# Investigations on a Finned Tube Type Heat Exchanger as a Liquid Air Contacting Device

**R V Thakkar[1], P B Zinzala[2], S M Gandhi[3]**
[1, 2, 3] Department of Mechanical Engineering
[1, 2] L.J. Institute of Engineering & Technology, Gujarat Technological University, India
[3] Govt. Polytechnic, Ahmedabad, India

***Abstract-*** *The use of Air Conditioners, popularly known as AC, has become almost compulsory in number of homes and offices. In fact it has become necessity instead of being a luxury. Liquid Air Contacting device is a key component of the Air Conditioning system which can be used for number of processes such as evaporating cooling, heating and humidification, cooling and dehumidification etc. In the present work finned tube type heat exchanger is tested for its performance as a humidifier.*

***Keywords-*** Air conditioning; Liquid Air Contacting device, Humidifier

## I. INTRODUCTION

Now a day's increasing demand of air conditioning is observed globally. In India being a tropical country, a sustainable amount of energy is consumed in air conditioning. The conventional Vapor Compression Refrigeration (VCR) System of air conditioning imparts heavy load on the grid as well as CFCs used in this system as a working medium are responsible for ozone layer depletion. Liquid desiccant Air Conditioning (LDAC) can be a promising alternative to the conventional VCR system to overcome the above problems, as it can run on renewable sources of energy and it does not use CFCs. A Liquid Air Contacting Device is a key component of this system. A finned tube type Liquid Air Contacting Device is developed in this work, which is simpler as it is fabricated by integrating liquid desiccant pumping and distribution system with a conventional cooling coil used in air conditioning applications. Experiments were carried out to check its working and to determine its effectiveness for its further use in LDAC system. Results of this work are reported in this paper.

## II. EXPERIMENTAL SET-UP AND INSTRUMENTATION

An experimental test rig is developed at L.J. Institute of Engineering and Technology, Ahmedabad. As shown in Fig.1 it consists of an internally cooled liquid desiccant air contacting device, LD pump, LD distribution system, an air conditioning duct, and Air circulating fan. An internally cooled contacting device consists of four row finned tube flooded water type coil of 14 inch x 14 inch with fin density and fin thickness of 4 FPI and 0.8 mm respectively. There are 14 tubes with internal diameter 8.8 mm, arranged in a serpentine fashion in each row. All four rows are arranged in series and staggered fashion with transverse pitch of 25 mm and diagonal pitch of 22 mm. An effective distribution system is required for uniform wetting of the fins for effective cooling and humidification/dehumidification to be carried out. Different arrangements of the showers and piping were tested and the arrangement which gave the best distribution was adopted for the experimentation. Induced Draught fan of centrifugal type was used to circulate the air in the duct. In order to vary the air flow rate, provision to vary the fan speed was also provided. Two pumps of centrifugal type were used to circulate the LD/water and cooling water in the circuit.


Fig.1 Experimental set-up

The cooling water flow rate was measured using an ISO certified Water Meter, Air flow rate was measured Using an Anemometer in which time in second per count is measured using stopwatch and velocity of air in m/min was found from the William's Chart. Temperature at inlet and outlet points of Air, LD and water was measured using K-type steel encased copper constantan thermocouple. Relative humidity of air was calculated from Dry Bulb Temperature (DBT) and Wet Bulb Temperature (WBT) measured using a sling Psychrometer. The specifications of different instruments used are tabulated in Table 1.

TABLE 1: SPECIFICATIONS OF INSTRUMENTS USED

| Sr. No | Property Measured | Name of Instrument | Measuring Range | Accuracy |
|---|---|---|---|---|
| 1 | Water, LD Temperature | SELTECH Thermometer DT-305 (RTD PT-100) | -50 to 1300 $^0$C | ±0.1 |
| 2 | DBT & WBT of air | Psychrometer | -10 to 50 $^0$C | ±0.1 |
| 3 | LD Specific Gravity | Hydrometer | 1 to 1.5 | 0.001 |
| 4 | Air Velocity | Anemometer | 0 to 12 m/min | ±0.1 |

## III. EXPERIMENTATION

To carry out experiments the components of the system were assembled in proper sequence. Leakage test was carried out to check for leakage of water and air and rectified the same. To check the performance of the Liquid Air Contacting Device as a humidifier, cooling water from the cooling tower was circulated in the tubes of the Liquid Air Contacting Device. Tap water was sprinkled from the top of the Liquid Air Contacting Device through the distribution system designed and air was made to pass through the Liquid Air Contacting Device from the duct designed using an induced draught fan. This made the water to come in contact with the outdoor air. Due to vapor pressure difference between the outside air and water sprinkled dehumidification of water took place. Readings of inlet and outlet DBT, WBT air velocity, and water flow rate were measured after achieving the steady state conditions. The results of the experiments are tabulated in table 2.

