Experimental Investigations on Novel Geometry Counter Flow Air Cooler

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***Abstract*— As there is rapid increase in thermal comfort requirements, more and more advancement is taking place in the field of HVAC day by day. This study investigates the test performance of Dew Point Evaporating Cooler (DPEC). Altered fluid flow channels are used to augment the heat transfer rate. The setup consists of a counter flowing heat exchangers which comprises of vertically placed trapezoidal plates with alternate wet and dry channels. Moisture wicking cotton cloth and coir fiber are used to keep the plates wet for longer period of time. Water is sprinkled in the wet passages with the help of submersible water pump. To study the effect of the setup at different incoming air conditions an air handling unit is used. The performance is based on laboratory trials. The trials resulted in varying wet bulb and dew point efficiencies between 47.8% and 29.7%, 75% and 44% respectively.**

Keywords - Flow Passages, Counter Flow, Coir Fiber, Air handling unit, Dew Point

I. INTRODUCTION

Energy demand has increased sharply for the cooling purpose in the last few decades which results in increased depletion of energy resources and leading to global warming. These problems are caused by using traditional air conditioning systems which uses artificial refrigerants. Since there is need of alternative system which consumes less energy than the traditional air coolers.

Against the flow Indirect evaporative cooling, often known as IEC, is an exciting new technology that shows promise for use in cooling applications in arid and hot regions. IEC uses less energy than conventional air coolers, which require a large amount of power. Against the flow The IEC has a number of benefits that other cooling systems do not have. To begin, it consumes a far lower quantity of energy than other conventional coolers do because it simply needs power to run the pump and fans that are responsible for moving air and water. Second, it does not utilise any toxic refrigerants, which means that it does not contribute to the warming of the planet or the depletion of the ozone layer. It is possible for it to provide a higher level of control over the humidity. A counter flow IEC can achieve energy savings up to 50% compared to conventional air-cooling system [1-2].

Researchers led by Abohorlu Dogramaci and colleagues investigated the potential of eucalyptus fibres as a substantial for use in cooling pads as an alternative to the conventionally employed commercial items. The study reveals, an utmost temperature drop, cooling efficiency and COP as 11.3^{0}C, 71% & 4.05 respectively. For an inlet air velocity of 0.6 m/s [3]. In this study, Jain and Hindoliya investigated the potential use of coconut fibres and palash fibres as replacements for commercial fibres through the use of controlled laboratory experiments. A temperature drop of 14.9^{0}C and 16.23^{0}C for coconut fiber and palash fiber respectively was observed [4].

Evaporative cooling's performance and efficiency are influenced by the incoming air velocity, air mass flow rates, and environmental moisture content. It also depends on the thickness of the evaporative media and the placement of the system[5].

Comparison of both trapezoidal and sinusoidal plates were done and concluded that trapezoidal plates has more heat transfer rate, efficiency and cooling capacity than sinusoidal plates [6].

Results of operational parameters (COP, DPT) of the prototype depends on the space to be conditioned. The cooler can be utilized in buildings with a variety of applications because to its large COP and small geometrical shape. The cooler can reach temperatures near to DPT regardless of the temperature of the input air when R (ratio of emissions to inlet air flow-rate) is high and the inlet air flow-rate is low. By using polymer sheets wrapped with hydrophilic materials to observe water, heat exchangers capable of observing vast amounts of water can be produced. [7]

Compared the 1-D and 3-D model of counter flow DPEC system. The 1-D model gives low outlet temperature nearby 1.86% compared with 3-D model. Air handling unit is used to control inlet air conditions which consists of heating and dehumidifying elements.

The 1D model is used to examine the effects of geometric and functional variables on the various parameters. While mass flow rate only has a minor impact on WBE, the has a significant impact on it. The WBE also rises as the recirculation factor rises, but the WBE falls as the mass flow rate rises. In wet areas, longer channels increase the amount of time and surface area where air and water come into contact. WBE diminishes when the channel width rises. A greater outlet-temperature was the result of a higher inlet-air temperature. The experimental results showed that WBE of the DIEC Can reach the value as high as 125%. The heat transfer rate of can be increased by using Aluminium foil in the channels than the hydrophilic materials. [8-9].

