Experimental Analysis of Various Cooling Pads in Evaporative Cooling System

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Abstract - Evaporative cooler is a very common form of cooling media for domestic and industries purposes. Since it is cheap and requires less energy than many other forms of cooling. In evaporative coolers requires an abundant water source as evaporate and is only efficient when the relative humidity is low. This thesis investigate a performance of desert cooler using six different pad materials in terms of cooling efficiency at various speed and various time. Pads of cellulose 5090, cellulose 7090, jute, aspen, coconut coir and stainless steel weir were fabricated and tested using laboratory scale experimental arrangement. Maximum efficiency observed in cellulose 5090 (94.56%), aspen (89.88%), cellulose 7090 (84.94%), jute (76.31%), coconut coir (73.07%) and SS weir (47.61%) at medium speed of cooler at 670 rpm. It has been observed that highest efficiency at time interval of 12PM to 3PM at constant speed of all pads. And aspen have the relatively little drop of cooling efficiency at various speed. Maximum and minimum cooling efficiency were found in cellulose 5090 and stainless steel weir mesh pad respectively.

Key words: Cooling Pad, Cooling Efficiency, Cellulose 5090, Cellulose 7090 and aspen pas etc.

I. INTRODUCTION

The cooling of air is achieved by the evaporation of water. Evaporative coolers are different from the two known refrigeration cycles i.e. vapor compression and vapor absorption. Apart from cooling buildings evaporative cooling principle is widely used in cooling towers and air washers. Evaporative cooling is successful for the place where the relative humidity is low as well as temperature of air is high. It is much cheaper than the refrigerative cooling devices especially in dry climates and can save up to 75-80% cost of operation and installation. Though for optimal results both techniques can be implemented. They can be also used as humidifiers at high atmospheric temperatures. The place where intermediate or moderate humidity and dry climate is present evaporative cooling has many applications such as in industries, workshops, restaurants, theatres, sports events, construction sites etc. In developing nations after cultivation the agricultural products like fruits and vegetables are wasted due to lack of storage. It can saved by cooling in controlled atmosphere i.e. refrigeration, but that is expensive both in operating and as well as maintaining. In developing countries which can't spend high amount for refrigerative cooling are interested to get cheaper and effective cooling evaporative which is obviously have less operating and running cost.

1.1 PRINCIPLES OF EVAPORATIVE COOLING SYSTEM

The simple starting point for understanding any air conditioning, dehumidification and evaporative cooling is psychrometrics. Psychrometry consists of the contacts between heat, dampness and air. It is essentially the study of air-water mixtures and is an essential basis for understanding, how to change air from one state to another. As air warmth rises, its capability to hold dampness rises also; and warmer air becomes less dense. This makes dampness a very dominant factor for heat gain, both for comfort and in calculations. The knowledge of systems consisting of dry air and water vapor is essential for the design and analysis of air conditioning devices, cooling towers, and industrial processes requiring close control of the vapor content in air. Air dampness and heat contacts are rather intricate; providentially, these contacts can be pooled in a single chart (see figure below). However before explaining the details of how to use the chart, some terms, definitions, and principles used in the study of systems consisting of dry air and water must be introduced.

II. METHODOLOGY

In evaporative cooling process the water evaporation or any other fluid according availability in case of draught, with a following chilling of the air. These systems have great significance to provide thermal comfort in spaces where the dry bulb temperature is high. Direct evaporative cooling apparatus cool the air by direct contact with a liquid surface or with a wet solid surface, or even with sprays. In this system the water vaporization takes place because of dry hot air which is drawn by fan and thus the temperature of the hot air decreases and this air is blown in to the confined spaced for the requisite purpose, during this process dry bulb temperature is decreased substantially and thus humidity is increased. The efficiency of an evaporative cooler is the rate between the real decreasing of the dry bulb temperature and the maximum hypothetical decrease that the dry bulb temperature could be if the equipment was 100 percent efficient and the outlet air was saturated. In this case, the exit dry bulb temperature would be equal to the wet bulb temperature of the inlet air. To perfect evaporative cooler the dry bulb temperature and the dew point might be equal to the wet bulb temperature. The methodology includes:

- Fabricate the evaporator cooler by considering all the components like water tank, motor, fan, water pump and pad material.
- Formed experimental set up.
- Experiment test carried out to evaluate performance of evaporative cooling unit.
- To determine the air temperature and relative humidity inlet and outlet point as well as considering different pad material and air flow rate.
- Calculate the cooling efficiency of evaporator cooler with different padding material.

