STUDY ON EFFECT OF MOISTURE CONTAIN ON TEMPERATURE

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Abstract - *A mechanical direct evaporative cooler unit uses a fan to draw air through a wetted membrane, or pad, which provides a large surface area for the evaporation of water into the air. Heat transfer not only depends on temperature gradient but also on humidity content in the air. Keeping the above in mind, desert coolers employ the processes of cooling+humidification(increase humidity) unlike coolers used in normal regions which apply cooling+dehumification(decrease humidity) If the moisture contain increases, temperature drop will also increase , so we have to study the effect of moisture contain on temperature*.

The experimental study is carried out at Chandrapur (19.9705ºN, 79.3015ºE) during the month of April and May.

Key Words: *Desert Cooler, Humidity, Throtteling Process, Optimisation, Moisture.*

1. INTRODUCTION

An air cooler serves to cool down the hot air in a room or vehicle. Air cooler cools the atmospheric air in a room or vehicle by adding water to the air. The water is added in the form of minute droplets. The air cooler has a fan installed in it that pulls the warm air from outside through a water wetted filter medium. The water in the cooler is evaporated by the warm air drawn by the fan. The evaporated water releases in the room. The temperature of the room comes down because the warm air is drawn by the fan of the air cooler.

An air cooler is not the same as an air conditioner. The air cooler does not use compressor and refrigerant gas. We can say that though the air cooler is not as effective as air conditioner, it is not harmful for the environment and is cost effective. The air coolers cool the atmospheric air mostly by the process of evaporation of water.

The temperature of the room falls owing to several reasons such as:-

- Relative Humidity Level.
- Air Temperature
- The size of the room
- The amount of cross ventilation.

Normal cooler can drop room temperature around $6^{O}C$-$7^{O}C$. It is simple mechanism. If the moisture contains increase, temperature drop will also increase, so we have to study the effect of moisture contain on temperature drop.

2. BASIC CONCEPT OF THERMODYNAMICS

2.1 THERMODYNAMICS PROPERTIES

Enthalpy a property of a thermodynamic system, is equal to the system's internal energy plus the product of its pressure and volume. In a system enclosed so as to prevent matter transfer, for processes at constant pressure, the heat absorbed or released equals the change in enthalpy.

The unit of measurement for enthalpy in the International System of Units (SI) is the joule. Other historical conventional units still in use include the British thermal unit (BTU) and the calorie.

Enthalpy comprises a system's internal energy, which is the energy required to create the system, plus the amount of work required to make room for it by displacing its environment and establishing its volume and pressure.

Enthalpy is defined as a state function that depends only on the prevailing equilibrium state identified by the system's internal energy, pressure, and volume. It is an extensive quantity.

Enthalpy is the preferred expression of system energy changes in many chemical, biological, and physical measurements at constant pressure, because it simplifies the description of energy transfer. In a system enclosed so as to prevent matter transfer, at constant pressure, the enthalpy change equals the energy transferred from the environment through heat transfer or work other than expansion work.

The total enthalpy, H, of a system cannot be measured directly. The same situation exists in classical mechanics: only a change or difference in energy carries physical meaning. Enthalpy itself is a thermodynamic potential, so in order to measure the enthalpy of a system, we must refer to a defined reference point; therefore what we measure is the change in enthalpy, ΔH. The ΔH is a positive change in endothermic reactions, and negative in heat-releasing exothermic processes.

For processes under constant pressure, ΔH is equal to the change in the internal energy of the system, plus the pressure-volume work $p \Delta V$ done by the system on its surroundings (which is > 0 for an expansion and < 0 for a contraction). This means that the change in enthalpy under such conditions is the heat absorbed or released by the system through a chemical reaction or by external heat transfer. Enthalpies for chemical substances at constant pressure usually refer to standard state: most commonly 1 bar pressure. Standard state does not, strictly speaking, specify a temperature (see standard state), but expressions for enthalpy generally reference the standard heat of formation at 25 °C.Enthalpy of ideal gases and incompressible solids and liquids does not depend on pressure, unlike entropy and Gibbs energy. Real materials at common temperatures and pressures usually closely approximate this behavior, which greatly simplifies enthalpy calculation and use in practical designs and analyses.

