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Performance Enhancement of Evaporative Dessert Cooler By Using Cooling Duct

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ABSTRACT-In this work an indirect evaporative cooling system is applied in a dessert cooler instead of direct evaporative cooling system. This work is carried out to cool the air without letting air come in direct contact with coolant (water) and it was done to contain the humidity at low level inside the room which is to be cooled. To achieve this object a heat exchanger was introduced where indirect evaporative cooling takes place and to enhance air cooling a cooling tower and forced air draught on surface of heat exchanger was also added. This work had shown efficiency up to 72-89% and was able to bring the room temperature from 35℃ to 30℃.

I. INTRODUCTION

In India air conditioning is a very important task as in summer most of the Indian subcontinent have extremely hot weather condition. In India mostly dessert coolers are used for air cooling because of their low cost, low running cost and low electricity consumption in comparison of air conditioner.dessert cooler works on the principle of direct evaporative cooling,therefore dessert coolers needs water in large volume which is a problem for regions like Rajasthan and Madhya Pradesh where water is not available in large volume. Also dessert coolers increases humidity of air which is not desired in rainy weather condition and also increased humidity also creates heath problem.To overcome these problems, in this work a modified dessert cooler was developed which work on the principle of indirect evaporative cooling.

II. RESEARCH METHODOLOGY

Proposed dessert cooler works on indirect evaporative cooling principle. In proposed work a tube in tube heat exchanger was prepared. In proposed work instead of mixing air with water, air is cooled by surface cooling by using heat exchanger. Air is passed from between the cooling duct and cooling pad of heat exchanger.

a) Efficiency of evaporating dessert cooler

$$\eta = \frac{T_{d1} - T_{d2}}{T_{d1} - T_{wb}}$$

Here,
η = Efficiency of dessert cooler
T_{d1} = Dry bulb temperature at inlet.
T_{d2} = Dry bulb temperature at outlet.
T_{wb} = Wet bulb temperature.

b) Relative humidity

$$H = \frac{0.622\ P_v}{P_b - P_v}$$

c)Specific humidity

$$W = \frac{P_v}{P_s}$$

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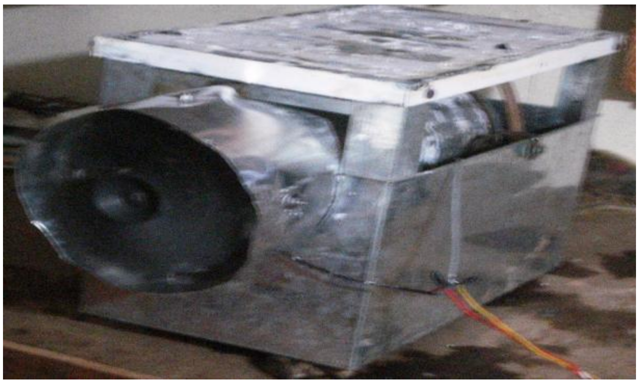
III. EXPERIMENTAL SETUP

Complete Setup

1	Length	24inch
2	Height	18inch
3	Wreath	12inch
4	Weight	14.2kg

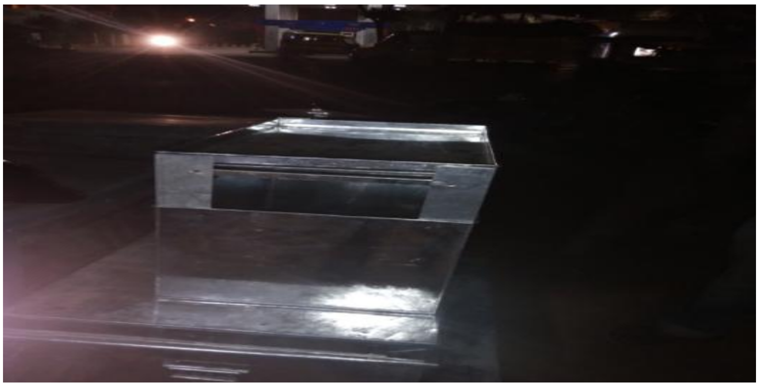


IV. COMPONENTS OF SETUP

a) Cooling tower

The cooling tower is mounted at the top of the cooler. The water flow is made to strike onto the bowl of the cooling tower .the water droplets gets cooled by evaporation before passing through the cooling duct and therefore cools the cooling duct.