FACILITIES REQUIRED FOR PROPOSED WORK

III. EXPERIMENTAL SET UP

FigureIII.I Experimental setup from side

FigureIII.2 Experimental setup from front

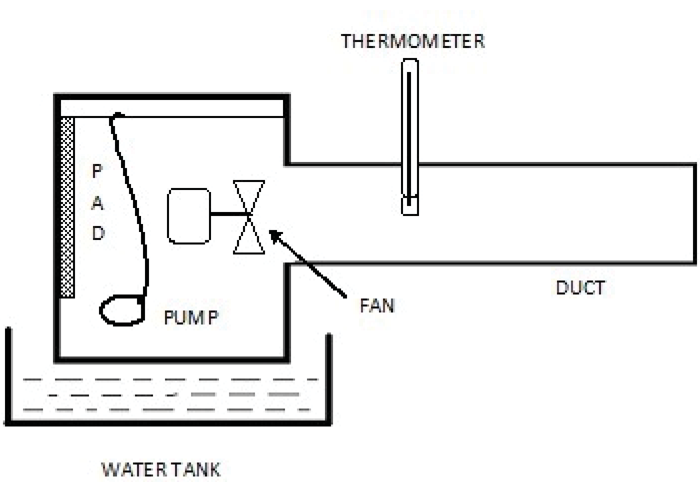

Figure III.3Block diagram of experimental setup

3.1.2. Setup Table

Parameters	**Winter**
Room upto	10×11 ft^2
Blower/Fan	Fan
Fan diameter	26 cm
Speed regulator	6 speeds
Wattage 230 V/ 50Hz	185
Tank capacity	
Cooling media	Cellulose 5090, cellulose 7090, jute, aspen, coconut coir, SS weir.

Area of pad	cm^2
Air velocity	In April and May months

Table III.1 Cooler configuration

Instruments Used

Various measuring instruments like sling psychrometer, anemometer and tachometer used for measurement of dry bulb temperature, wet bulb temperature, air flow rate and RPM of the motor, and thermocouple for temperature measurement.

Sling Psychrometer

Figure Sling Psychometer

The sling psychrometer is used to evaluate the amount of water vapour in the air. It consists of two glass thermometers containing a liquid, usually mercury. One thermometer determines the air temperature while the other one measures the wet-bulb temperatures.

After the wick is soaked in distilled water, a weather observer rotates the sling psychrometer round by with help of a handle provided on the instrument. As the instrument is whirled, evaporation of water takes place from the wick on the wet-bulb thermometer and cools the thermometer.

Anemometer

An anemometer is a apparatus used for measure wind speed, and is a common weather station instrument. The term is copied from the Greek word anemos, which means wind, and is used to determine speed of wind of any air blowing devices . It is extensively used as measurement instrument in meteorology department .

Figure Anemometer

Tachometer

A tachometer is an instrument which is used for measuring the rotation speed of a shaft or fan, which in a motor or other machine. The device usually displays the revolutions per minute (RPM) on a calibrated analogue dial, but digital displays are ever more commonly used.

Figure Tachometer

Thermocouple

A Thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. A junction is created by welding of the two wires, this junction is used for calculating or measuring temperature of the body or space which is to be known. The equipment which we have used is digital thermocouple in which the temperature is shown on a digital display of the inlet and outlet.

SAMPLE CALCULATIONS

For cellulose 5090

Cooling Efficiency

$$\mu = \frac{Tair - Tduct}{Tair - WBT} \times 100$$

μ= cooling Efficiency

T_{air}= Ambient air temperature (atmospheric temperature) T_1

T_{duct}= air outlet temperature measured inside the duct T_2

WBT= wet bulb temperature (saturation temperature) $T_1^{'}$

T_1=35˚C

T_2=29.5˚C at 480rpm

$T_1^{'}$=27.23˚C at 480rpm

μ = (35-29.5)/(35-27.23)×100 %

μ = 70.78%

EVAPORATIVE COOLING PADS

Evaporative cooling pads effectiveness depends highly on the capability of the evaporative pads or "media" to provide a high wetted surface area and negligible airflow resistance. There have been different materials are used for evaporating media as natural and synthetic fabrics. The following padding materials were used in the experiments:

Cellulose (5090):

In this commercial classification the first two digits indicates the average distance between the two adjacent layers in mm and the last two digits refer to the angle between two chronological ribbed layers. Test pad modules are fabricated from several wavy thin layers of corrugated papers bonded together.

