CHAPTER 7

SUMMARY AND CONCLUSIONS

7.1 SUMMARY

The Ozone Depletion Potential (ODP) is the major driving force for the phaseout of R-22. The phaseout of R-22 requires air-conditioning sector to find suitable alternatives in a relatively short time period. The present investigation was focused on the development of an eco-friendly, energy efficient, user friendly, and safe alternative refrigerant for R-22 to retrofit window air-conditioners. Based on the extensive literature survey, it was observed that the R-407C/HC mixture could be a viable alternative to R-22. Four different mixtures viz., M10, M15, M20 and M25 were considered for the study to arrive at an optimal mixture. A mathematical simulation study was carried out with reference to window air-conditioner using MATLAB software. An experimental investigation was also carried out in a room calorimeter fitted with a window air-conditioner with EIAT varying from 21°C to 29°C and CIAT varying from 30°C to 45°C. The performance parameters such as refrigeration capacity, COP, energy consumption, compressor operating pressure and temperature, mass flow rate, pull down time, temperature distribution along the evaporator coil, etc. of the mixtures were studied and compared with those of conventional refrigerant R-22. Based on the theoretical and experimental study M20 was evolved to be the optimal mixture. Capillary tube flow characteristics study was also carried out for the optimal refrigerant mixture along with that of R-22. Several adiabatic capillary tubes with different lengths and inner
diameters were considered. Mass flow rate through the capillary tube was measured experimentally for several condensing temperatures and various degrees of subcooling at the inlet of each capillary tube. A new correlation was developed to predict the mass flow rate through the capillary tubes by performing a regression analysis on the experimental data. Based on the above investigations the following conclusions are drawn.

Of all the four mixtures considered, M20 was found to be superior to other mixtures as well as R-22 for all operating conditions. Hence the following conclusions are made based on a comparison of M20 with the conventional R-22 refrigerant.

7.2 CONCLUSIONS
7.2.1 Simulation Study

At 27°C evaporator inlet air temperature, the system was simulated for various condenser inlet air temperatures ranging from 30°C to 45°C in steps of 5°C and the various performance parameters were calculated for R-22 and for different mixtures M10, M15, M20, M25. From the observation it is found that the predicted compressor power for M20 at different operating conditions is higher than that of R-22 by 4.67% to 7.45% while the predicted refrigeration capacity of M20 is also higher than that of R-22 by 19.2% to 22.1%. The predicted COP of M20 is 10.97% to 16% higher than that of R-22. But the prediction falls within 25% deviation from the experimental results. However, this supports the validity of the model.
7.2.2 Experimental Study-System Performance

The behaviour of R-22 and R-407C with various proportions of HC blend (10 to 25%) with mineral oil as compressor lubricant has been experimentally analysed with a range of test conditions in a window air conditioner. From the discussion it is found that the actual COP of M20 is 8.19 to 11.15% higher than that of R-22 at various condenser inlet air temperatures. The power consumption of M20 during pull down was 2.34 to 10.45% higher than that of R-22. However the pull down time was reduced by 32.51% resulting in lower energy consumption. This mixture demanded lengthening of condenser by 19% in order to maintain discharge pressure with in acceptable limits. During the continuous operations of the system no significant deviation from the initial oil level in the indicator was observed and hence the oil miscibility of M20 with mineral oil is ascertained. Among the mixtures considered M20 would be the best choice for R-22 window air-conditioners without changing the mineral oil. However the price of obtaining solubility with mineral oil is likely to be flammability. This may not be a high risk to the consumer because of the small charge and sealed system but to the manufacturer who has to handle bulk quantities in the factory, it is of importance.

7.2.3 Experimental Study-Capillary Flow Characteristics

The mass flow rates through the adiabatic capillary tubes with different tube inlet conditions and tube geometries were measured for the refrigerants R-22 and M20. The mass flow rates of M20 are greater by 3.825% on an average than those of R-22. Based on the measured mass flow rates of R-22 and M20 a non-dimensional correlation was developed to predict the mass
flow rates through the adiabatic capillary tubes as a function of several non-dimensional parameters using the Buckingham \( \pi \) theorem. The developed correlation yields good agreement with the measured data for R-22 and M20 with average deviations of 0.618\% and –0.11\% and mean deviations of 5.536\% and 4.448\% respectively. Also the present correlation matches very well (±5\%) with the results in published literature reported by previous investigators.

Thus it can be concluded that the M20 mixture could be an ozone friendly, energy efficient, safe and economically viable alternative to R-22 for window air-conditioning systems. The fact that POE oil can be dispensed with by using M20 in the place of R-407C is a significant finding in this work. It is believed that this mixture M20 could be a solace to the air-conditioning sector that is challenged with the conditions of Montreal Protocol to phase out R-22.

### 7.3 KEY OBSERVATIONS ON THE USE OF M20 IN RETROFITTING CIRCUMSTANCE.

1. M20 is a 18.4/20/41.6/10.96/9.04 mass \% blend of R-32, R-125, R-134a, R-600a and R-290.

2. M20 is a zeotropic blend mixture which will fractionate or change composition during evaporation and condensation and will show about 7\°C to 9\°C temperature glide across the heat exchangers due to this composition change.
3. The results from the present study indicate that M20 can be used in the existing window air-conditioner without changing the mineral oil and an improvement in the system performance also can be realized.

4. The new mixture called for capillary tube replacement with 1.5 m length and 1.1176 mm diameter as against 1.75 m length and 1.1176 mm diameter for R-22.

5. One drawback of the M20 is that it has a system operating pressure relatively higher than that of R-22 and hence design changes will be required to accommodate M20 by way of increasing the condenser surface area of approximately 19%.