ABSTRACT

Today’s refrigeration and air-conditioning industries are moving towards chlorine free working fluids, as chlorine is one of the important causative agent for the ozone layer depletion. R-22 the generally accepted and more suitable refrigerant for air-conditioners has to be phased out by 2030 in developed countries and by 2040 in developing countries because of its Ozone Depleting Potential (ODP). Millions of air-conditioners all over the world operating with R-22 have to be retrofitted suitably in the event of the above phase out. Many refrigerants have been reported as alternatives to R-22. The recommended alternatives are mainly classified under HFC and HC refrigerants and they have their own drawbacks. HC is highly flammable and considering the safety norms in many countries, it cannot be charged above a certain quantity in domestic appliances. Thus HC cannot be considered as the sole refrigerant in air-conditioners. HFCs are used with polyolester (POE) oil only as it is immiscible with the conventional mineral oil. This POE oil is highly hygroscopic and makes the system vulnerable to problems due to moisture entry. R-407C is considered as a potential drop-in substitute for R-22. The miscibility issue of R-407C with mineral oil could be overcome with the addition of hydrocarbon to it. However, choosing a suitable hydrocarbon refrigerant and optimising its concentration for better performance is a challenge in the refrigeration and air-conditioning sector.

In this present work, the performance of R-407C/HC blend, an eco-friendly refrigerant mixture, as a retrofit for HCFC22 has been investigated.
The HC blend contains R-600a and R-290 in the ratio of 54.8% and 45.2% respectively. The theoretical studies have been carried out using MATLAB software integrated with REFPROP database for property reference. The experimental investigation was carried out in a room calorimeter set-up fitted with a 1050W capacity window air-conditioner. Condenser inlet air temperature was held constant at 30°C, 35°C, 40°C and 45°C, while evaporator inlet air temperature was varied over a range from 21°C to 29°C in steps of 2°C during the experimentation. The mass percentage of HC blend was varied from 10% to 25% in steps of 5% to evolve an optimal percentage of HC blend in the mixture. The investigation includes study of system performance parameters such as refrigeration capacity, actual COP, per day energy consumption, pull down power and time etc. The results obtained from the simulation have been compared with the experimental values. To have a realistic assessment of the performance of the proposed mixtures, the experiment was carried out initially with R-22 and the results were compared.

The performance analysis revealed that the new refrigerant mixture performed better than that of R-22. It has been found that the new refrigerant R-407C/HC blend mixture containing 20% HC blend has better performance that improved the actual COP of the system by 8.19 to 11.15 % from that of R-22 for different condenser inlet air temperatures. The oil miscibility of the new mixture with mineral oil was also confirmed. The deviation between predicted values of COP obtained from the simulation and experimental results is found to be within 25%. The new refrigerant mixtures demand longer condenser length to decrease the high discharge pressure and match with that of R-22 systems.
Further an experimental study on the capillary flow characteristics of R-407C/HC blend refrigerant mixture that contains 20% of HC blend in adiabatic capillary tubes was also carried out and compared with that of R-22. The effects of capillary length, capillary diameter, condensing pressure and degree of subcooling on the mass flow rate through the capillaries have been studied. Based on the experimental data for R-22 and R-407C/HC blend refrigerant mixture, a new correlation has been developed to predict the mass flow rate through the adiabatic capillary tubes for different operating conditions. In order to validate the correlation the predicted mass flow rate for R-22 has been compared with that of published literature. The mass flow rates predicted through the non-dimensional correlation are in good agreement with the experimental data for R-22 and R-407C/HC blend refrigerant mixture with average deviations of 0.618% and –0.11%, and mean deviations of 5.536% and 4.448% respectively.

The results of the present investigation have proved that the new alternative refrigerant R-407C/HC blend refrigerant mixture (80/20 mass percentage) could be an excellent substitute for R-22 and can be used for retrofitting old systems without changing the mineral oil. However, it is needless to say that the same mixture can be used for new systems also.