1	Material	Steel foil
2	Length	24 inch
3	Height	18inch
4	Wreath	12inch
5	Weight	3.5kg



b) Strainer:

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The strainer is used at the exit of the cooled air flow. The purpose of strainer is to eliminate the extra water particle from the air stream.it has number of small passage through which when air stream passes the suspended water particles gets drained.

1	Material	aluminium
2	Inner diameter	6 inch
3	Outer diameter	9 inch
4	Weight gm	200 gm

c) cooling pad

The cooling pad is an aluminium sheet hollow duct. A 1 cm thick cotton layer has been wrapped around the duct. The cold water from the cooling tower is made to fall on the cooling pad. It takes the heat from the hot air flowing through the duct. Evaporation takes place at the cotton pad leaving the duct cold.

1	Material	Steel, cloth
2	Diameter1	6.2 inch
3	Diameter 2	9 inch
4	Thickness of cotton	40 mm

d) The Exhaust fan:

The exhaust fan is used the through the cold air from the cooling duct to the cabin bringing down the temperature the temperature of the cabin. It also limits the flow of the air stream to the cabin. An exact diameter and R.P.M exhaust fan should be used to maintain the temperature of the cabin.

1	Weight	2.8 kg
2	Diameter of Fan	12 inch
3	Power of Motor	40 watt
4	R.P.M of Motor	800
5	Material of Fan	Fibre

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e) Cooling duct

Cooling duct is the hollow aluminium sheet duct on which the cooling pad has been provided. The cooling duct allow the air stream to pass through and air gets cooled in this section. It has a flanged portion at its end to receive the strainer.

1	Material	steel
2	Diameter inch	13
3	Weight kg.	1.2
4	Length inch	26

V. OBSERVATION

After preparing the complete setup a no of experiments were conducted on the designed set up and currently available dessert cooler. The observation taken during experiments are as follows:

Experiment no 1 (Dessert Cooler)

DAY	T_{i-1} (℃)	T_{o-1} (℃)	T_{w-1} (℃)	Water consumed (Liter)
1	36.5	30.7	28.3	23.8
2	37	32.5	30	26
3	38	32.8	31	26.4
4	39.2	33.3	31.2	27.2
5	41.3	34.5	32.9	25.4

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Experiment no 2 (Modified Dessert Cooler)

DAY	T_{i-2} (℃)	T_{0-2} (℃)	T_{w-2} (℃)	Water consumed (Liter)
1	36.5	30.4	28.3	18.9
2	37.0	32	30	21.8
3	38.0	32.5	31	21.3
4	39.2	33.0	31.2	22.8
5	41.3	34.2	32.9	21.4

Here,

Here,

T_{i-1} = Inlet Dry Bulb Temperature for dessert cooler

T_{o-1} = Outlet Dry Bulb Temperature for dessert cooler

T_{w-1} = Wet Bulb Temperature for dessert cooler

T_{i-2} = Inlet dry bulb temperature for modified dessert cooler

T_{o-2} =Outlet dry bulb temperature for modified dessert cooler

T_{w-2} =Wet bulb temperature for modified dessert cooler

VI. RESULTS

On conducting mathematical calculation on the basis of observation data. Certain results were obtained. The tables of result are as follows:

a) Result for Experiment no 1

Day	T_{i-1}	T_{o-1}	T_{w-1}	H_1	W_1	η_1
1	36.5	30.7	28.3	0.0312	48.1	70.73
2	37.0	32.8	30.0	0.0313	48.2	68.0
3	38.0	32.5	28.0	0.0317	48.8	77.1
4	39.2	33.3	31.2	0.0319	45.6	73.50
5	41.3	34.5	32.9	0.0343	52.7	80.95

b) Results for Experiment no 2

Day	T_{i-2}	T_{o-2}	T_{w-2}	H_2	W_2	η_2
1	36.5	30.4	28.3	0.0310	45.20	77.50
2	37.0	32.0	30.0	0.0311	47.40	71.00
3	38.0	32.5	28.0	0.0317	48.80	78.50
4	39.2	33.0	31.2	0.0315	45.20	77.50
5	41.3	34.2	32.9	0.0342	52.7	84.52

