EXPERIMENTAL PERFORMANCE OF DIRECT EVAPORATIVE COOLER

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Abstract - *This paper presents testing and experimentation of Direct Evaporative Cooler. The performance of direct evaporative cooling system is evaluated with different operating conditions. Rectangular shaped cellulose pad is used as cooling media. It has been observed that temperature difference of 6˚ to 7˚ can be achieved with Relative humidity in the range of 65% to 80%. Maximum cooling capacity of 1.1267 KW and maximum COP of 19.47 can be achieved.*

Key Words: Direct Evaporative Cooler, cooling capacity, humidity.

1. INTRODUCTION

Evaporative cooling differs from typical air conditioning systems, which uses Vapour Compression System or Vapour Absorption System for providing cooling effect. In evaporative cooling, liquid is converted into vapour using thermal energy of air, resulting in a lower air temperature. The energy required to evaporate the water is taken from the air in the form of sensible heat, which affects the temperature of air, and gets converted in to latent heat. The evaporative cooling therefore results in temperature drop in air corresponding to sensible heat drop and increase in humidity is proportional to latent heat gain. [1]

Direct and Indirect Systems are the two basic types of evaporative cooling systems. In Direct Evaporative Cooling, air and water are in direct contact with each other and also it adds some amount of moisture to the air. Whereas in Indirect Evaporative Cooling, air and water does not come in contact with each other. Although, IEC does not add moisture to air but its cooling effectiveness is generally low than DEC. [2]

2. Literature Review:

1) **Ibrahim U. Haruna, Lateef L. Akintunji:** They have theoretically analysed the performance of direct evaporative cooler in hot and dry climate with kano being the study area. The performance of cooler was determined at different air velocities at saturation effectiveness of 50% to 90%.These results shows that leaving air temperature of 21.9℃ and relative humidity of 82% were obtained with pad material of 90% saturation effectiveness. The cooling capacity and water consumption rate are found to vary linearly with the saturation effectiveness.

2) **Abdulrahman Th. Mohammad,Sohif Bin Mat**: They have done experimental investigation on direct evaporative cooler in hot and humid region ,experimental study is based on weather data Kuala Lumpur ,Malaysia, the performance of evaporative cooler is evaluated using output temperature ,saturation efficiency, and cooling capacity .During experimentation ,the inlet air conditions were as follows, the dry bulb temperature 29.6˚ to 36˚. The air relative humidity 42.5 to 81.1 % and the solar radiations 307.4 to 903.7 W/m^2 .the average velocity during the experiment was 5.5 m/s and water flow rate 10 lit/min. Experiment indicated that DBT decrease upto 7.6˚ is obtainable by using direct evaporative cooling unit in hot and humid region, saturation efficiency varies from 77.3% to 63.5% and cooling capacity ranges from 1.384 KW to 5.358 KW.

3) **J.k. Jain ,D.A Hindoliya**: They have presented development and testing of a regenerative evaporative cooler ,they have been modified conventional direct evaporative cooler by adding water to air, heat exchanger in the path of outgoing air stream and heat exchanger cools the air further by using cooled water available in the cooling tank. They have been found that efficiency and COP of regenerative system is increased by 20-25%,they have conducted experiment and found that regenerative evaporative cooler is advantageous for providing more cooling compare to an ordinary direct evaporative cooler which can make cooler more useful for providing thermal comfort in residential and commercial building. They have plotted graphs for DEC and regenerative DEC.

4) **Rajesh Maurya,Dr Nitin Shrivastava,Vipin Shrivastava**: They have studied three types of cooling pad made of cellulose ,aspen fiber, coconut coir, this study is performed in summer and best on weather conditions of Bhopal having maximum DBT and calculated saturation efficiency and cooling capacity ,result shows that saturation efficiency at air velocity 0.5 m/s is highest for aspen material at 80.99% compare to 69.58% for cellulose pad.

3 Principle of Working:

The principle of DEC is to convert sensible heat to latent heat. Non-saturated air is cooled by heat and mass transfer, which increases by forcing the moment of air through an enlarged liquid water surface area for evaporation by using fans or blowers.

Fig 1 shows the schematic diagram of direct evaporative cooling system where water is running in loop and the makeup water entering the sump to replace evaporated water must be at same adiabatic saturation temperature of the incoming air. In DEC, heat and mass transferred between air and water decreases the dry bulb temperature of air and increases its humidity, keeping the enthalpy constant in an ideal process.

