ABSTRACT

Air conditioners are widely used in for personal comfort and process control. Vapour compression refrigeration system occupy over 90% of the applications. Due to environmental problems, refrigerant R12 has been phased out and R22 is in pipeline. Efforts are ongoing to find out a suitable alternative to R22. Efforts are made to improve the performance of small as well as large capacity systems. Air conditioners with compact size are now necessary for many applications. In order to obtain the compactness of air conditioners, smaller size of heat exchanger and high heat transfer fluid are needed. But conventional air conditioners have heat exchangers of larger size along with heat removal fluids of lower heat capacity. To achieve high heat transfer rate, the thermal behavior of the fluid must be changed. Metals and metal oxides have high capacity in heat transfer, so suspension of nanometer sized metal oxide particles really improves the performance of base fluid. Induced nanoparticles improve the thermal conductivity of the base fluid and so the thermal performance of base fluid increases. In this direction, in the present research work (i) performance of small capacity (0.75 TR) R22 systems are tested with air-cooled and water-cooled condenser to enhance the performance (ii) the effect of retrofitting R22 system with R410A and R407C and (iii) energy conservation in air-conditioning system by introducing Al$_2$O$_3$/water and CuO/water nanofluid-cooled condenser are studied.

An experimental facility has been created as per BIS standard 1391. The facility has a test window air conditioner of 2.46 kW capacity with air-cooled, water-cooled and nanofluid-cooled condenser. Facilities are provided
to test the air conditioner at a specified evaporating and condensing temperatures. Temperature and pressure at various locations are measured. Refrigerant charge and capillary optimisation are done for R22, R410A and R407C. Infiltration heat has been measured and properly accounted. The error analysis has indicated that the maximum probable error on COP is ±3.06%. Experiments are done as per BIS standard 1391. The evaporator temperature has been varied as 5°C, 10°C and 15°C by keeping condenser temperature at 40°C, 45°C and 50°C. Similarly condenser temperature has been varied as 40°C, 45°C, 50°C and 55°C by keeping the evaporator temperature at 5°C, 10°C and 15°C. Experiments are done with R22 system, R410A system and R407C are carried out. Each experiment is done twice and the average values are taken for calculation.

Performance parameters analyzed in this study are refrigerant mass flow rate, refrigeration capacity, pressure ratio, compressor power, COP and the outlet temperature of the cooling water / nanofluid from condenser. From the experimental study it has been observed that the small capacity window air conditioner improves the refrigerant mass flow rate, refrigeration capacity and COP and reduces the pressure ratio and compressor power for all the refrigerants selected for the study.

Experimental results with R410A and R407C as refrigerant shows that the mass flow rate, refrigeration capacity and COP are lower compared to R22 whereas pressure ratio and compressor power are higher. The addition of water-cooled condenser improves the performance of R407C system also. The present results are in good agreement with the results in published literature reported by previous investigators. Usage of nanofluid-condenser further
improves the performance of the air-conditioning system by reducing the
energy consumption.

In conclusion, the inclusion of water-cooled and nanofluid-cooled
condenser in small capacity window air conditioner improves the
performance of both R22 and R407C. Even though the performance of R407C
has been found to be slightly inferior to R22, because of the ozone - friendly
nature, it can be a suitable alternate refrigerant in small window air
conditioner provided water-cooled and nanofluid-cooled condenser.