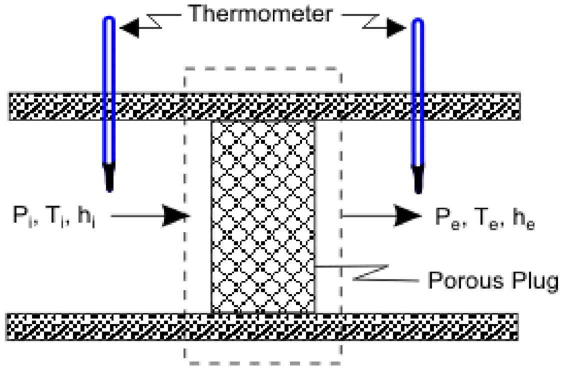
2.2 THROTTLING PROCESSES

A throttling process is a thermodynamic process, in which the enthalpy of the gas or medium remains constant (h = const). In fact, the throttling process is one of isenthalpic processes. During the throttling process no work is done by or on the system (dW = 0), and usually there is no heat transfer (adiabatic) from or into the system (dQ = 0). On the other the throttling process cannot be isentropic, it is a fundamentally irreversible process. Characteristics of throttling process:

1. No Work Transfer
2. No Heat Transfer
3. Irreversible Process
4. Isenthalpic Process

A throttling of the flow causes significant reduction in pressure, because a throttling device causes a local pressure loss. A throttling can be achieved simply by introducing a restriction into a line through which a gas or liquid flows. This restriction is commonly done by means of a partially open valve or a porous plug. Such pressure losses are generally termed minor losses, although they often account for a major portion of the head loss. The minor losses are roughly proportional to the square of the flow rate.

The porous plug experiment was designed to measure temperature changes when a fluid flows steadily through a porous plug which is inserted in a thermally insulated, horizontal pipe. The apparatus used by Joule and Thomson.



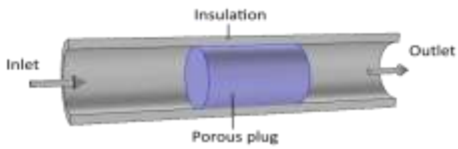
A gas at pressure and temperature flows continuously through a porous plug in a tube and emerges into a space which is maintained at a constant pressure P_e. The device is thermally insulated and kept horizontal. Consider the dotted portion as control volume.

Q_i=0 **W_e=0** Therefore result for these is **h_i=h_e**

Therefore, whenever a fluid expands from a region of high pressure to a region of low pressure through a porous plug, partially opened valve or some obstruction, without exchanging any energy as heat and work with the surrounding (neglecting, the changes in PE and KE), the enthalpy of the fluid remains constant, and the fluid is said to have undergone a **throttling process**.

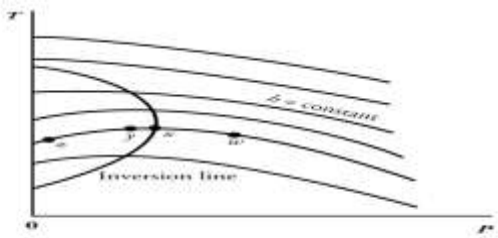
2.3 Joule–Thomson effect – Joule Thomson coefficient

For several years, James Prescott Joule and William Thomson – both British physicists – worked in collaboration, conducting experiments designed to analyze and advance thermodynamics. In 1852, the researchers made a particularly notable discovery. They found t hat a temperature change can occur in a gas as a result of a sudden pressure change over a valve. Known as the *Joule-Thomson effect* (or sometimes the *Thomson-Joule effect*), this phenomenon has proven to be important in the advancement of refrigeration systems as well as liquefiers, air conditioners, and heat pumps. It is also the effect that is responsible for a tire valve getting cold when you let out the air from a bicycle tire.



