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Experimental Investigation on Desert Cooler Using Different Cooling Pad Materials

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Abstract: ***Desert coolers are important in society, especially in arid regions with hot and dry climates. They provide a cost-effective and energy-efficient alternative to air conditioners, which can be expensive to operate and maintain. Desert coolers use natural cooling mechanisms such as evaporation to cool the surrounding air, which makes them more environmentally friendly than air conditioners. In this case, the cooling materials being considered are coconut coir, wood wool, and honeycomb mesh. This involves constructing a desert cooler with a removable cooling pad compartment to allow for the insertion and removal of the different cooling materials. Install each of the cooling materials in the cooler one at a time and record the temperature and humidity of the air passing through the cooler over a set period of time. Compare the results obtained from each of the cooling materials to determine which one provides the most effective cooling. Honeycomb has been found to have excellent water absorption and retention capacity, which helps in maintaining a high level of humidity in the air passing through the cooler, resulting in better cooling. Honeycomb mesh, on the other hand, has a large surface area and a complex structure that enhances the evaporation process and improves the cooling efficiency. While wood wool is also a popular cooling material used in desert coolers, its efficiency may not be as high as coconut coir or honeycomb mesh. However, the choice of the most efficient cooling material can also depend on other factors such as availability, cost, and environmental impact. Overall, the selection of the most efficient cooling material for a desert cooler may require careful consideration of several factors.***

Keywords: Evaporative Cooling, Cooling Pads (Wood wool, Honeycomb mesh, Coconut coir), Cooling Efficiency.

I. INTRODUCTION

Desert coolers are important in society, especially in arid regions with hot and dry climates. They provide a cost-effective and energy-efficient alternative to air conditioners, which can be expensive to operate and maintain. In this work the experimental investigations will be carried out on desert cooler using different cooling pad materials with three different RPMs in the terms of temperature, humidity and cooling efficiency.

The investigation will also highlight several important performance indicators, including as cooling efficiency, temperature drop, cooling capacity and water consumption that are used to assess the efficiency of cooling pads.

Three alternative cooling pad materials, including wood wool, coconut coir and honeycomb, will be put to the test. A variety of performance criteria, including as cooling efficiency, water usage and temperature drop will be utilized to evaluate each cooling pads performance.

II. EVAPORATIVE COOLING

A. Evaporative Cooling

Evaporative cooling is a thermodynamic process in which hot and humid air passes over a wet surface, thus water evaporates due to hot air and latent heat is gained by air at the expense of sensible heat thereby its temperature is reduced. Thus cooling effect depend on amount of water evaporated, larger the amount of evaporation, maximum the cooling effect. As air gains latent heat thus its relative humidity increases.

Therefore this system is more useful and efficient in hot and dry climate where humidity levels are low. In the most general evaporative cooling system air passes at a constant rate through wetted pad thus it get saturated after some time and water is fed from upper side through pump.

However like air conditioning evaporative cooler is not able to control temperature and humidity accurately. Their cooling capacity depends on outside condition of air.

B. Types of Cooling pad Material

1) *Wood wool:-* Wood wool cooling pads are also called aspen cooling pads. They are made of synthetic fiber and wood shavings and resemble dry grass. Wood wool cooling pads have a comparatively low water retention capacity.
2) *Coconut coir:-* Coconut coir is one of the natural fibers available in tropical regions and is extracted from the husk of coconut fruit.
3) *Honeycomb:-* They are made of well designed cellulose material and are known to have good levels of water retention. The water retention compartments in honeycomb cooling pads quickly transform the outside hot air into cool humid air**.**

III. EXPERIMENTAL SETUP

A. Specification

Parameters	Value
Room upto	16*8 ft^2
Blower/ Fan	fan
Cooler dimensions	43.5cm*34.4cm*61.5cm
Tube capacity	28.24 litres
Fan diameter	23 cm
Speed regulator	3 speeds
Power	230 Watt
Frequency	50Hz
Cooling media	Wood wool, Honeycomb, Coconut coir