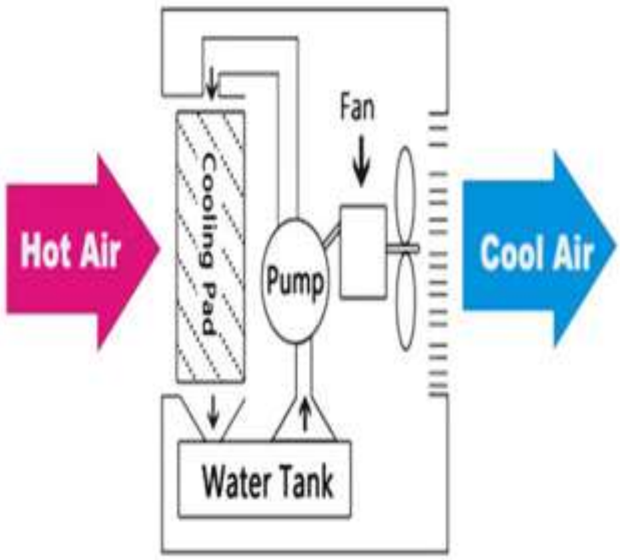

Figure 1. Direct Evaporative Cooling (DEC)

Figure 2 represents the cooling process of Direct Evaporative Cooling on Psychometric Chart.

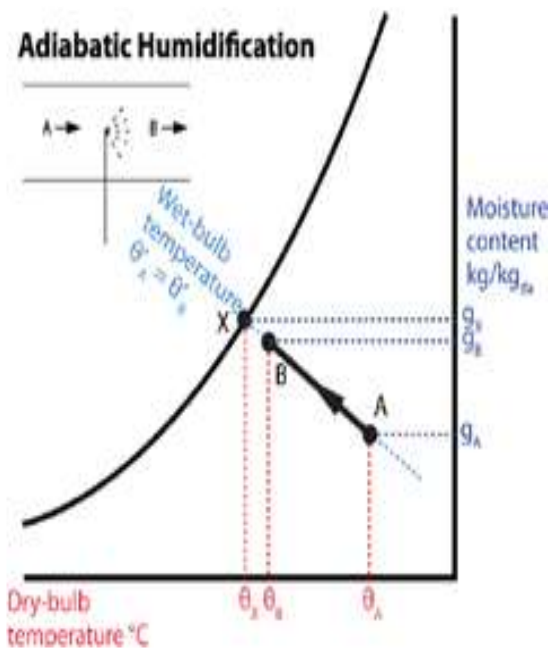

Figure 2: Cooling process on Psychometric chart

4. Experimental Setup:

The direct evaporative cooling that is used for study consists mainly of two blowers at the end of unit and a submersible pump to sprinkle water on the upper side of the pad. Air passes through the unit in horizontal configuration. The evaporative cooling is made of aluminium. A cellulose pad is used as cooling media with a length of 250mm, width of 220 mm, and height of 155 mm. Both the blowers are made to run at around 2500 rpm and 12V DC submersible pump has a flow rate of 3.33 lit/min.

Measurements and Instruments:

The performance of direct evaporative cooling system is evaluated with different operating conditions. To measure the dry bulb temperature of air sling psychrometer is used. Then by plotting the temperatures on psychometric chart relative humidity is calculated. One Anemometer is used to measure the air velocity.

The mass flow rate of air entering the evaporative cooling unit is determined by using the air velocity and the cross sectional area of the inlet duct.

Methodology:

The experiment was conducted in the summer month of May. The evaporative cooling unit was run for sufficient time to obtain steady state conditions. Dry bulb temperature and wet bulb temperature for ambient air were recorded by using sling pyschrometer. Sufficient number of observations were taken.

Saturation effectiveness is dependent on the thickness of pad. It is calculated as,

$\epsilon = (T_1 - T_2) / (T_1 - T_{wbt})$

Cooling capacity is given by,

$Q_c = m_a \times C_{pa} \times (T_1 - T_2)$

where,

T_1= DBT of air inlet

T_2= DBT of air outlet

T_{wbt}= WBT of air

m_a= mass flow rate of air

C_{pa}= specific heat of air

Results and Discussions:

Experiments were performed during summer season and the values of DBT of inlet and outlet of air, relative humidity, and cooling capacity are shown in Table 1.

