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Experimental Investigation on the Performance of Modified Evaporative Cooler

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Abstract:
Cooling on vaporizing be the most primitive methods used by human being for chilling their residents. Now it's been placed on noise footing thermodynamically. It is a method of adiabatic infiltration of air while a squirt of water converted to evaporates interested lacking transfer of heat from or toward surrounding. Despite of some limitations evaporative cooling will produce a condition well within the summer comfort zone. Generally human being feels comfortable when desiccated bulb heat is within 22^{0}C to 25^{0}C and comparative moisture is within 55% - 60%. Modifying the existing evaporative cooler some experimental examination is carried out. Result shows that the DBT is reduced by 13^{0}C; relative humidity maintained in range of comfort zone i.e. 56 % and evaporative cooling efficiency of cooler is improved up to 55% when compared with summer outdoor conditions in Vidarbha (Maharashtra, India) region.

***Keywords:**Evaporative cooling, Evaporative cooling efficiency, Venturi effect, DBT, Relative humidity.*

I. INTRODUCTION

There is increasing in demand of evaporative coolers in the regions such as Rajasthan, Bihar and Vidarbha in Maharashtra as they are quite inexpensive compared with refrigerated air conditioning system. During summer dry bulb temperature of air reached up to 50^{0}C while relative humidity is below 48%. This climate is suitable for evaporative cooling. Cooling and humidification simultaneously can be accomplished by evaporative cooling. It involves either spraying of liquid water into air or forcing the air through a soaked pad that is kept saturated with water as in desert cooler, also known as evaporative cooler. The use of evaporative coolers is widespread in residences and commercial and industrial establishments throughout the south-west part of U.S.A. The different types of evaporative coolers which are commonly used are, Pad Type: In this type of coolers, the water is allowed to trickle over the pad under gravity or sometimes forced and the air is passed through the pad of wood excelsior or plastic extrusions which are generally arranged in series with the help of blower. This type of coolers is generally preferred for cooling small rooms and halls. Spray Type: The spray system may include either one or two banks and may be arranged for opposed or parallel spray. The baffles located on the entering side of washer provide good uniformity of air flow across the face of the washer and the eliminator on the leaving side prevents moisture carryover to the leaving air stream. The spray coolers are best suited to large commercial and industrial applications. Rotating type: The rotating type evaporative cooler has rotating evaporator pad made of various layers of flat or crimped copper, bronze or plastic screen. It is kept wet by rotation through water tank. Prefilters are always used to minimize maintenance of the rotating pad and to provide uniform air distribution. With this cooler, air can be cooled to within 2^{0}C to 4^{0}C of wet bulb temperature. Booster Type: The booster system is preferred over other types of coolers when high relative humidity greater than 90% is required to be maintained in the system. This system is well adopted to textile industry.

A. Evaporative Cooling Efficiency

First, Evaporative Cooling Efficiency of evaporative cooler is define as the ratio of actual drop in dry bulb temperature to the wet bulb depression of the entering air.

$$\eta = \frac{t1-t2}{t1-ts}$$

Where,
t_1 = Inlet dry bulb temperature
t_2 = Outlet dry bulb temperature
ts = Inlet wet bulb temperature

II. LITERATURE REVIEW

Wu J.M. [1] et. al theoretically analyzed temperature as well as accumulation transfer among air with water film during a straight evaporative chiller by soaked long-lasting honeycomb papers and basic association of cooling competence is tested by the examination outcome of straight evaporative cooler. Dai Y. J. [2] et. al experimentally studied the characteristics and the performance of a cross flow evaporative cooler using honeycomb paper as packing material. Result showed that the air temperature is reduced by 9^0C and increased in humidity ratio by about 50%. The minimum air temperature can be obtained at the length of the air channel to be about 5–10 cm. Qiang Zhang [3] et. Al also showed the investigational plus hypothetical examination of a TSEC component. The vent air warmth fall next to the two-stage evaporative chiller lying on inlet air soaked bulb warmth, resultant air comparative moisture and protective material width of DEC. Rawangkula R. [4] et. al carried out a presentation investigation intended for fresh production appliance toward constructively recycle an plentiful agricultural ravage, coconut coir (Cocos nucifera), in evaporative chilling pads. Heidarinejad Ghassem [5] et. al experimentally establish with the intention of beneath a variety of outside circumstances, the efficacy of IEC stage changes between 55–61% and the efficacy of IEC/DEC component changes from 108–111%.

III. WORKING PRINCIPLE OF MODIFIED EVAPORATIVE COOLER

The evaporative air coolers takes a shot at the standard of cooling the indoor air by including fine water particles, which expands the moistness level noticeable all around. In Vidarbha locales, moistness level is low and dry bulb temperature is high in the mid year season particularly in the month, mid of April to mid of June, which prompts human distress. Consequently, to defeat this uneasiness adjusted evaporator cooler is built to accomplish comfort cooling without modification in moistness level. The "Altered Evaporator Cooler" fills the need. This venture clears an approach to research the presentation of changed evaporator cooler, which would be a benchmark for future improvement.