B. Experimental Procedure

1) Experiment is performed on desert cooler with different type of pad material.
2) Cooling pad material wood wool is attached to the desert cooler.
3) Set fan speed to three RPMs, starting from the lowest.
4) Fill the tank with normal water and note down the temperature.
5) Switch ON electric supply of desert cooler.
6) Open fully the flow of control valve to keep water flow rate maximum initially so that cooling pad is completely wet in desert cooler.
7) Hygrometer is placed in front of desert cooler. Hygrometer continuously shows temperature and humidity. Note down this temperature and humidity at an interval of 20 minutes.
8) Anemometer is placed in front of desert cooler. Take down the air flow rate at an interval of 20 minutes and also note down the temperature of water.
9) Now comparison is made on the basis of temperature, humidity and cooling efficiency.
10) Similarly experiment is performed for other cooling pad materials and note all the corresponding temperature and humidity shown be hygrometer.
11) Finally a comparison is to be made between these pad materials and suitability of the best pad material is to be evaluated.

C. Formulae Used

1) Cooling efficiency is determined by using following relation is given below:

$$\eta_{cooling} = \frac{T_{dbo} - T_{dbi}}{T_{dbo} - T_{wbo}} \times 100$$

Where,
T_{dbo} = outdoor dry bulb temperature □
T_{dbi} = indoor dry bulb temperature □
T_{wbo} = outdoor wet bulb temperature □

Cooling Capacity

$$Q_c = m_a\,(h_o - h_i)$$

Where,
Q_c = Cooling Capacity, KW
m_a = Air mass flow rate, kg/sec
h_o = *outdoor air enthaply* kj/kg air
h_i = indoor air *enthaply* kj/kg air