Table 1: Experimental Data and Performance Parameters

Time` (Minute)	DBT (input) (°C)	WBT (input) (°C)	RH(input) (%)	DBT (output) (°C)	DPT (%)	RH(output) (%)	Q_c (KW)
11.00	32.5	23	44.39	28	20.92	65.44	0.7243
11.10	33	23.5	44.87	28.5	21.47	65.77	0.7243
11.20	33	23.5	44.87	28.5	21.47	65.77	0.7243
11.30	33.5	24	45.84	29	22.03	66.10	0.7243
11.40	33.5	24	45.34	29	22.03	66.10	0.7243
11.50	34	24	45.34	29	22.03	66.10	0.8048
12.00	34.5	24.5	43.93	29	22.78	69.21	0.8852
12.10	34.5	24.5	43.93	28.5	22.98	72.10	0.9657
12.20	35	24.5	42.14	29	22.78	69.21	0.9657
12.30	35.5	25	42.60	29	23.52	72.37	1.046
12.40	35.5	25	42.60	29	23.71	75.37	1.046
12.50	35	24.5	42.14	28.5	23.18	75.12	1.046
01.00	35.5	25	42.60	29	23.52	72.37	1.046
01.10	35	25	44.39	28	23.90	78.47	1.1267
01.20	35	25	44.39	28	23.90	78.47	1.1267
01.30	35.5	25.5	44.84	28.5	24.25	75.59	1.1267
01.40	35.5	25.5	44.84	28.5	24.25	75.59	1.1267
01.50	35.5	25.5	44.84	28.5	24.25	75.59	1.1267
02.00	36	26	45.27	29	24.78	75.82	1.1267
02.10	36	26	45.27	29.5	24.78	75.82	1.046
02.20	35.5	25.5	44.84	29	24.25	75.59	1.046
02.30	36	26	45.27	29.5	24.78	75.82	1.046
02.40	36	26	45.27	29.5	24.78	75.82	1.046
02.50	35.5	25.5	44.84	29	24.25	75.59	1.046
03.00	35.5	25.5	44.84	29	24.25	75.59	1.046
03.10	35	25	44.39	28.5	23.71	75.12	1.046
03.20	35.5	25.5	44.84	29	24.43	78.68	1.046
03.30	34	25	48.18	28	23.90	78.47	0.9657
03.40	34	24.5	45.80	28	22.64	74.87	0.9657
03.50	33.5	24.5	47.75	27.5	22.64	74.87	0.9657
04.00	33	24	47.30	27	22.84	78.04	0.9657

During experimentation, dry bulb temperature of air varies between 32.5 ˚ to 36 ˚ and relative humidity from 44.39% to 45.27% for different operating conditions. Whereas, dry bulb temperature of air varies from 28 ˚ to 29.5 ˚ and relative humidity from 65.44% to 75.82%. Maximum temperature difference of 6.5 is achieved with relative humidity of 75.82%. It can be observed that maximum cooling capacity of 1.1267 KW can be obtained around 1:30 pm to 2:00 pm as shown in fig 5.

Also, COP of the system is given by,

$COP = Q_c / P$

$COP = 1126.7/57.24$

$COP = 19.4995$

where,

P= Total Power Consumption

Q_c= Cooling Capacity

Figure 3: DBT vs Time

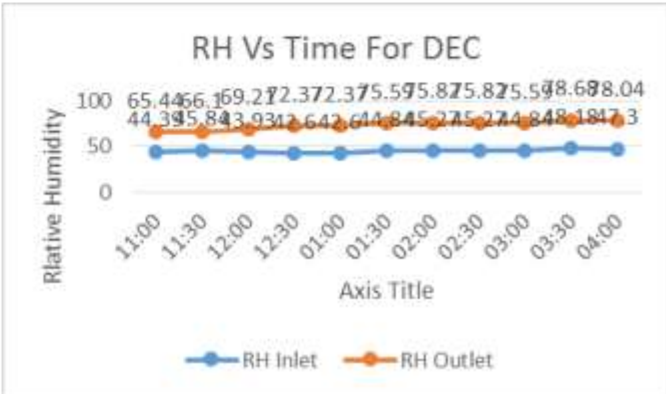

Figure 4: RH vs Time

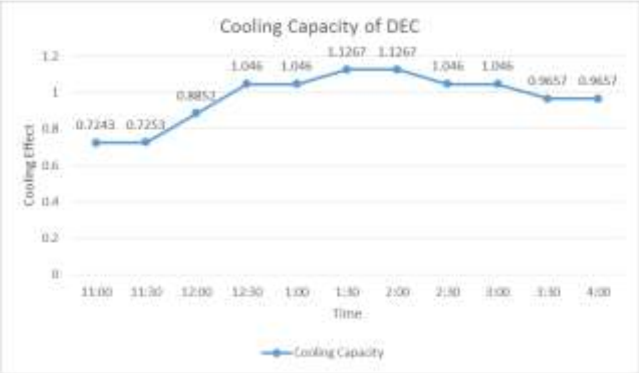

Figure 5: Cooling Capacity vs Time

Conclusion:

The performance of direct evaporative cooling system is evaluated with different operating conditions. Average inlet dry bulb temperature varies between 32 °C and 36°C and relative humidity between 42.14% and 48.18% for different operating condition. The outlet temperature of system varies between 27 °C and 29 °C and relative humidity varies from 65.44 % to 78.68%.Cooling capacity of the system varies between 0.7243 to 1.1267 KW respectively.

From the tests carried out at different conditions the maximum COP of the Direct Evaporative System is found out to be 19.47.

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