The temperature change pertaining to the Joule-Thomson effect can occur when a flowing gas passes through a pressure regulator, which acts as a throttling device, valve, or porous plug. Here, a temperature change is not necessarily desirable. To balance out any Joule-Thomson related temperature changes, a heating or cooling element can be used.

$$\mu_{JT} = \left(\frac{\partial T}{\partial p}\right)_h$$



3. PSYCHROMETRIC PROPERTIES

Dry-bulb temperature (DBT)

The dry-bulb temperature is the temperature indicated by a thermometer exposed to the air in a place sheltered from direct solar radiation. The term dry-bulb is customarily added to temperature to distinguish it from wet-bulb and dewpoint temperature. In meteorology and psychrometrics the word temperature by itself without a prefix usually means dry-bulb temperature. Technically, the temperature registered by the dry-bulb thermometer of a psychrometer. The name implies that the sensing bulb or element is in fact dry.

Wet-bulb temperature (DBT)

The thermodynamic wet-bulb temperature is a thermodynamic property of a mixture of air and water vapor. The value indicated by a wet-bulb thermometer often provides an adequate approximation of the thermodynamic wet-bulb temperature.

The accuracy of a simple wet-bulb thermometer depends on how fast air passes over the bulb and how well the thermometer is shielded from the radiant temperature of its surroundings. Speeds up to 5,000 ft/min (~60 mph) are best but it may be dangerous to move a thermometer at that speed. Errors up to 15% can occur if the air movement is too slow or if there is too much radiant heat present (from sunlight, for example).

A wet bulb temperature taken with air moving at about 1–2 m/s is referred to as a screen temperature, whereas a temperature taken with air moving about 3.5 m/s or more is referred to as sling temperature.a psychrometer is a device that includes both a dry-bulb and a wet-bulb thermometer. A sling psychrometer requires manual operation to create the airflow over the bulbs, but a powered psychrometerincludes a fan for this function. Knowing both the dry-bulb temperature (DBT) and wet- bulb temperature (WBT), one can determine the relative humidity (RH) from the psychrometric chart appropriate to the air pressure.

Dew point temperature

The saturation temperature of the moisture present in the sample of air, it can also be defined as the temperature at which the vapour changes into liquid (condensation). Usually the level at which water vapor changes into liquid marks the base of the cloud in the atmosphere hence called condensation level. So the temperature value that allows this process (condensation) to take place is called the 'dew point temperature'. A simplified definition is the temperature at which the water vapour turns into "dew" (ChamunodaZambuko 2012).

Specific Humidity

Specific humidity is defined as the proportion of the mass of water vapor and mass of the moist air sample (including both dry air and the water vapor); it is closely related to humidity ratio and always lower in value.

Absolute humidity

The mass of water vapor per unit volume of air containing the water vapor. This quantity is also known as the water vapor density.

Relative humidity

The ratio of the vapor pressure of moisture in the sample to the saturation pressure at the dry bulb temperature of the sample.

Specific enthalpy

Analogous to the specific enthalpy of a pure substance. In psychrometrics, the term quantifies the total energy of both the dry air and water vapour per kilogram of dry air.

Specific volume

Analogous to the specific volume of a pure substance. However, in psychrometrics, the term quantifies the total volume of both the dry air and water vapour per unit mass of dry air.

Pressure

Many psychrometric properties are dependent on pressure concept:

vapor pressure of water;

Atmospheric pressure at the location of the sample.

4. CONSTRUCTION DETAILS

The parts of prototype model:-

FRAME :-The frame is the main supporting structure of the machine to which all the components are attached.

ELECTRIC MOTOR:-Electric motor is an electrical machine that convert electrical energy into mechanical energy.Most electric motor operate through the interaction between the motors magnetic field and winding currents to generate force in the form of rotation.

PVC PIPES:-PVC Pipes Manufacturing Process. PVC pipes are made out of a material known as polyvinyl chloride, a durable,

strong plastic-like substance. Pipes are constructed from this material and used in various applications from plumbing to construction.

WATER PUMP :-submersible water pumps are mostly used on air coolers, aquariums, and fountains. If the pump runs out of water and continues to operate an issue known as dry running it can become damaged. This circuit protects submersible water pumps from dry running with thehelp of associated level electrodes. The circuit detects the absence of water and monitors the water level to prevent dry running from occurring.

FAN:-fan is a Single phase Induction motor. Generally we use a capacitor start & run AC Motor for ceiling Fans. Working principle: whenever current carrying conductor is placed in a magnetic field-it experiences force. AC motor needs a rotating magnetic field in order to turn the rotor shaft.

