6.1. CONCLUSIONS

The experimental analysis have been carried out to study the fundamental understanding of heat and mass transfer for different inlet parameters of main components of liquid desiccant cooling system i.e. absorber and regenerator. The counter flow of the air and desiccant solution with cellulose structured celdek pads as packing material and CaCl$_2$ as desiccant material has been studied first time. The inlet process parameters are air mass flow rate, air inlet temperature, inlet specific humidity, solution inlet temperature, solution mass flow rate, inlet concentration of the solution and the corresponding outlet parameters are change in specific humidity, moisture removal rate, water evaporation rate, mass transfer coefficient, air outlet temperature, solution outlet temperature, effectiveness of the dehumidifier and effectiveness of the regenerator. The effect of inlet parameters has been studied on the outlet and performance parameters of the absorber and regenerator. Modeling and simulation of the absorber and regenerator have been carried out using Warner technique and FORTRAN 77 as the coding language. The effect of process parameters have been studied along length from top to bottom of the absorber and regenerator. The following conclusions are emerging from the present research work:

- The change in specific humidity through the absorber is found increasing with increase in solution flow rate, inlet concentration of the desiccant and inlet specific humidity while same is found decreasing with increase in air mass flow rate, inlet air temperature and inlet solution temperature. Solution flow rate and inlet specific humidity have shown the major effect on the change in specific humidity.
For the regenerator, change in specific humidity is found increasing with increase in air inlet temperature, solution inlet temperature and solution flow rate while same is found decreasing with increase in other inlet parameters; air flow rate, concentration of the desiccant and specific humidity. Here, inlet temperature and flow rate of the desiccant solution are emerged as the main parameters of the regenerator and shown an increase of 34% for the change in specific humidity across it.

- Air-desiccant interface mass transfer coefficient in the dehumidification process is increased with increasing air mass flow rate, inlet air temperature, solution flow rate, inlet concentration of the desiccant and inlet specific humidity while it is decreasing with increase in temperature of the solution at inlet of the dehumidifier.

For the regenerator, mass transfer coefficient from the desiccant solution to air is increased with increasing mass flow rate of the air, inlet temperature of the air, solution inlet temperature and mass flow rate of the desiccant solution while same is decreased with increasing inlet concentration of the desiccant and inlet specific humidity of the air.

Mass transfer coefficient of the absorber and regenerator is found highly dependent upon the air flow rate and inlet temperature of the desiccant solution.

- Moisture removal rate in the absorber is found increased with increasing air mass flow rate, inlet air temperature, solution flow rate, inlet concentration of the desiccant and inlet specific humidity of the air while it is found decreased with increasing inlet temperature of the desiccant solution. Maximum increase in moisture removal rate is found 187% with increasing inlet specific humidity of the air. MRR is increased by 144% with increasing solution flow rate in the absorber.

For the regenerator, evaporation rate is observed to be increased with increasing mass flow rate of air, inlet temperature of air, solution inlet temperature and mass flow rate of desiccant solution while same is observed to be decreased with increasing inlet concentration of desiccant.
and inlet specific humidity of the air. Water evaporation rate is increased by 137% and 110% with increasing inlet solution temperature and air flow rate respectively in the regenerator.

- The outlet air temperature in the absorber is found increased with increasing inlet air temperature, flow rates of the air and solution, inlet concentration of the desiccant while it is found decreased with increasing temperature of the desiccant solution at inlet of the absorber. Outlet temperature of the air has been increased by 10% with increasing solution inlet temperature and 7% with increasing inlet air temperature. The temperature of the air at outlet of dehumidifier has not shown much effect with particular trend with increasing inlet specific humidity. For the regenerator, outlet air temperature is observed to be increased with increasing air inlet temperature, desiccant inlet concentration and inlet specific humidity of the air while decrease in outlet air temperature is observed with increasing other inlet parameters; temperature of the solution, mass flow rate of the air and desiccant solution. Inlet desiccant concentration has shown the maximum increase of 33% with increasing outlet air temperature from 32°C to 42.2°C in the regenerator.

- The outlet temperature of desiccant solution in the absorber is observed to be increased with increasing all inlet parameters and maximum increase of 25.89% is observed with varying the inlet solution temperature from 29.9°C to 39.2°C. Solution temperature at the outlet of the regenerator is observed to be decreased with increasing inlet parameters. Solution outlet temperature is found majorly effected by desiccant concentration, mass flow rate and inlet temperature of desiccant solution. Maximum decrease of 9% has been obtained with increasing concentration of the desiccant solution from 0.35 kg/kg to 0.40 kg/kg.
• The effectiveness of the absorber is found to be increased with increasing solution flow rate and inlet specific humidity while decrease in effectiveness was observed with increasing mass flow rate of the air, inlet air and solution temperature and concentration of the desiccant solution. Maximum increase of 26% has been observed with increasing the solution flow rate from 0.056 kg/s to 0.112 kg/s.

Regenerator effectiveness is found increased with increasing the solution flow rate, desiccant concentration and it is decreasing with increase in air mass flow rate, inlet temperature of the air and desiccant solution. An increase of 28% has been obtained with increasing solution flow are from 0.056 kg/s to 0.112 kg/s. The effectiveness of regenerator has not shown much variation with increasing inlet specific humidity.

• It is important in conclusion that previous studies have mainly studied the moisture removal rate and the effectiveness of the absorber as performance parameters and in the regenerator, the main performance parameters have been studied are the water evaporation rate and regenerator effectiveness. Only a few researchers have studied mass transfer coefficient.

In the present work, change in specific humidity, mass transfer coefficient, outlet temperature of the air and desiccant solution which are outlet parameters of the main components; dehumidifier and regenerator, have been studied along with the performance parameters.

• To predict behavior of the absorber in all respect, the model and simulation worked well showing the change along length of absorber. The Predicted variations of specific humidity, temperature of air, temperature and concentration of desiccant solution from the top to bottom of the absorber have been studied. Variation of all these predicted parameters follow the same trend as obtained in experimental work. The deviation of experimental and predicted values of change in specific humidity, moisture removal rate and concentration of desiccant are found in the range of +20% to -15%, +15% to -12% and +4% respectively for the absorber.
To predict the overall behavior of the regenerator, a simple model of the regenerator has been developed and simulated using a set of experimental values. Specific humidity, temperature of air, temperature and concentration of desiccant solution from the top to bottom of the regenerator has been studied and predicted results of these parameters are found very close to the experimental results. The maximum deviation observed between experimental and predicted values is ±15% for the change in specific humidity of air in the regenerator. Deviation of +1% to -5% between predicted and experimental data has been obtained for the concentration of desiccant at outlet of the regenerator. The evaporation rate of water in the desiccant solution is found to be deviated by ± 8% between predicted and experimental results.

6.2. FUTURE SCOPE

In the present work, the analysis of celdek packed absorber and regenerator with calcium chloride has been analyzed in depth. To further develop the technology of liquid desiccant cooling systems, the following are some future aspects:

- Present experimental study may be extended by varying the different range of the inlet parameters.
- Experiments may be performed by connecting the present system with conventional air conditioning system for the detailed study of hybrid desiccant cooling system.
- Study and comparison with other types of flow; parallel and cross flow between the desiccant solution and air can be incorporated in future by the researchers.
- Different type of liquid desiccants and mixtures of the desiccants can be used for further studies.
- Solar based liquid desiccant cooling system can also be used for the regeneration of the desiccant in the regenerator.
Other computational techniques i.e. ANSYS, MATLAB etc., can be used for the simulation of the absorber and regenerator and results so obtained can be compared with the present work or with the literature work.