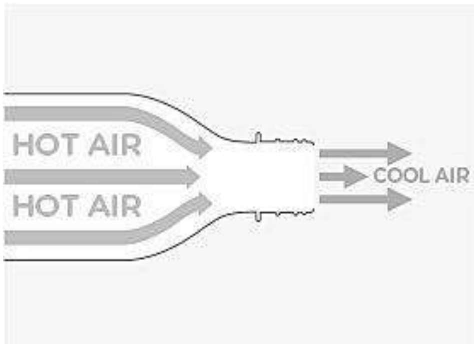

Fig. 1 working principle of modified evaporative cooler

When hot air rushes into the funnel, the air contracts as it approaches the rim of funnel. This results in a decrease in pressure. Based on the Venturi effect, the drop in pressure results in an increase in velocity, which gives air its cooling effect. Further this cooled air passes over the cooling pads of evaporator cooler where it's get humidified. The process followed by air entering into the conditioning room is cooling and humidification which maintains the human comfort conditions.

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IV. EXPERIMENTALSETUP DISCRIPTION AND WORKING

The experimental setup is as shown in fig. It consists of cooler body made up of MS and GI material having dimensions (600 mm x 600 mm x 900 mm). Electric motor (Single phase A.C. motor) operated at 220/230 V, Power -130 W, Speed -1400 RPM. Fan blades having sweep of 16 inches, re-circulating water pump, wood wool as a cooling pad material, calibrated battery operated thermometer with connected temperature measuring sensor having LCD display and hygrometer for measuring relative humidity of air. In addition to this three attachments are provided over cooling pads of cooler which has funnels arranged in series combination which we have called it as modified evaporative cooler as shown in fig. Outside air having high DBT and low relative humidity passes through the funnel arrangement from three sides of evaporative cooler due to Venturi effect, the drop in pressure results in an increase in velocity of air, which results in decreasing DBT. Now the low humidity and decreased dry bulb temperature air passes through a water soaked pads, a part of water evaporates and mixed with air. The energy for evaporation is extracted from the water body and air stream, thus both water and air cooled. Therefore, the stream of air leaving into the conditioned space is rich in moisture and low in temperature.

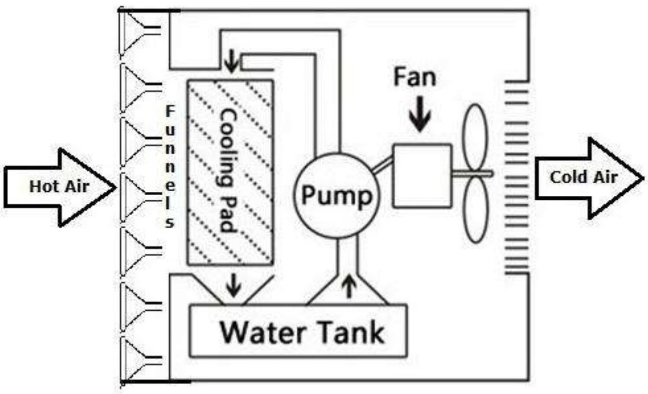

Fig. 2 Schematic of experimental setup

V. RESULTS AND DISCUSSIONS

The experimental investigation has been carried out in summer conditions during afternoon (between 12:00 noon to 5:00 PM) with modified evaporative cooler and various result obtained were compared with evaporative cooler without modification are discussed below.

TABLE I. DETAILS OF TIMING AND DBT WITH AND WITHOUT MODIFICATION

Timing (PM)	**DBT(^{0}C) Without modification**	**DBT(^{0}C) With modification**
12:00 PM	36.9	23.9
1:00 PM	38.6	24.8
2:00 PM	38.9	25.2
3:00 PM	39.3	25.5
4:00 PM	39.1	25.4
5:00 PM	38.7	24.5

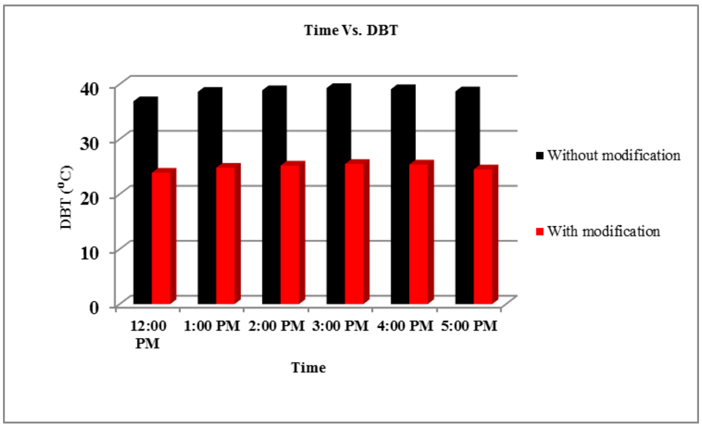

Fig. 3 Graph between time and dry blub temperature DBT (^{0}C)