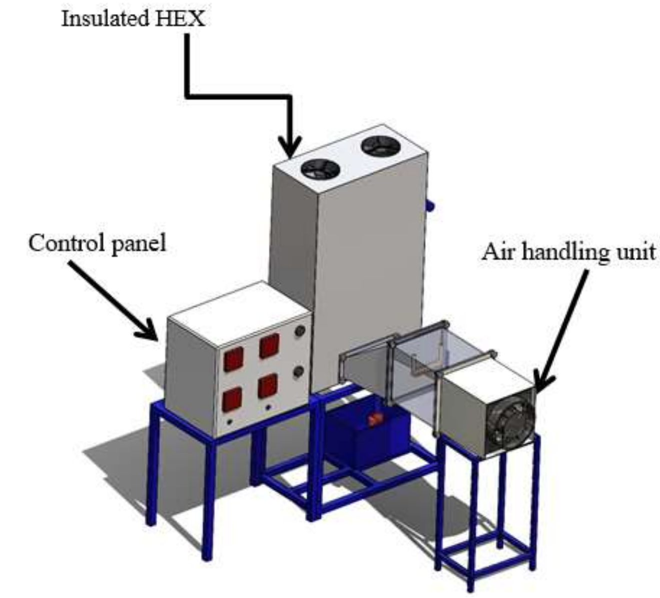

Figure 1 : Layout of the proposed cooler

The innovative DPEC was able to cool the air to a temperature that was below the WBT at the entry point and near to the DPT. This was accomplished by moving the air through a series of heat exchangers. According to modelling studies, the cooler could operate with variable inlet conditions (air temperature and humidity ratio) and achieve WBE of up to 132% and DPE of up to 93%[10-13].

A. Equations

1. Wet-Bulb Cooling Effectiveness

$$E_{wb} = \frac{DBT_1 - DBT_2}{DBT_1 - WBT_1} \quad (1)$$

2. Dew-Point Cooling Effectiveness

$$E_{dp} = \frac{DBT_1 - DBT_2}{DBT_1 - DPT_1} \quad (2)$$

3.Cooling Capacity

$$Q_{cool} = C_p (T_{db1} - T_{db2}).(1-\varphi).mass \quad (3)$$

3. Coefficient of Performance (COP)

$$COP = \frac{Q_{cool}}{P_{fan} + P_{pump}} \quad (4)$$

Fig.2 Fabricated Prototype

II. EXPERIMENTAL TESTING METHODOLOGY

The laboratory small scale model is subjected to trials at different air inlet conditions. The inlet air and supply air temperatures were recorded by PT-100 thermometers. The relative humidity was recorded by the hygrometer. The power input for inlet and exhaust fans , water pump was recorded by power meters and incoming air velocity by hot wire anemometer.

A. Inlet air temperature influence on supply-air temperature

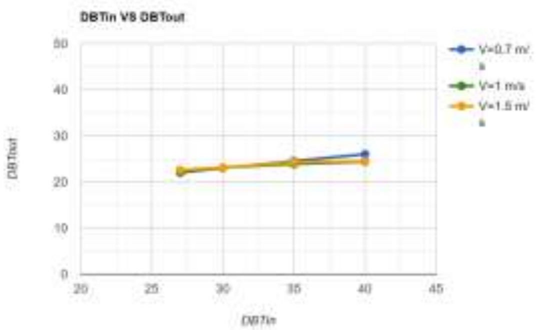

Fig.3: Changes in supply air temperature with inlet air temperature

IV.EXPERIMENTAL RESULTS AND DISCUSSIONS

Laboratory trials were done subject to various air inlet velocities (0.7 m/s, 1 m/s, 1.5 m/s) at different air inlet temperatures (27 ^{0}C, 30 ^{0}C,35 ^{0}C,40 ^{0}C).

The experimental results obtained for the prototype are presented below.