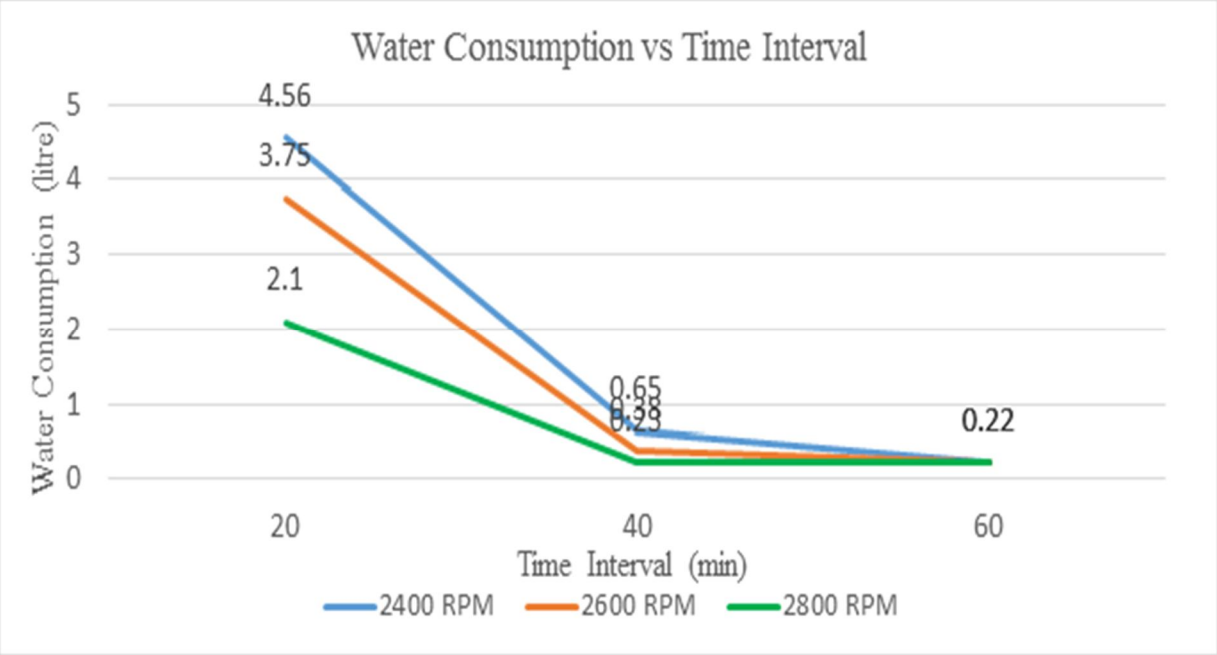
OBSERVATION TABLES

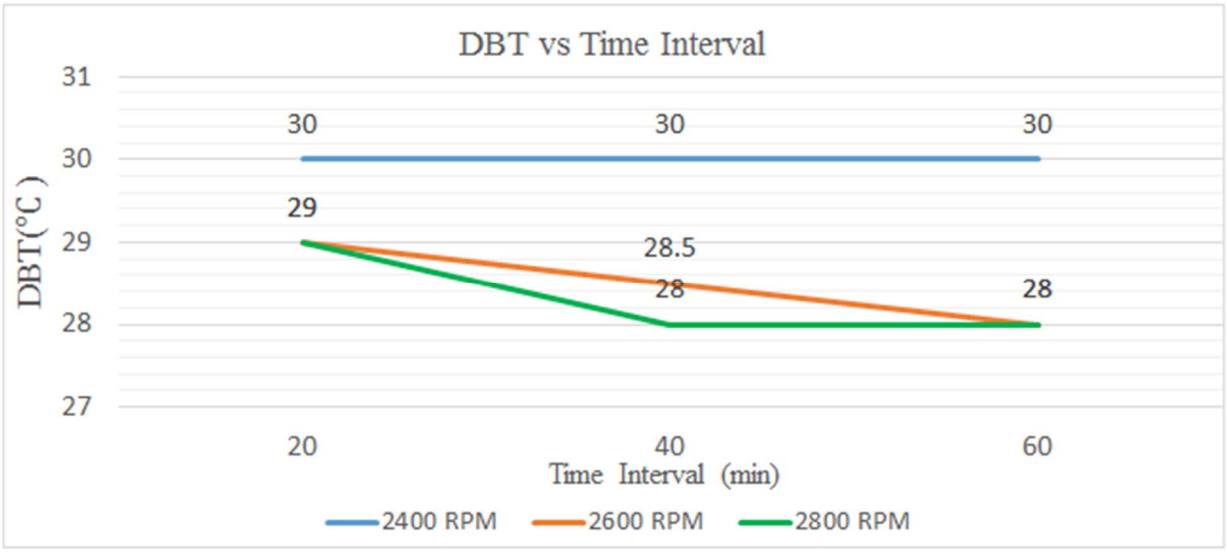
Type of speeds	Speed	DBT (°C)		WBT (°C)		RH(%)		Duration of time (min)	Water consumption (litre)	Air Flow Rate m/s	Temp. Of Water (°C) (26.4°C)	Efficiency (%)	Cooling Capacity kW
		IN	OUT	IN	OUT	IN	OUT						
Coconut Coir (thickness = 7mm) Density =329.51 kg/m^3	2400	30	32	25.5	27	71	69	20	4.56	2	24	40	0.6285
		30	31	26	27	74	73		0.66	1.98	22.6	25	0.4355
		30	31	25	27	66	74		0.22	1.94	22.2	25	0.7980