Figure Cellulose 5090 pad

Coconut Coir:

Coconut coir is obtained from coconut it is basically a waste that is produced in reasonable quantities in some developing countries of the world. It is easily available in abundant quantity at very low cost. It can be used for different purposes.

Figure Coconut Coir Pad

Jute:

Figure Jute Pad

Jute is a long, soft, shiny vegetable fibre that can be spun into coarse, strong threads. It is produced from plants in the genus Co chorus, which was once classified with the family Tiliaceae more recently with Malvaceae, and has now been reclassified as belonging to the family Sparrmanniaceae.

IV.RESULTS OF VARIOUS PAD

The graph is plotted between the various rpm and dry bulb temperature for different pads.

I.Cellulose 5090

Cellulose 5090					
S. No	Speed in (RPM)	Ambient temperature (T1) in ˚C	Duct inside temp (T2) in ˚C	WBT (T1') in ˚C	Efficiency %
1	480	35	29.5	27.23	70.78
2	670	35	26.3	25.8	94.56
3	850	35	28.1	25.82	75.16
4	930	35	28.4	25.89	72.44
5	1100	35	29.1	25.79	64.06
6	1350	35	29	25.83	65.43

Table IV. Various results of cellulose 5090

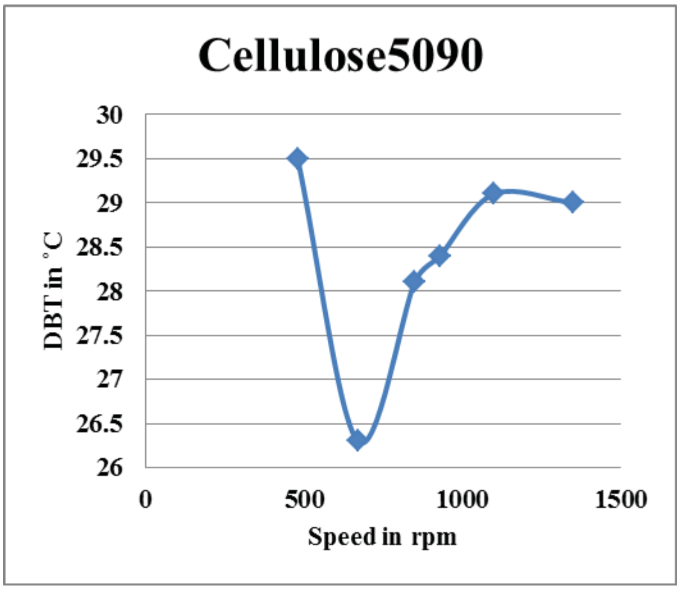

Figure Graph between RPM and DBT for cellulose 5090

First we take the cellulose 5090 as a media pad and regulate the speed at various rpm with the help of speed control regulator. From the above graph we observed that at 670 rpm the maximum drop of temperature. Maximum temperature drop is from 35˚C to 26.3˚C and 25.80 WBT.

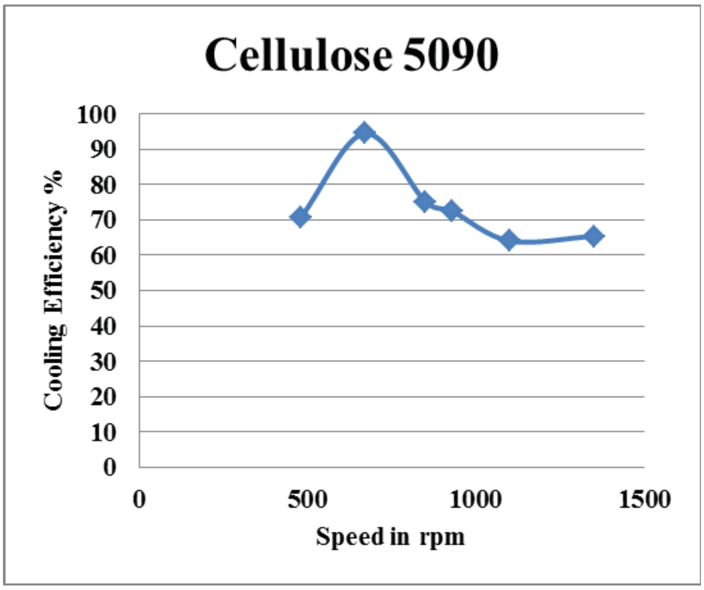

Figure Graph between RPM and Efficiency in % for cellulose 5090

It is also observed that, when we increse speed (more than 670 rpm), then with increse in speed the temperatutre drop is not much increase. Therefore ideal temperature drop at 670 rpm.

