ABSTRACT

In the present work, theoretical and experimental investigation have been carried out with two hydrocarbon refrigerant mixtures as a possible alternatives to R134a in 297 liter domestic refrigerator.

Theoretical performance of an ideal vapor compression refrigeration cycle using propane/butane and propane/isobutane in the composition range of 0.3 to 0.7 propane mass fraction was studied and the results were compared with those of R134a. The performance parameters including the refrigerating effect, coefficient of performance and volumetric refrigeration capacity were studied at a condensation temperature of 50°C and evaporating temperatures ranging between -30°C to 5°C. The thermodynamic properties for R134a and the hydrocarbon mixtures are all estimated by using REFPROP program. Theoretical results showed lower pressure ratio, higher coefficient of performance, lower power per ton of refrigeration and higher volumetric refrigeration capacity by about 12.7%, 2.2%, 2.2% and 4%, respectively, for the hydrocarbon mixture R290/R600 (70/30)% compared with those of R134a at evaporating temperature of -20°C. The effects of the main parameters such as refrigerant type, degree of subcooling and superheating on the coefficient of performance, volumetric refrigeration capacity and refrigeration power were also investigated at various evaporating temperatures. The results showed that the effect of increasing 5 degrees of subcooling/superheating yield to a higher coefficient of performance, higher volumetric refrigeration capacity and lower refrigeration power by about 6.1%, 6.3% and 5.8% respectively, for R290/R600 (60/40)% and evaporating temperature of -20°C compared with those without superheating/sub-cooling case.

The performance of the hydrocarbon mixtures of R290/R600 with (0.4 to 0.7) mass fraction of propane and R290/R600a with (0.4 to 0.6) mass fraction of propane were experimentally investigated as a drop-in alternatives to replace R134a in a locally manufactured domestic refrigerator designed to work with R134a. Two experimental tests were performed in this investigation, in the first one, the refrigerator was run at steady state condition with the freezer unloaded in order to study the performance characteristics for the refrigerants examined. In the second one, the freezer compartment was loaded with 1 kg of water in order to simulate the actual cooling performance. The results showed a lower freezer air temperature, lower cabinet air temperature, lower discharge temperature, higher coefficient of performance, lower pressure ratio and lower electrical power by about 3.2°C, 2.3°C, 3.1°C, 4.9%, 7% and 9.4%, respectively, for the hydrocarbon mixture R290/R600 (60/40)% with 60g mass charge and 50% longer capillary tube compared with those of R134a with 120g mass charge.

In conclusion, the hydrocarbon refrigerant mixtures of R290/R600 seems to be an appropriate candidates to replace R134a in terms of selecting an environmentally friendly refrigerants.