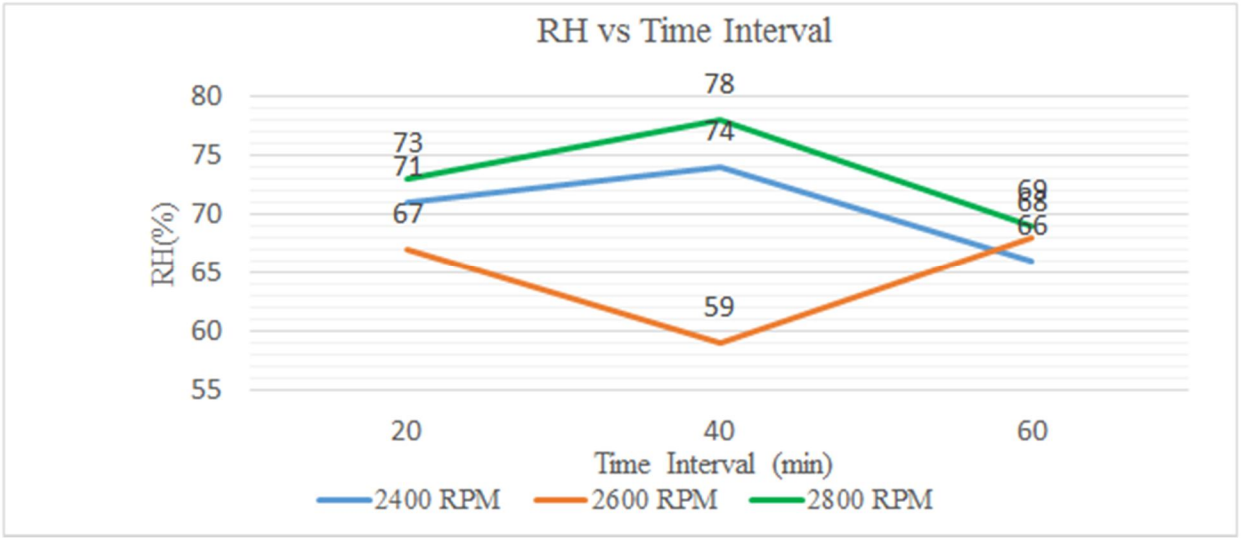
Type of speed	Speed/ Temp. of water	DBT (°C)		WBT (°C)		RH(%)		Duration of time (min)	Water consumption (litre)	Air Flow Rate m/s	Temp. Of Water (°C)	Efficiency (%)	Cooling Capacity kW
		IN	OUT	IN	OUT	IN	OUT						
Honey-comb (Thickness =4cm) Density =25.08 kg/m^3	2400 (25.7°C)	26	27	24	25	85	83	20	6.74	2.14	24.2	50	0.4195
		25	28.5	23.5	24.5	86	75		1.02	2.48	23.5	87	0.4881
		25	29	23.5	24	86	73		0.44	2.33	22.3	80	0.6879
	2600	26	30	24	25.5	85	70		2.8	2.1	24.4	88	0.6179
		26	31.5	24	25	85	66		0.44	2.4	23.2	84.61	0.9416
		26	31.8	23.5	25	74	59		0.43	2.3	22.9	85	0.6768
	2800 (25.7°C)	26	32	23	24	76	57		6.75	2.9	24.7	75	0.5689
		25.5	33	23	24	81	47		0.43	2.9	23.8	83	0.5699
		25	33	23.5	24	86	53		0.87	2.7	22.8	88	0.2657

Type of speed	Speed/ Temp. of Water	DBT (°C)		WBT (°C)		RH(%)		Duration of time (min)	Water consumption (litre)	Air Flow Rate m/s	Temp. Of Water (°C)	Efficiency (%)	Cooling Capacity kW
		IN	OUT	IN	OUT	IN	OUT						
Wood Wool Density= 85.5 kg/m^3	2400 (29°C)	33	34.2	24.6	25.3	51	48	20	4.13	2.5	25.1	13.48	0.299
		31.6	32.3	24.5	25.3	57	56		0.87	2.3	23.6	10	0.276
		30.5	32.6	24.1	25.1	59	55		0.55	2.8	22.9	28	0.60
	2600 (23.9°C)	31.8	32.4	25	25.3	58	57		3.26	2.5	23	8.45	0.17
		31.7	32.4	24.4	24.5	59	54		1.68	2.5	22.9	8.86	0.17
		31.3	32.4	22.6	24.2	48	52		0.5	2.54	22.8	13.41	0.72
	2800 (26.6°C)	29.1	29.8	24.7	24.8	69	67		0.435	2.53	23.4	14	0.11
		28.2	29.1	24.1	24.9	70	71		0.434	2.45	22.9	21.42	0.44
		28.2	29	24.5	24.9	73	72		0.652	2.12	22.6	19.51	0.25