## IV. RESULTS AND DISCUSSION

Table 2 presents the performance of the coil with water sprinkled from the top to the Liquid Air Contacting Device and air passed through the duct. It is seen that when water is made to come in contact with the outdoor air the relative humidity of air increases. With increase in air velocity, air flow rate increase so more mass of air comes in contact with water because mass flow rate of water was kept maximum. So humidity effectiveness increases with increase in flow rate. In the very first reading rise in humidity and humidity effectiveness are maximum. This may be due to the reason that in the initial experiment outdoor air was supplied at the inlet which was quiet dry and hence there were maximum potential for mass transfer to take place from water to air. This can also be observed from the graph of humidity effectiveness versus air velocity as shown in figure 2.

TABLE 2 EFFECT OF WATER ON PERFOMANCE OF SYSTEM

| Velocity of air, m/s | Specific Humidity, kg/kgda | | % rise | Humidity Effectiveness, % |
|---|---|---|---|---|
| | Inlet | outlet | | |
| 0.015 | 0.0116 | 0.020114 | 73.39 | 163.73 |
| 0.08 | 0.0224 | 0.0232 | 3.5 | 44.44 |
| 0.125 | 0.0202 | 0.02308 | 14.25 | 90.00 |

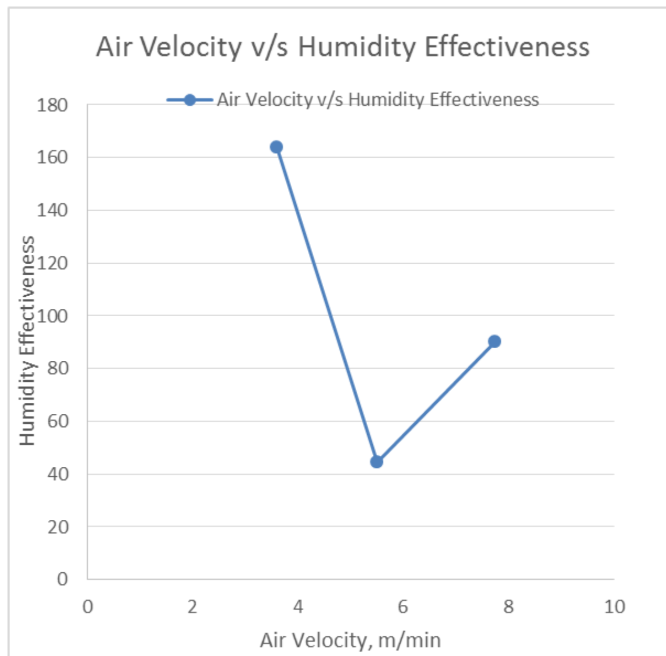


Fig.2 Humidity effectiveness versus air velocity

## V. CONCLUSION

From experimental investigation it has been observed that the liquid air contacting device developed has potential to carry out humidification/dehumidification for air conditioning system. It can be used for dehumidification of room air using Liquid Desiccant. More experiments are required to be carried out to understand the effects of the various parameters in details.

## REFERENCES

[1] J. R. Mehta, and H. C. Badrakia, Fresh air dehumidification in a novel desiccant-air contacting

device, IOSR Journal of Mechanical and Civil Engineering, vol 11 pp 79-82.

[2] J. R. Mehta, and M. V. Rane, Liquid desiccant based solar air conditioning sysem with novel evacuated tube collector as regenerator, Procedia Engineering, 51, 2013, 688 – 693.

[3] J. R. Mehta, and A. A. Sujela, Conditioning of outdoor air using rotating disk type liquid desiccant-air contacting device, IOSR Journal of Mechanical and Civil Engineering (ICAET-2014), 41-45.

[4] S. Jain, and P. K. Bansal, Performance analysis of liquid desiccant dehumidification systems, Int J. Refrig.,30, 2007, 861-872.

[5] M. V. Rane, S. V. Kota Reddy, and R. R. Easow, Energy efficient liquid desiccant-based dryer, Applied Thermal Engineering, 25, 2005, 769-981.

[6] K. Gommed, and G. Grossman, Experimental investigation of liquid desiccant system for solar cooling and dehumidification, Solar Energy, 81, 2007, 131-138.