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Here,
T_{i-1} = inlet dry bulb temperature of dessert cooler
T_{o-1} = outlet dry bulb temperature of dessert cooler
T_{w-1} = wet bulb temperature of dessert cooler
W_1 =specific humidity of dessert cooler
H_1= relative humidity of dessert cooler
η_1 = coil efficiency or by pass factor of dessert cooler
T_{i-2} = inlet dry bulb temperature of modified dessert cooler
T_{o-2} = outlet dry bulb temperature of modified dessert cooler
T_{w-2} = wet bulb temperature of modified dessert cooler
W_2 =specific humidity of modified dessert cooler
H_2= relative humidity of modified dessert cooler
η_2 = coil efficiency or by pass factor of modified dessert cooler

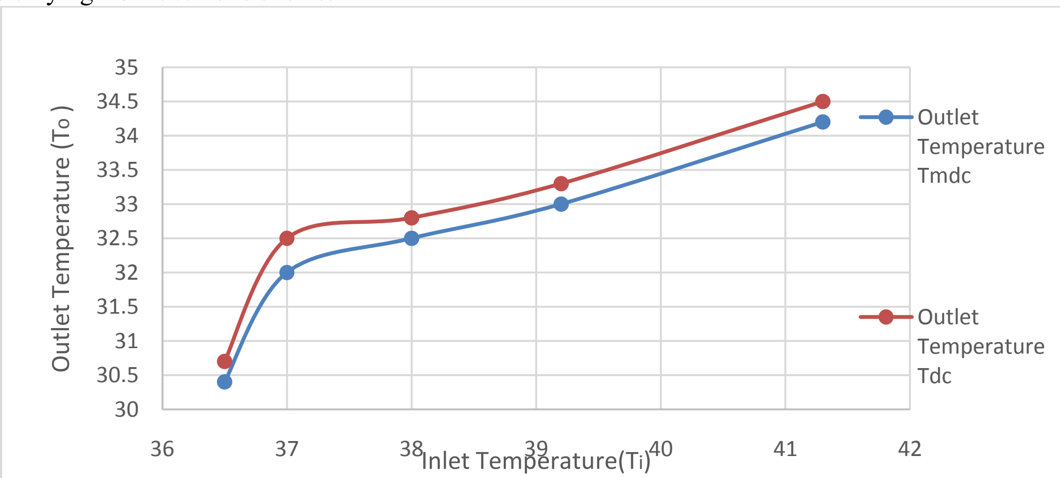
c) Water Consumption Rate

Day	Water Consumed (Per Day)(Lit.)		Water consumption rate(Lit./hr)	
	Dessert Cooler	Modified Dessert Cooler	Dessert cooler	Modified dessert cooler
1	23.8	18.9	3.9	3.15
2	26.0	21.8	4.3	3.63
3	26.4	21.3	4.4	3.55
4	27.2	22.8	4.5	3.8
5	25.4	21.4	4.2	3.56

VII. DISCUSSION OF RESULTS

a) Comparison of outlet temperature of dessert cooler and modified dessert cooler with inlet temperature

Here outlet temperature of dessert cooler varied from 30.7˚c to 34.5˚c while outlet temperature of modified dessert cooler was varying from 30.4˚c to 34.2˚c.



