tube and corrugated tubes, the two-phase friction factor decreases with increasing equivalent Reynolds number. The two-phase friction factor at higher mass flux is always higher than that at lower mass flux for a given equivalent Reynolds number. However, the heat flux and evaporating temperature have unremarkable effects on the two-phase friction factor.

3. Comparing the heat transfer coefficient of the evaporation process in the corrugated tubes with that in the smooth tube under the same conditions, it is revealed that the heat transfer coefficient for the corrugated tubes is higher than that for the smooth tube. Moreover, the effect of corrugation on the heat transfer coefficient is weak

at low vapor quality region. In the other hand, the effect of corrugation becomes stronger at high vapor quality. The effects of corrugation pitch on the evaporation heat transfer coefficient of R-134a inside vertical corrugated tubes are also investigated. It is found that the heat transfer coefficient increases with the decrease of corrugation pitch. The maximum heat transfer enhancement is up to 22% for a pitch of 6.35 mm, 16% for a pitch of 8.46 mm and 11% for a pitch of 12.7 mm in comparison with the smooth tube. It is observed that the corrugation depth has slight effect on the heat transfer coefficient. The maximum heat transfer coefficient of the corrugated tube is up to 11% higher than that for the smooth tube.

4. The two-phase friction factor of the smooth and the corrugated tubes are compared at the same condition. It is found that the two-phase friction factor for the corrugated tubes is higher than that for the smooth tube. The experimental results also show the effect of the corrugation pitch on the two phase friction factor. It is observed that the higher two-phase friction factor is obtained from the tube with lower corrugation pitch. The maximum value of two-phase friction factor enhancement corresponds to the tube with the lowest corrugation pitch of 6.35 mm. This tube increases the two-phase friction factor by 280% in comparison with the smooth tube. For the tube having different corrugation depths and a constant corrugation pitch of 12.7 mm, it is shown that the tube having a corrugation depth of 1 mm has higher two-phase friction factor than that obtained from the tube having corrugation depths of 0.5 mm and 0.75 mm. The maximum value of two-phase friction factor enhancement is up to 220% for a depth of 1 mm in comparison with the smooth tube. For the tube having corrugation depths of 0.75 mm and 0.5 mm, the two-phase friction factor obtained from those tubes are nearly the same. These tubes increase the two-phase friction factor up to 160% in comparison with the smooth tube.

6.1.2 Heat transfer and flow characteristics of HFC-134a during condensation inside vertical corrugated tube.

1. For smooth tube and corrugated tubes, the average heat transfer coefficient tends to increase with increases in average quality and mass flux. As the evaporation temperature and heat flux are increased, the heat transfer coefficient is changed by a relatively small amount.

2. For smooth tube and corrugated tubes, the frictional pressure drop is increased with the rises of average vapor quality and mass flux. However, it decreases with an increase in saturation temperature. Nevertheless, the heat flux has an insignificant effect on the frictional pressure drop in the range of investigated heat flux.

3. Comparing the heat transfer coefficient in the corrugated tubes with that in the smooth tube under the same conditions, it is revealed that the heat transfer coefficient for the corrugated tubes is higher than that for the smooth tube. The variation of the average heat transfer coefficient with average vapor quality in the smooth tube and corrugated tube having different corrugation pitches of 6.35, 8.46 and 12.7 mm are also investigated. It can be seen that the heat transfer coefficient increases with the decrease of corrugation pitch. Maximum heat transfer enhancement is up to 28% for the tube having corrugation pitch of 6.35 mm in comparison with the smooth tube. It is observed that the corrugation depth has only small effect on the heat transfer coefficient. The maximum heat transfer coefficient of the corrugated tube is up to 12% higher than that for the smooth tube.

4. The frictional pressure drops of the smooth and the corrugated tubes are compared at the same condition. It is observed that the frictional pressure drop in the corrugated tube is higher than that in the smooth tube. The effect of tube having different corrugation pitches and a constant corrugation depth of 1 mm on the frictional

pressure drop is also shown. It is seen that the frictional pressure drop increases as the corrugation pitch decreases. The maximum frictional pressure drop enhancement is up to 70% for a pitch of 6.35 mm, 63% for a pitch of 8.46 mm and 53% for a pitch of 12.7 mm in comparison with the smooth tube. For the tube having different corrugation depths and a constant corrugation pitch of 12.7 mm, it is observed that the frictional pressure drop obtained from the tube having corrugation depth of 1 mm is higher than that obtained from the tube having corrugation depths of 0.75 mm and 0.5 mm. The maximum value of frictional pressure drop enhancement is up to 53% for a depth of 1 mm in comparison with the smooth tube. For the tube having corrugation depths of 0.75 mm and 0.5 mm, the frictional pressure drop in those tubes are nearly the same. These tubes increase the frictional pressure drop up to 43% in comparison with the smooth tube.

6.2 Recommendations for Future Work

The experimental apparatus can be applied for investigating the heat transfer performance and flow characteristic of HFC-134a during evaporation and condensation flowing through new type of enhanced tube.