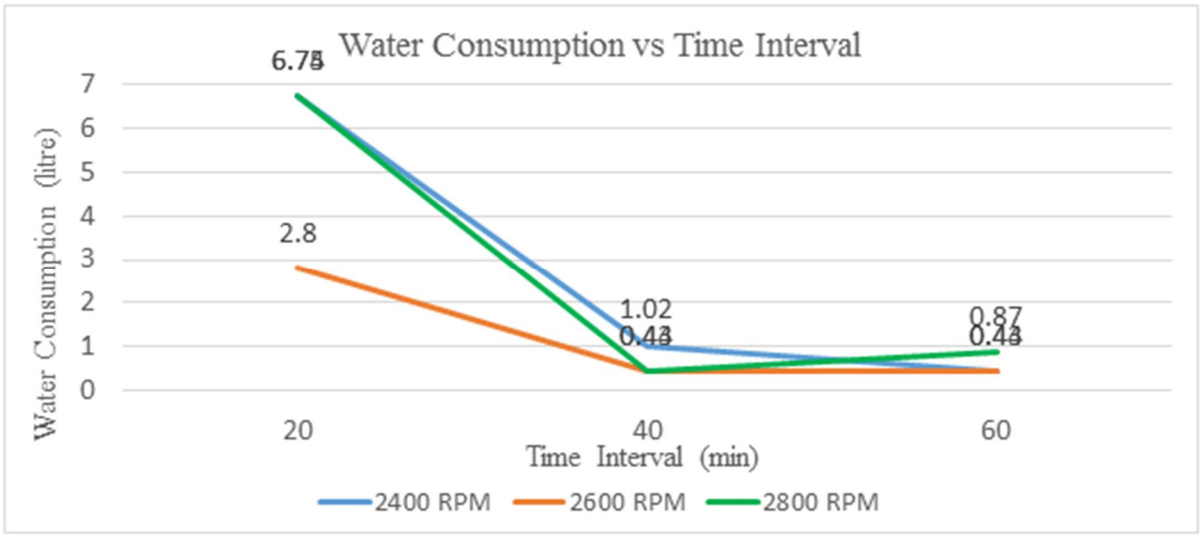
GRAPHS



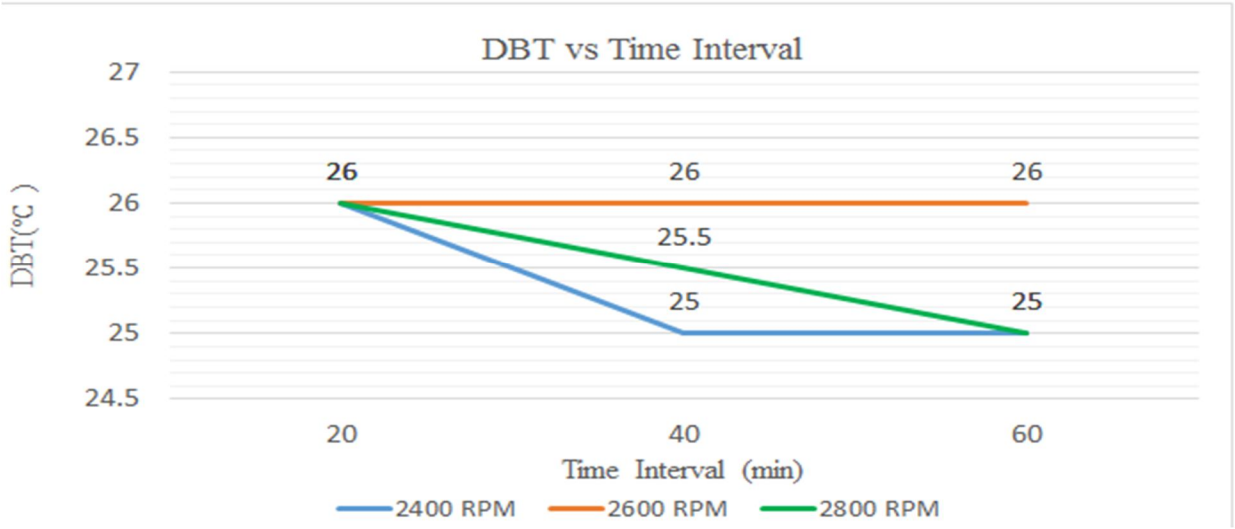


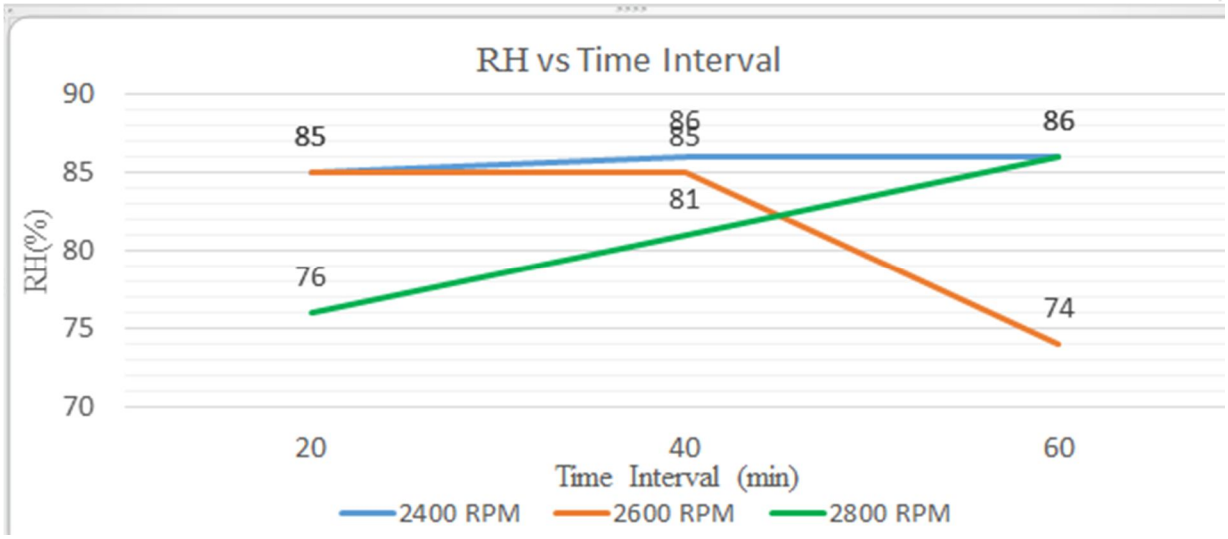


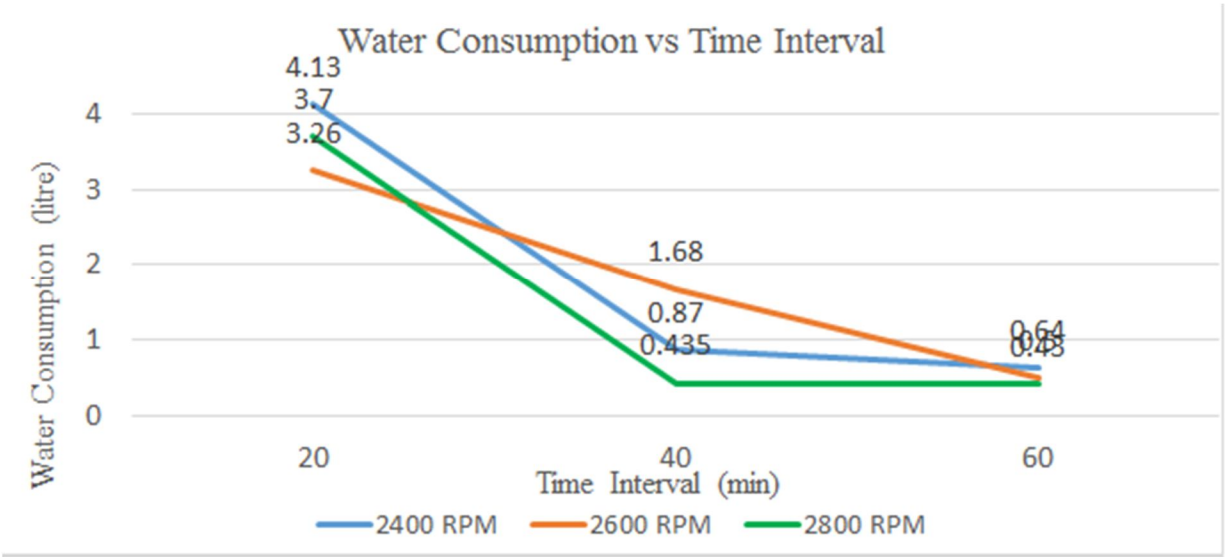
Coconut coir

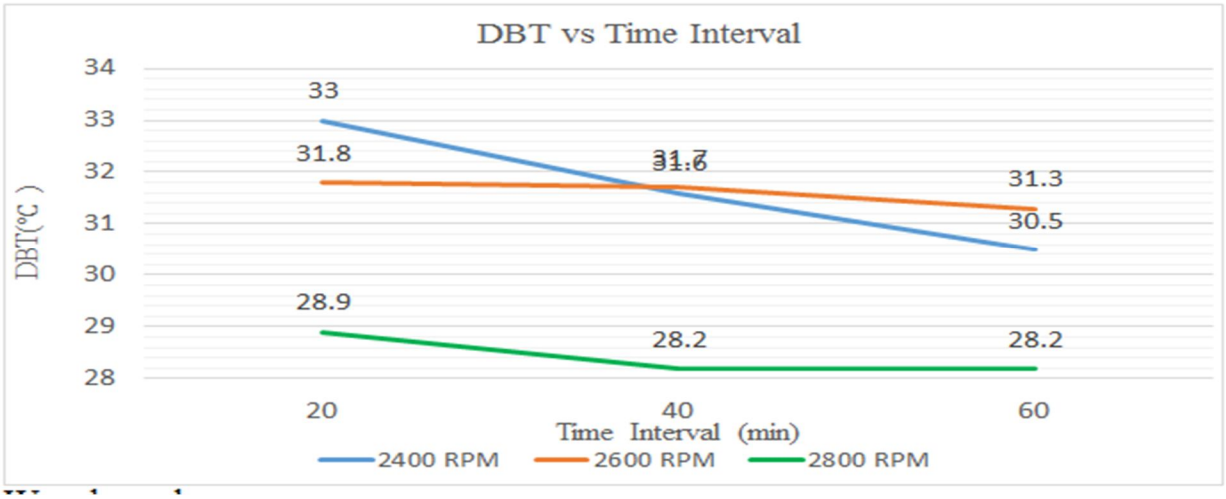


Honeycomb


DBT vs Time Interval
DBT(°C)
27
26.5
26
25.5
25
24.5
26
26
26
25.5
25
25
20
40
60
Time Interval (min)
2400 RPM
2600 RPM
2800 RPM


RH vs Time Interval
RH(%)
90
85
80
75
70
85
86
85
86
81
76
74
20
40
60
Time Interval (min)
2400 RPM
2600 RPM
2800 RPM


Water Consumption vs Time Interval
Water Consumption (litre)
4
3
2
1
0
4.13
3.7
3.26
1.68
0.87
0.435
0.64
0.45
20
40
60
Time Interval (min)
2400 RPM
2600 RPM
2800 RPM



Wood wool

IV. RESULT