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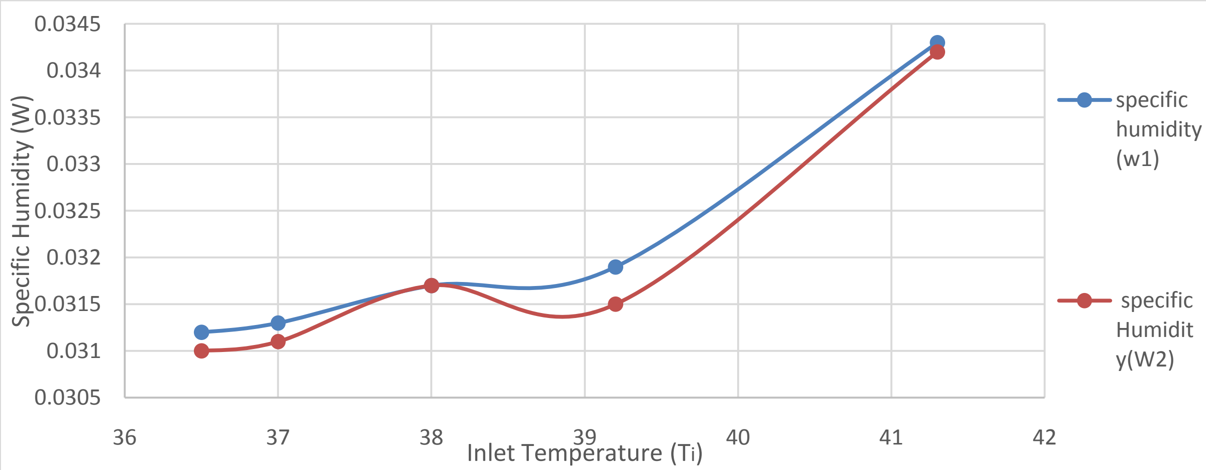
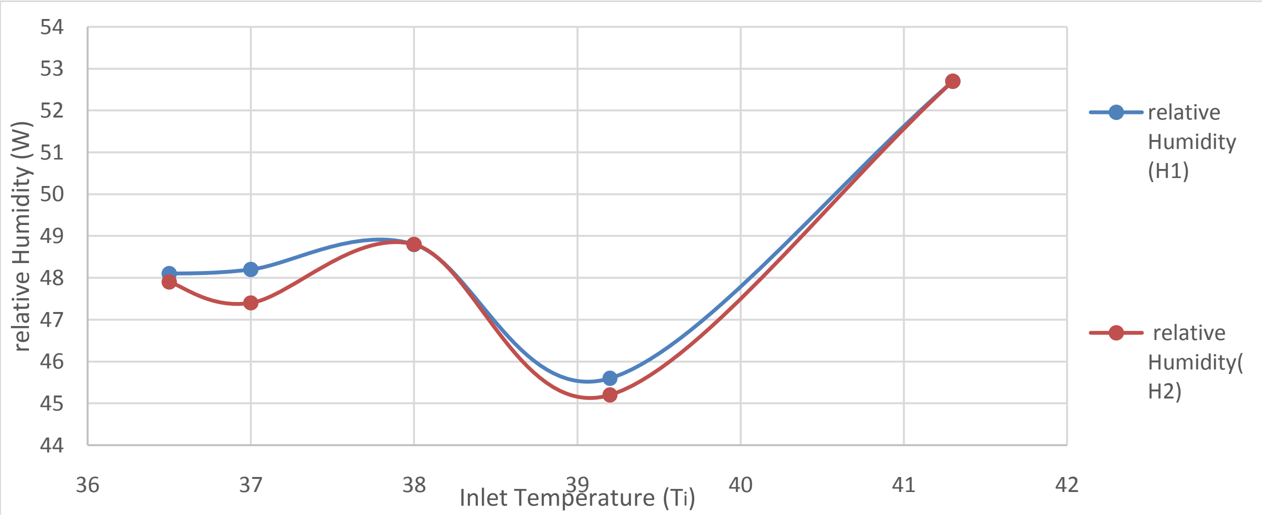
b) Comparison of specific humidity of dessert cooler and modified dessert cooler with inlet temperature

Here specific humidity of dessert cooler varies from 0.0312 to 0.0343 while specific humidity of modified dessert cooler was varying from 0.0310 to 0.034.



c) Comparison of relative humidity of dessert cooler and modified dessert cooler with inlet temperature

Here relative humidity of dessert cooler varies from 45.6 to 52.7 while relative humidity of modified dessert cooler varying from 45.2 to 52.7.



