ABSTRACT

Studies carried out in recent times show that carbon dioxide (CO_2) can be used as a secondary refrigerant in forced or natural circulation loops (NCLs). However, literature review shows that studies on CO_2 based NCLs are scarce. Hence, in the present thesis theoretical and experimental studies are carried out on CO_2 based NCLs suitable for refrigeration and air conditioning applications. Using a simple analytical model of a single phase NCL, various fluids have been compared in terms of tube diameters and temperature change across heat exchangers. Results show that use of CO_2 as loop fluid results in smallest diameter and temperature change. Next, steady state models are developed for design and simulation of CO_2 based NCLs (both single phase and two phase) with heat exchangers. The results show that CO_2 based NCLs can be used in a wide variety of applications over a fairly large range of capacities and temperatures. Using these models it is possible to optimize the system dimensions and CO_2 inventory so that the loop heat transfer rate is maximized. Next mathematical models are developed to design and simulate vapour compression refrigeration systems (VCRS) coupled to CO_2 based NCLs for applications of water cooling and room air conditioning. Results show that in case of a water cooler, the same level of performance as that of the base system (without NCL) can be obtained at the cost of increased system size. In case of room air conditioner, for the same cooling coil dimensions, integrating the CO_2 based NCL with VCRS results in a minor loss of capacity and COP compared to the base system (less than 10% for both capacity and COP). Based on the theoretical models, an experimental test-rig of CO_2 based NCL is designed, fabricated and tested in gas, liquid and liquid-vapour modes. The test-rig was found to operate satisfactorily without any instability. A good agreement is found between the experimental and theoretical results. Based on the

experimental results, a simple correlation is proposed for CO_2 based single phase NCLs in terms of Reynolds and Grashof numbers.

Keywords: *carbon dioxide, natural circulation loops, refrigeration and air conditioning, mathematical models, experimental studies*