Test Rig for Evaluating the Pad Parameters with Respect to Desert Cooler Design Parameters

Bikramjeet Singh
Mechanical Engineering DepartmentChandigarh University, Gharuan, Punjab, India,
Email: singhbikramjeet62@yahoo.com

ABSTRACT –

To increase the comfort level of urban public areas during the summer period, several passive strategies can be implemented. In areas characterized by hot and dry summers, the most common techniques are based in solar shading, natural ventilation and evaporative processes. Evaporative coolers are widely used in India because of their economical feasibility. So its need to make it more efficient for their better performance. And in order to do the evaluation we designed a test rig to evaluate effect of different parameters on the effectiveness of cooling process which we can use to enhance the parameters of desert cooler for their better performance in summer.

Keywords- Aspen Pad, Cellulose Pad.

I. Introduction-

Evaporative cooling - Evaporative cooling is basically used for air coolingof spaces like greenhouses and also for human comfort with the help of desert coolers or evaporative coolers. In evaporative cooling when water evaporates it absorb heat from particular region, the region from where the evaporation is taking place and which result in decrease in temperature of that particular region. Where Desert coolers which are also called evaporative coolers are commonly used cooling of spaces for human comfort in summer.

Basic principle - In evaporative cooling the phase change phenomenon occur. Mostly in desert coolers water is used for evaporative cooling. When water change its phase from liquid to vapor state. It need some energy for that phase transition and that energy it absorb in the form of sensible heat from air which result in decrease in temperature of air and increase in relative humidity of air. The basic principle is that the latent heat required for transition of phase of water is equal to the latent heat absorbed from the air which results evaporative cooling.[2]. As shown in Fig.1.1 when airpasses through the wet pad it drops its temperature due to the evaporation of water in wet pad. Fan is the driving force for air which produces low pressure inside desert cooler for the continuous flow of air through the pad.

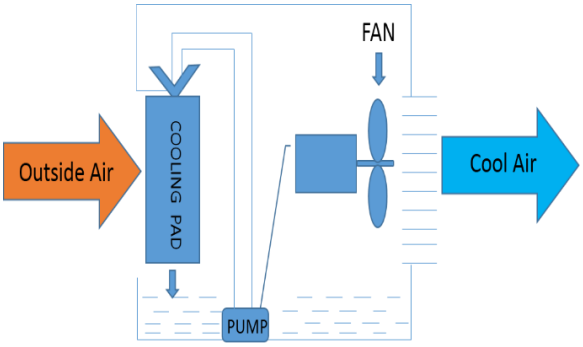

Fig.1.1: Schematic diagram of Desert cooler

1. Description of test rig-

The test rig we fabricated is different than the experimental setups used for evaluation in your mentioned papers.

a. First of all it's a test rig to evaluate the performance of **cooling pads** generally used in desert or evaporative coolers. For example aspen pad, cellulose pad.
b. It's a setup where we can alter number of parameters to evaluate the performance of pads. Like the different parameters effecting cooling pad performance.

<u>These parameters are</u>

- Aspect ratio of pad
- Different combinations of two pad materials (Hybrid pad)

- Distance between pad and Cooler fan
- Pad thickness
- Frontal velocity (Velocity of fan air)
- Water flow rate
- Panel slot design

How we made this flexibility I am going to explain it with photographs of test rig.

1.1 Schematic representation of test rig-

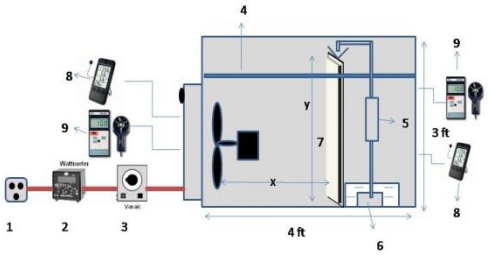

FIG Fig.1.2

Schematic diagram of test rig

1.2 Components of test rig-

a. Power supply
b. Wattmeter
c. Variac
d. Measuring Tape
e. Rota meter
f. Water pump
g. Pad holding frame
h. Hygrometer
i. Anemometer

X – Representing variability in distance between pad and fan of test rig

Y- Representing variability in height of pad so we can change aspect ratio.

a. Power supply – AC power supply
b. Wattmeter- Wattmeter is used to measure the wattage of power supply so we can evaluate pad performance at different value of power supply.
c. Variac – Variac is used to increase or decrease the power supply. The frontal velocity is changeable with the help of variac.
d. Measuring tape- measuring tape is used to measure the length between pad and fan in test rig. So as to evaluate the effect of distance between two on performance of pad.
e. Rota meter- Rota meter is used to alter and measure the water flow rate. So we can evaluate the
f. Water pump- Water pump is used to pump the water from tank to top of the pad.
g. Pad holding frame- pad holding frame is used to hold the pad in test rig.
h. Hygrometer – This is four in one hygrometer in that hygrometer we can calculate following parameters.
    - Temperature (Both inlet air and outlet air)
    - Relative Humidity (Both inlet air and outlet air)
    - Dry bulb temperature (Both inlet air and outlet air)
    - Time
i. Anemometer- Anemometer is used to measure the Frontal velocity or we can say fan air.

i. As shown in schematic diagram we can change water flow rate with the help of Rota meter to evaluate the effect of water feed rate on cooling pad performance.
ii. And frontal velocity can be changed with the help of increase and decrease in power supply and that can be done with the help of variac.