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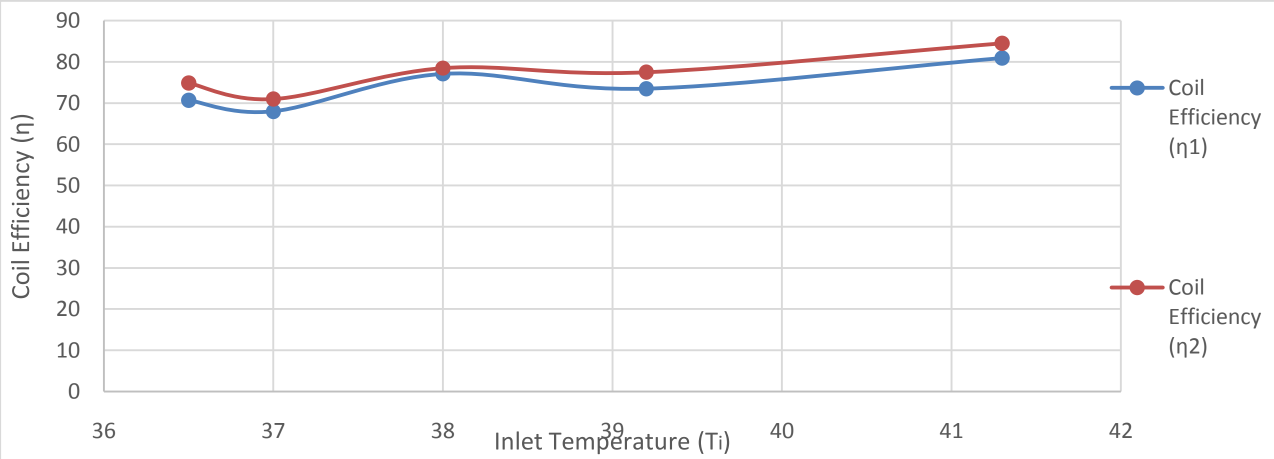
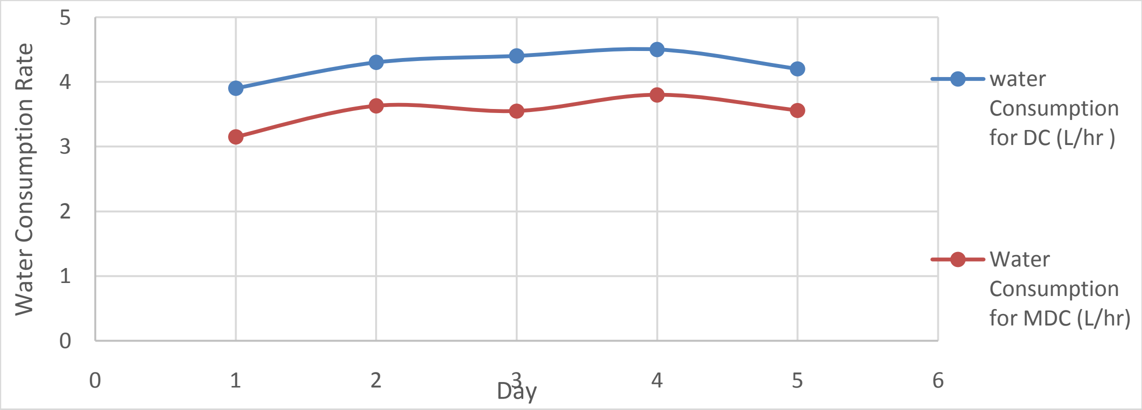
d) Comparison of coil efficiency of dessert cooler and modified dessert with inlet temperature

Here coil efficiency for dessert cooler varies from 68% to 80.95% while coil efficiency for modified dessert cooler varying from 71% to 84.52 %.



e) Comparison of water consumption rate of dessert cooler and modified dessert cooler

Here water consumption rate for dessert cooler varies from 3.9 Lit./hr to 4.5 Lit./hr while water consumption rate for modified dessert cooler was varying from 3.15 Lit./hr to 3.8 Lit./hr.



VIII. CONCLUSION

After a detailed study on the result and analysis following observation were made:

- The present evaporative cooler consumes less water than the existing desert cooler.
- At the increased temperature the cooler with cotton cooling pad is more efficient.

The final and most important observation is that the cotton based cooler gives an excellent humidity ratio than the existing cooler one during rainy season.

IX .FUTURE SCOPES:

Experiments may be carried out by varying the cooling pad material which is friendly to the exposer of water and better result may be obtained.

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