The graph is plotted between various speed and cooling efficiency for cellulose 5090. From the above graph we can see that maximum efficiency is 94.56% obtained at 670 rpm. After incresing the speed efficiency is slowly decrease.

Coconut Coir

Coconut Coir					
S. No	Speed in (RPM)	Ambient temperature (T1) in ˚C	Duct inside temp (T2) in ˚C	WBT (T1') in ˚C	Efficiency %
1	480	35	32	28.6	46.87
2	670	35	29.6	27.61	73.07
3	850	35	30	27.7	68.49
4	930	35	30.3	27.63	63.77
5	1100	35	30.8	27.63	56.98
6	1350	35	30.5	27.58	60.64

Table.various results of Coconut coir

After that we take the Coconut Coir as a media pad and regulate the speed at various rpm with the help of speed control regulator. From the above graph we observed that at 670 rpm the maximum drop of temperature. Maximum temperature drop is from 35˚C to 29.60˚C and 27.61˚C WBT.

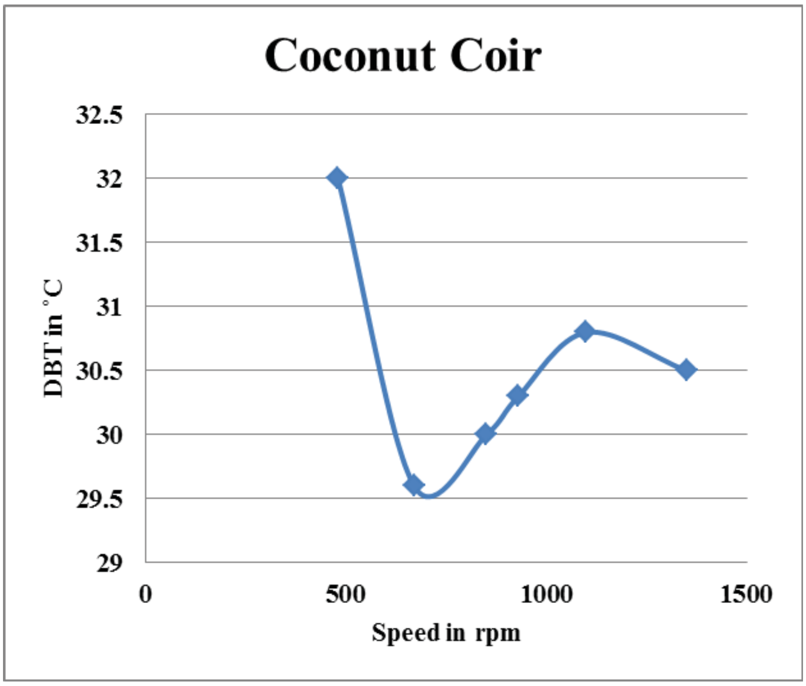

Figure .Graph between RPM and DBT for Coconut coir

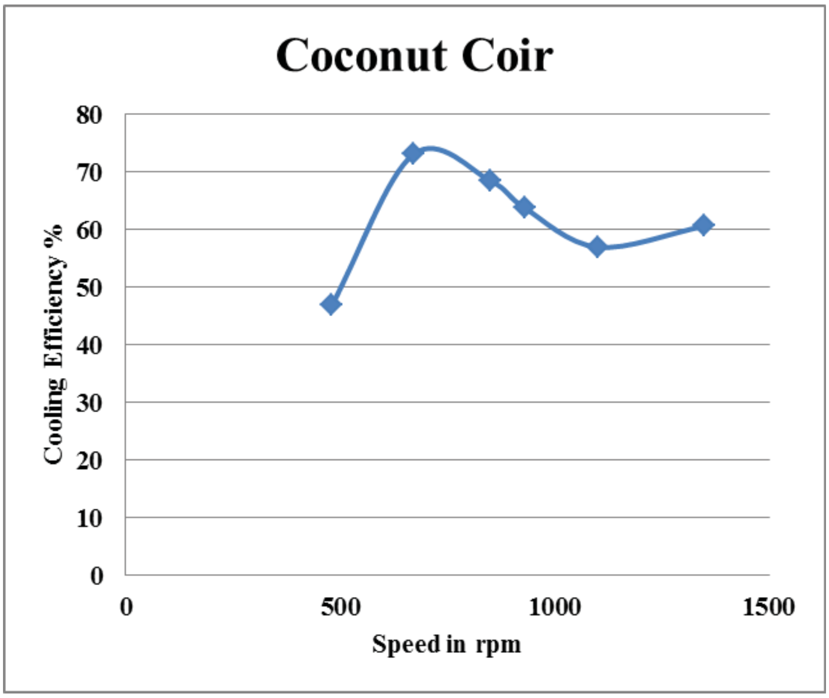

Figure. Graph between RPM and Efficiency in % for coconut coir

The graph is plotted between various speed and cooling efficiency for Coconut coir. From the above graph we can see that maximum efficiency is 73.07% obtained at 670 rpm. After incresing the speed efficiency is slowly decrease.

Jute

Jute					
S. No	Speed in (RPM)	Ambient temperature (T1) in ˚C	Duct inside temp (T2) in ˚C	WBT (T1') in ˚C	Efficiency %
1	480	35	31.3	28.43	56.31
2	670	35	29.2	27.4	76.31
3	850	35	30.5	27.7	61.64
4	930	35	30.8	27.7	57.53
5	1100	35	30.4	27.53	61.57
6	1350	35	31.1	27.5	52

Table.Various results of Jute

After that we take the Jute as a media pad and regulate the speed at various rpm with the help of speed control regulator. From the above graph we observed that at 670 rpm the maximum drop of temperature. Maximum temperature drop is from 35˚C to 29.20˚C and 27.40˚C WBT.