Fig. 3 shows the variation in dry bulb temperature when modified evaporative cooler compared with normal cooler without modification. From the experimental result it is observed that there is about 13^{0}C drop in DBT between modified and normal cooler. This is because of Venturi effect, the drop in pressure results in an increase in velocity, which gives air its cooling effect. Generally during summer conditions with normal cooler without modification gives 5^{0}C to 6^{0}C drop in DBT. It is also seen that the DBT of modified evaporative cooler well within the

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range of comfort zone as shown in fig.3 which validates the usefulness of this concept.

TABLE II. DETAILS OF TIMING AND RELATIVE HUMIDITY WITH AND WITHOUT MODIFICATION

Timing (PM)	**RH (%) Without modification**	**RH (%) With modification**
12:00 PM	63	53
1:00 PM	56	55
2:00 PM	57	56
3:00 PM	55	57
4:00 PM	58	57
5:00 PM	57	60

Fig. 4 shows the variation in Relative humidity when modified evaporative cooler compared with normal cooler without modification. From the experimental result it is observed that the changes in relative humidity for both cases are in the comfort zone only. This implies that modification done on the evaporative cooler does not affect the humidity factor.

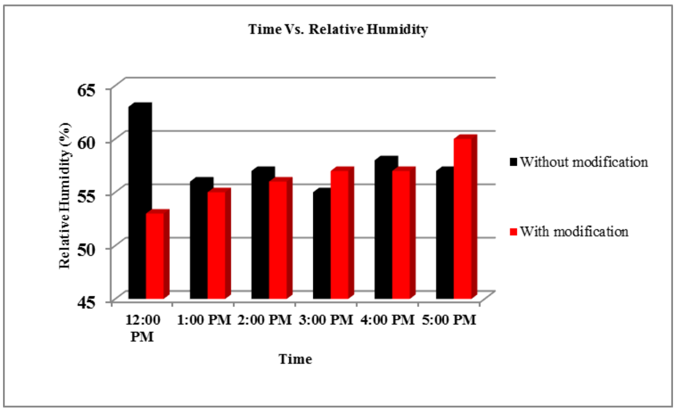

Fig. 4 Graph between time and Relative Humidity RH (%)

TABLE III. DETAILS OF TIMING AND EVAPORATIVE COOLING EFFICIENCY WITH AND WITHOUT MODIFICATION

Timing (PM)	**η (%) Without modification**	**η (%) With modification**
12:00 PM	17.85	69.37
1:00 PM	15.15	70.83
2:00 PM	21.11	71.23
3:00 PM	16.5	71.1
4:00 PM	12.37	70.28
5:00 PM	12	75.12

Fig. 5 shows the variation in evaporative cooling efficiency when modified evaporative cooler compared with normal cooler without modification. From the experimental result it is observed that the maximum evaporative cooling efficiency obtained in case of without modified cooler is about 21% only, where as in case of modified cooler it is about 75%. This proves that the modification done on evaporative cooler surely increase the cooling efficiency up to 55% because the DBT of air supplied over cooling pad is already reduced by funnels arrangement which improves cooling effect.

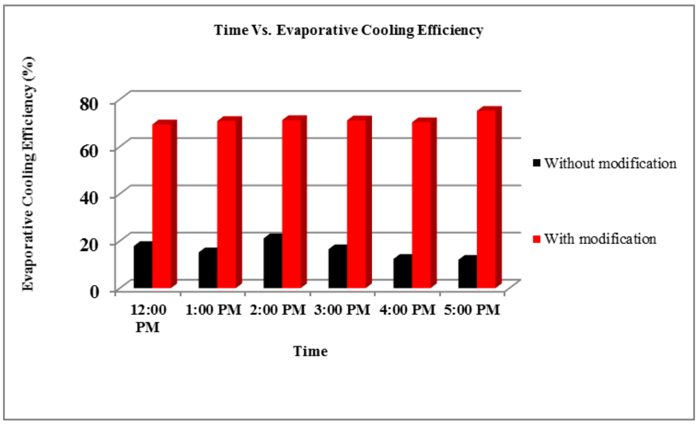

Fig. 5 Graph between time and Evaporative cooling efficiency η (%)

VI. CONCLUSIONS

Experimental investigation on modified evaporative cooler is carried out in the present study. The investigation shows that by employing the additional arrangement to evaporative cooler, with the application of venturi effect the DBT of incoming air reduces, which gives more cooling effect when compared with normal evaporative cooler without modification. It also shows that the modification done on evaporative cooler does not create any impact on relative humidity i.e. the relative humidity on both the cases well within the comfort zone.

From experimentation we can see the evaporative chilling effectiveness is found to be more as compared to normal evaporative cooler.

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