Withthe help of this test rig we can evaluate evaporative cooling performance in two ways in case of desert coolers

1. The performance of cooling pads.
    i. Pad thickness
    ii. Hybrid pad(combination of two materials)
    iii. Material of pad
2. Design parameters of desert or evaporative cooler.
    i. Distance between fan and pad
    ii. Aspect ratio (number rows of slots)
    iii. Panel slot design
    iv. Frontal velocity
    v. Water flow rate

III. Design parameters considered in test rig performance analysis –

Aspect Ratio -

As the following photographs of panels representing the three different panels with different aspect ratio. To change the aspect ratio we just increases the rows of punched slots. Columns are same in all three panels but rows in panel showing fig.3.1 are 21 and in panel 2 showing in fig.3.2 are 17 and in 3rd are 13.

And the slot design can be changed by changing the punching die design to evaluate its effect.

Fig.3.1 panel 1

Fig.3.2 panel2

Fig.3.3 panel 3

Fig.3.4changing panel in test rig

We can change aspect ratio by just changing the panels in test rig as shown in fig.3.4

DISTANCE BETWEEN PAD AND FAN-

We can change distance between pad and fan to evaluate its effect on the performance of pad by just bolting the panel holding set up to next bolts as shown in fig.3.5.

Fig.3.5 Test rig.

PANEL SLOT DESIGN-
Panel Slot design can be changed by changing the design of sheet punching die. And by changing slot design we can evaluate the effect of different design of slots on performance of desert coolers on this test rig.
FRONTAL VELOCITY-
Frontal velocity can be changed with the help of variac by regulating the voltage. And its effect can be measured by considering performance parameters.
WATER FLOW RATE-
Effect of water flow rate through the pad can be measured by changing the flow rate with the help of rotameter.
IV.NOMENCLATURE[5]

V Air velocity of conditioned air, m/sec
T_{db1} Dry bulb temperature of outside air, °C
T_{db2} Dry bulb temperature of conditioned air by evaporative cooler, °C
T_{wb2} Wet bulb temperature of conditioned air by evaporative cooler, °C
H_1 Initial water level height in water tank of evaporative cooler, cm
H_2 Final water level height in water tank of evaporative cooler after running one hour, cm
H_2-H_1 Decrease in water level after one hour time running of evaporative Cooler at Particular wattage, cm
L, B length and breadth of water tank of evaporative cooler
V Volume of water consumed, liter
RH Relative humidity, %
E Effectiveness
E_t Evaporation rate, lph
t Running Time of cooler, hour

V. Data Collection
To evaluate the effectiveness of the evaporative cooling pad systems under test, the following data was collected:
The parameters like Relative humidity (RH) and temperatures are directly measured with the help of instruments.
The parameters which required data are

a. Effectiveness
b. Volume of water consumed
c. Rate of evaporation in evaporative cooler

a. Effectiveness-
Evaporative cooler performance is measured in terms of effectiveness. Effectiveness is measured to compare performance evaluation of two pads at different value of power supply.
Cooling efficiency, this is defined as the ratio of the actual dry-bulb temperature reduction to the theoretical maximum at 100% saturation (ASHARE, 1997). It is calculated as per the following equation- [3]

$$E = \frac{Tdb1 - Tdb2}{Tdb1 - Twb2} \times 100$$

b. Volume of water consumed in one hour -
Volume of water consumed is calculated by measuring the reduction in volume of water in water tank of evaporative cooler. Length and breadth are fixed. Only height dimension of volume of water varies due to evaporation.

Initial height of water level = H_1
After running one hour height of water level = H_2
Decrease in level of water = $H_2 - H_1$

Now the volume of Water consumed is

$$V = L \times B \times (H2 - H_1)$$

c. Rate of evaporation -
It's the amount of water consumed per unit time.

$$E_t = \frac{L \times B \times (H2 - H1)}{t}$$

V. Benefits to industry
In cooler industry or any industry where they are manufacturing evaporative cooling systems there they can use this test rig for investigate the effect of different parameters on performance of evaporative cooling and its results to enhance their products performance and also for further research in this field.

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