COOLER TANK :-It is the use to store the water and use as a receiver for water drop from cooling pads.

5. WORKING

A mechanical direct evaporative cooler unit uses a fan to draw air through a wetted membrane, or pad, which provides a large surface area for the evaporation of water into the air. Water is sprayed at the top of the pad so it can drip down into the membrane and continually keep the membrane saturated.Firstly, Heat transfer not only depends on temperature gradient but also on humidity content in the air. For example, in rainy season or in coastal areas though the temperature of the surrounding is less, but we still feel hot because humidity is more. Higher humidity at a given temperature leads to difficulty in heat transfer.

Secondly, for a water droplet to evaporate it absorbs energy that is Latent heat , the amount of heat that is needed to evaporate the liquid, is drawn from it's surroundings thus cooling the surroundings! A phenomenon that happens in porous earthern pots that leads to the water inside to be cooler!

Keeping the above in mind, desert coolers employ the processes of cooling+humidification(increase humidity) unlike coolers used in normal regions which apply cooling+dehumification(decrease humidity).

In deserts(dry climate), humidity is very less and temperature gradient more thus high rate of heat transfer, thus making us hot!! Apart from cooling surrounding air, water droplets are added to this air to reduce the rate of heat transfer, temperature gradient.

In normal regions, humidity is reduced in summers to aid heat transfer in the given temperature gradient, due to evaporation that is sweating in our case.

Coolers are based on the simple principle that when unsaturated air comes in contact with water,

the water evaporates. In the process, the moisture content of air increases, while its temperature decreases. The resulting cold but moist air is used for providing cooling. Thus a desert cooler is a simple device, which consists of an arrangement for blowing dry and hot air over a wet surface and an arrangement for keeping the surface wet continuously. The cooler normally consists of a blower and a pump. Desert coolers are economical (both initial and running costs are low) and are effective in hotand dry areas. They are not effective in humid areas.It is a device that cools air through simple evaporation of water.

5.1 PRINCIPLE OF WORKING

As the name implies , it is suitable for places where the humidity is quite low and temperature quite high. These conditions are in conformity with desert areas. Hence the coolers are called 'Desert coolers'. The principle on which a desert cooler works is Evaporative cooling'. Evaporative cooling is a process in which sensible heat is removed and moisture added to the air. When air passes through a spray of water it gives up heat to water, some of the water evaporated and picks up heat from the air equivalent to its latent heat. The vapour thus formed are carried along in stream. In this way air is cooled and humidified.

The water is filled in the sump of the cooler from water supply mains , the level of which is controlled by a float valve. A water pump lifts the water and supplies it at the top of the cooler to the water distribution system which consists of small branches of copper pipe or so equipped with orifices which deliver equal amount of water to the troughs which in turns supply water to the wetted pads. The water which drops back from the pads is recirculated. The pump may be made of brass , stainless steel or even plastic. The blower pulls the air through the wetted pads and deliver it to space to be cooled through an opening in the fourth side of the cabinet of desert cooler. The air which is sucked through the pads is cooled by the principle of evaporative cooling . The blower gives adequate velocity to the air before it is delivered to the spaces to be cooled.

To have long life of the desert cooler and better performance , pads should be changed every year and holes for water distribution system should be cleaned. The tank should be cleaned just after the season and coated with corrosion resisting paint.

6. PERFORMANCE AND TESTING

Reading-1 (Initial water Temp-26.6)

Sr No.	DBT	WBT	Water Temp	ODT	RH %	ENTHALPY Kj/kg	W Kj/kg
1	30	24.5	24.6	33.9	70	78	0.019
2	28.3	25.6	25	31.4	79	76	0.0195
3	27.7	24.7	25.6	33.5	75	75	0.0185
4	27	24	25.8	34	73	74	0.0183

Reading-2(Initial water Temp-26.6)

Sr No.	DBT	WBT	Water Temp	ODT	RH %	ENTHALPY Kj/kg	W kj/kg
1	29	25.4	25	31.5	73	77.5	0.019
2	28.5	25	24.9	34	72	76.5	0.018
3	27.9	25	25	34.5	79	76.5	0.0188
4	26.5	25	25.3	35	90	76.5	0.0195