An experimental setup is designed to evaluate the performance of cooling efficiency and cooling capacity of three different pad materials. The selected materials are wood wool, coconut coir and honeycomb. The performance criteria include the cooling efficiency and cooling capacity at various regulated speeds.

1) The result shows that the cooling efficiency is maximum found at an average speed of 2600RPM for all pad materials. Its is observed and compared with all pad material that maximum efficiency comes out to be of honeycomb(88%) at 2600RPM and 2800RPM and minimum efficiency is of wood wool(8.45%) at 2600 rpm.

2) The result show that the maximum cooling capacity of wood wool is 0.72kW at 2600RPM and maximum efficiency is 21.42% at 2800RPM.

3) The maximum cooling capacity of honeycomb is 0.94kW at 2600RPM and maximum efficiency is 88%.

4) The maximum cooling capacity of coconut coir is 0.79kW at 2400RPM and maximum efficiency is 50% at 2600RPM.

5) At 2400RPM honeycomb has maximum efficiency of 87% and coconut coir has maximum cooling capacity is 0.79kW.

6) At 2600RPM honeycomb has maximum efficiency of 88% and maximum cooling capacity is 0.94kW.

7) At 2800RPM honeycomb has maximum efficiency of 88% and maximum cooling capacity is 0.57 kW.

V. CONCLUSION

1) In conclusion, the use of alternative cooling materials such as coconut coir, wood wool, and honeycomb mesh can potentially improve the efficiency and sustainability of dessert coolers. Existing research suggests that these materials can effectively reduce the temperature inside dessert coolers and provide cost-effective and durable cooling solutions.

