Abstract of Ph.D. Thesis of Mr. S Sai Saran Yagnamurthy

Cooling accounts for a significant share of global energy demand, and is expected to grow triple fold by the year 2050. With the major dependency on fossil fuels for energy needs and their depletion over time, the world may experience a cold crunch due to an inability to meet the growing cooling energy demands. In addition to increasing the energy efficiency measures for the cooling technologies and spaces, alternative energy powered cooling technologies are needed to reduce the grid dependency for cooling.

Among the various alternatives explored for cooling needs, adsorption cooling technology has shown potential through its capability to operate with low grade energy sources, along with having lower maintenance issues due to fewer moving parts. However, their bulky system sizes and high cost in comparison to the conventional Vapor Compression Refrigeration (VCR) systems have been the primary setback to the wide scale deployment of this technology. Nevertheless, a significant potential for improvement is possible due to the wide variety of working pairs, design configurations and operational cycles in these systems. The present thesis attempts to further the research on some of these aspects of adsorption cooling systems, through both experimental and numerical studies.

To study the influence of operating cycle parameters and strategies, an experimental facility has been developed for testing a two-bed chiller system with the widely employed silica gel-water pair. Passive heat recovery and two-stage operation strategies have been proposed in this study for the enhancement of performance and operational envelopes through modifications in the chiller's valves sequencing. An improvement of 22-42% in COP has been observed with an optimized passive heat recovery strategy over the default operation mode of the chiller. Two kinds of two-stage operations viz., conventional two-stage and reheat two-stage have been explored, which yielded a lowering of minimum desorption temperature to 40°C.

To study the scope of the upcoming low GWP refrigerant of R32, activated carbon composites with H25 graphene nanoplatelets (GNPs), 1-Hexyl-3-methylimidazolium bis(trifluormethylsulfonyl)imide ([HMIM][Tf2N]) ionic liquid and Polyvinyl alcohol (PVA), have been studied for thermophysical properties and adsorption characteristics. Anisotropic thermal diffusivities have been studied for the GNP based composites, where a large improvement in thermal conductivity of up to 65.6 times has been observed over powdered activated carbon. Further, lumped and distributed parameter modeling studies of the composite-R32 pairs have been carried out for compact heat exchanger design selections.

A comparative assessment between the silicagel-water and AC-R32 systems has shown that the latter has 17-61% lower COPs over the former. However, since the AC-R32 system has the distinctive advantage of being applicable for sub-zero cooling temperatures, its performance has been studied for an evaporator temperature of (-5)°C where lower COPs (≤0.12) have been observed. A COP improvement up to 3.7 times has been estimated through a suitable cascading strategy between the silica gel-water and AC-R32 systems.