The difference in supply air that occurs with varying input air speeds is depicted in Figure 3. The air that is being drawn in has a higher temperature than the air that is being provided, which has less temperature. When the temperature at the entrance is low, there is less of a temperature drop. The research also showed that there is a correlation between a high temperature at the entrance and a large temperature drop.

B. Inlet- air effect on wet-bulb effectiveness

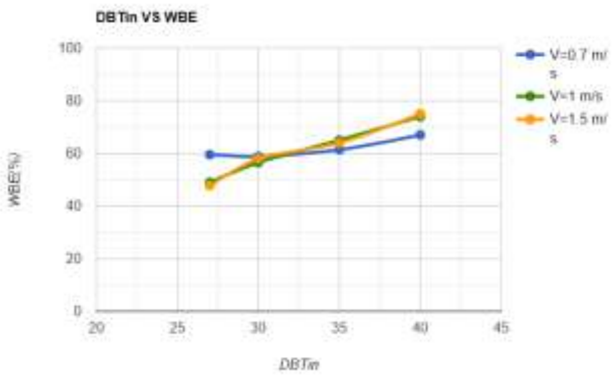

Fig.4:Changes in wet-bulb usefulness with inlet-air temperature

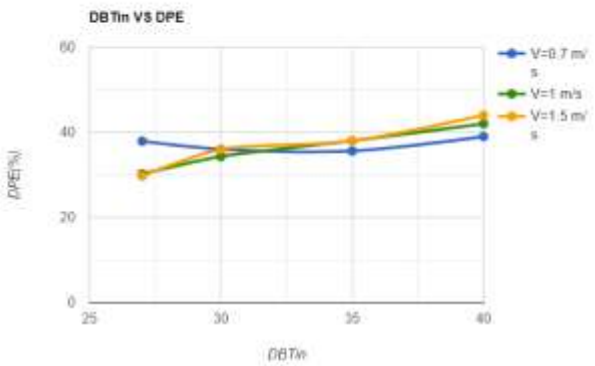

Fig.5: Changes in DPE with inlet air temperature

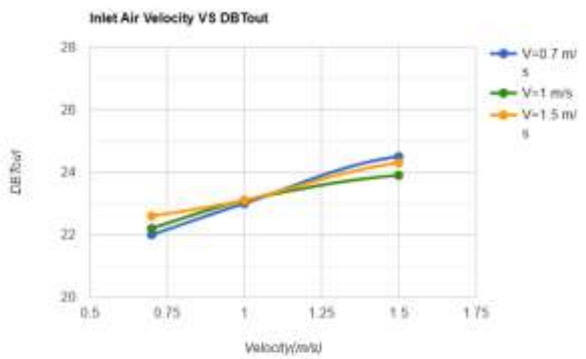

Fig.6: Changes in supply air-temperature with inlet-air velocities

The differences in WBE are depicted in Figure 4 for a range of varied inlet air temperatures. Calculating the WBE requires the temperatures of the incoming air to be known in advance. The WBE varies between 47% to 75% for the modified plate configuration. It is calculated from equation (1).

C. Inlet air influence on DPE

Fig.5 represents the variation in DPE by known variable inlet air temperatures. The DPE goes on increasing with rise in the inlet-air temperature as the temperature drop is high for high inlet-temperature. It is calculated from equation (2).

D. Inlet-air velocity impact on the supply-air temperature

Fig.6 shows the variation of supply-air temperature with different inlet-velocities. The supply-air temperature does not vary for velocity of 1m/s taken as input.

V. CONCLUSION

The In this work, the experimental performance of a suggested cooler that uses a heat exchanger comprised of trapezoidal plates plate configuration has been evaluated. The results of the experiment showed that WBE could be anywhere from 47.8% to 75%, and that DPE could be anywhere from 29.7% to 44%.

ABBREVIATIONS

WBT	Wet Bulb Temperature, ^{0}C
DBT	Dry Bulb Temperature, ^{0}C
DPT	Dew Point Temperature, ^{0}C
COP	Coefficient of performance
E_{dp}/DPE	Dew Point Effectiveness, %
E_{wb}/WBE	Wet Bulb Effectiveness, %
IEC	Indirect Evaporative Cooling

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