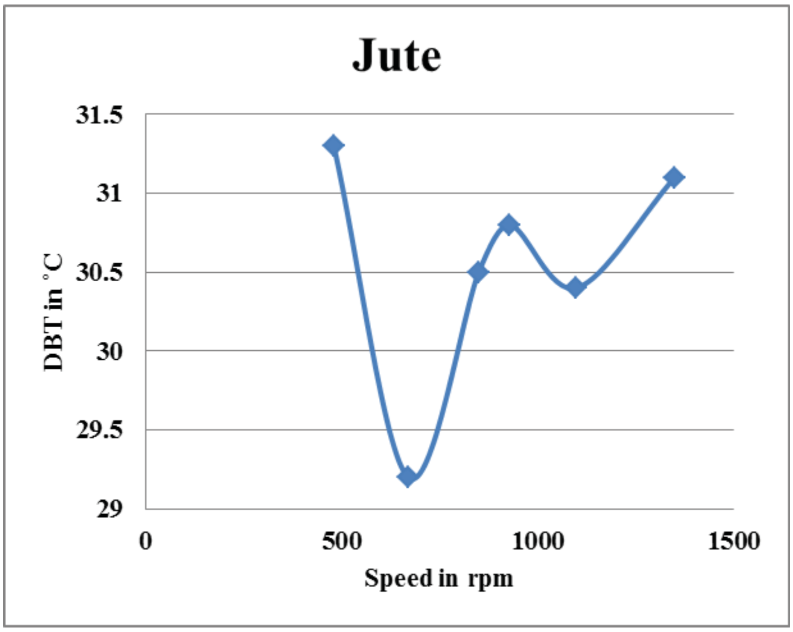

Figure.Graph between RPM and DBT for jute

Figure. Graph between RPM and Efficiency in % for jute

The graph is plotted between various speed and cooling efficiency for Jute. From the above graph we can see that maximum efficiency is 76.31% obtained at 670 rpm. After incresing the speed efficiency is slowly decrease.

V.CONCLUSION

An experimental setup is designed to evaluate the performance of cooling efficiency of three different pad materials. The selected materials are cellulose 5090, jute, coconut coir. The performance criteria include the cooling efficiency at various regulated speed and at steady time.

In this experimental setup to measure all the parameter with the help of some digital electronic equipment like tachometer, thermocouple, sling psychrometer for rpm of fan, temperature at inlet and outlet, wet bulb temperature for humidity measure respectively.

The result shows that the cooling efficiency is maximum found average speed at 670 rpm for all pad materials. Its also observe and compare all pad material the maximum efficiency is cellulose 5090(94.56%) and minimum efficiency coconut coir (73.07) at 670 rpm. its conclude that cooling efficiency at speed 670 rpm the highest is 94.56%cellulose 5090 compare to other pad material, jute (76.31%), coconut coir (73.07%) .

Its have observe dry bulb temperature is maximum drop at maximum high temperature of environment at 12p.m to 3 p.m. we found maximum efficiency is also maximum environment temperature at 12 p.m. to 3 p.m.

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