Dehumidification of air is an important process in many industries. It is found that the conventional static bed dehumidifiers using solid desiccants operate at low efficiency and the adsorption rate decreases with time. Hence energy and exergy analysis were carried out and it revealed that absorption process is energy efficient. Hence, a three phase counter current fluidized bed dehumidifier operating with concentrated calcium chloride solution and using absorption process has been theoretically and experimentally analysed in the present work.

Heat and mass transfer in a fluidized bed system is complex in nature. To understand the mechanism, initially a mathematical model of a static bed dehumidifier, using CaCl₂ solution as the desiccant, is considered. The heat and mass transfer studies have been carried out on this system.

Analytical investigations carried out to predict the heat and mass transfer in a three phase counter current fluidized bed involved, building of mathematical models and obtaining solution of resulting equations. A spherical particle, with a thin film of desiccant solution around it, is considered and the moisture transfer is assumed to take place between the surrounding air and the desiccant film.
The predicted heat and mass transfer rates, revealed that they are highly dependent on the thickness of the film, residence time and flow rates of the solution and air.

The results show the occurrence of temperature reversal in the dehumidification chamber. Further, the peak temperature is found to be a function of concentration and initial temperature of the dessicant solution. Moisture transfer from air to the dessicant solution will take place only when the temperature and concentration of the solution is kept below the critical value. This aspect is studied and it is found that the critical temperature increased with increase in initial concentration. Similarly the critical concentration increased with increase in the initial temperature.

An increase from 200 to 300 in Nusselt Number is noticed when Reynolds Number is varied from 1800 to 2200. The heat transferred in the bubble and emulsion phases is predicted separately and it is found that the heat transfer from the emulsion phase is about 15 times greater than that from bubble phase. In the case of mass transfer, it is found that the transfer rate from emulsion phase is about 5 times greater than that from bubble phase.
The experimental set up consists of two fluidized bed columns of size 0.2 m x 0.2 m x 1.2 m, made of acrylic plastic. One column is used for dehumidification and the other for regeneration of the dessicant. Distributor plates, designed and fabricated for the system are fixed between the bed and calming section. The dessicant solution is sprayed from the top of the columns through nozzles. Inert, thermocole (polystyrene) spheres of $2.54 \times 10^{-2}$ m diameter are used as the bed material. The atmospheric air is sent through the bottom using a blower. The dessicant solution, the thermocole spheres and the atmospheric air form the three phase system.

In the dehumidifier, the concentrated calcium chloride solution, and the humid air come in direct contact and moisture transfer takes place from the air to the solution, because of the difference in vapour pressures. After moisture absorption, the dessicant solution becomes diluted. The dessicant solution is then heated and sprayed in the regenerator, where, it comes in direct contact with a fresh stream of air and loses moisture. The concentrated solution thus obtained is sprayed back into the dehumidifier.

The effect of air and dessicant solution flow velocities and solution concentration on heat and mass
transfer is determined and plotted. The experimental values of Sherwood Number and Nusselt Number are compared with the results available in the literature.

Experiments were also conducted in a static bed. It revealed that there is a 25% increase in the moisture absorption rate in the case of a three phase counter current flow fluidized bed systems as compared to static bed systems.

A non-dimensional MOISTURE TRANSFER NUMBER has been defined. The design correlations have been found between the Moisture Transfer Number and the increment in percentage relative humidity for dehumidifier and regenerator.