2) Honeycomb is more efficient than other two i.e Coconut coir and Wood Wool based on Various Graphs such as Water Consumption vs Time Interval, Temperature of Water vs Time Interval, RH vs Time Interval, DBT vs Time Interval

3) Honeycomb has high efficiency (88%) than other materials based on various factors like Water consumption, Relative humidity and DBT.

4) After honeycomb we found that coconut coir was 2nd most efficient cooling material.

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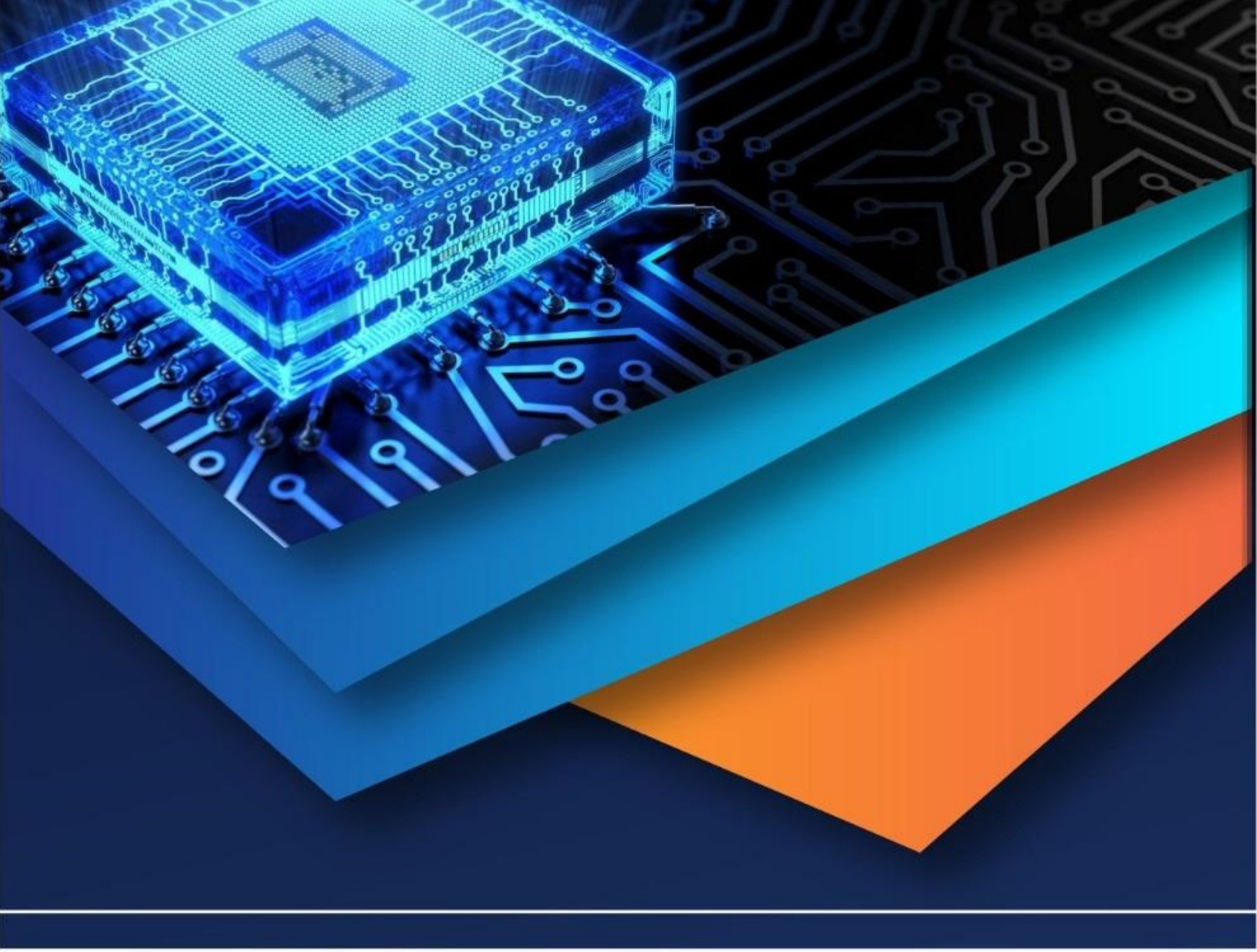

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