EFFECT OF OUTDOOR TEMPERATURE:-

Sr No.	DBT	WBT	DPT	RH %	Enthalpy Kj/Kg	W Kj/Kg	Time
1	28	24.5	23	75	74.5	0.018	10:30 am
2	29.3	25.6	24	75	78.5	0.019	11;20 am
3	30.5	26.3	25.2	72	83.5	0.025	12:10 pm
4	28	24.2	22.5	71	74	0.0175	1:20 pm
5	27.1	23.5	22.5	75	70	0.0170	2:10 pm
6	25	23	22.3	80	68	0.018	3;00 pm

Reading -1 with different number of panels and same thickness:-

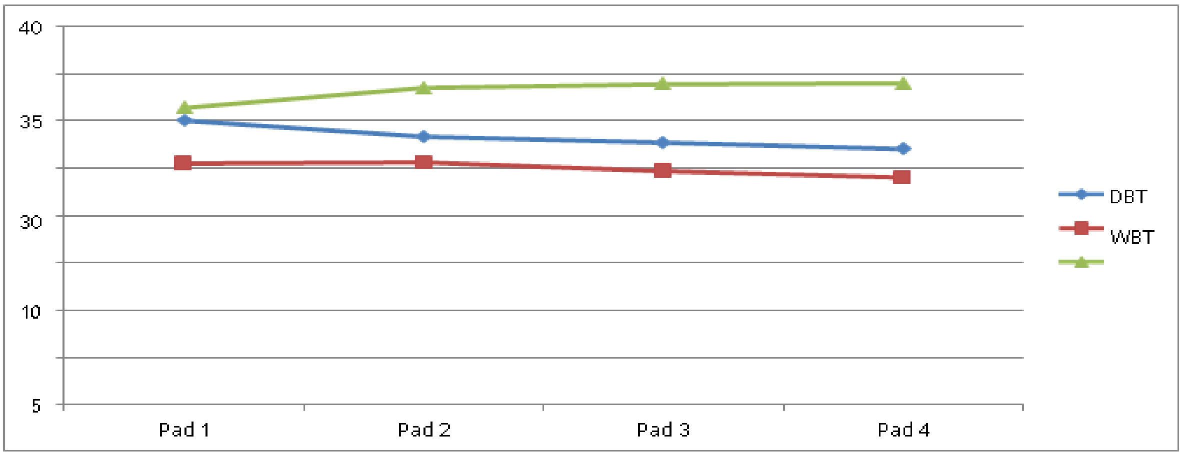
PADS	DBT	WBT	ODT
PAD 1	30	25.5	31.4
PAD 2	28.3	25.6	33.5
PAD 3	27.7	24.7	33.9
PAD 4	27	24	34

Reading-2 with different numberof panels and same thickness :-

PADS	DBT	WBT	ODT
PAD 1	29	25.4	31.5
PAD 2		25	34
PAD 3		25	34.5
PAD 4		25	35

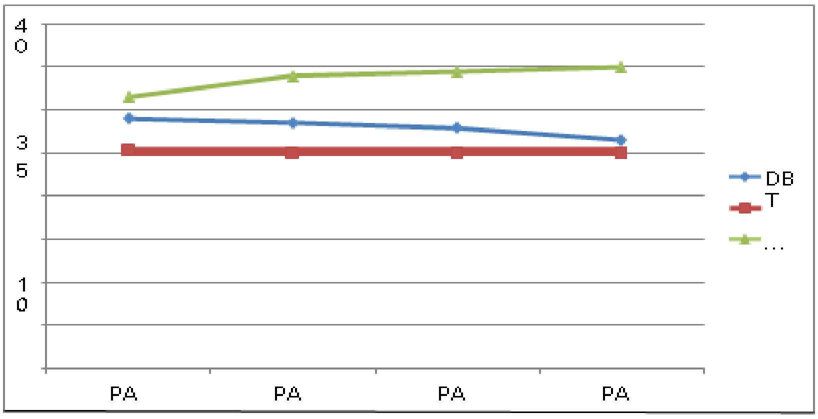
Reading with same panels and with different thickness panel-1:-

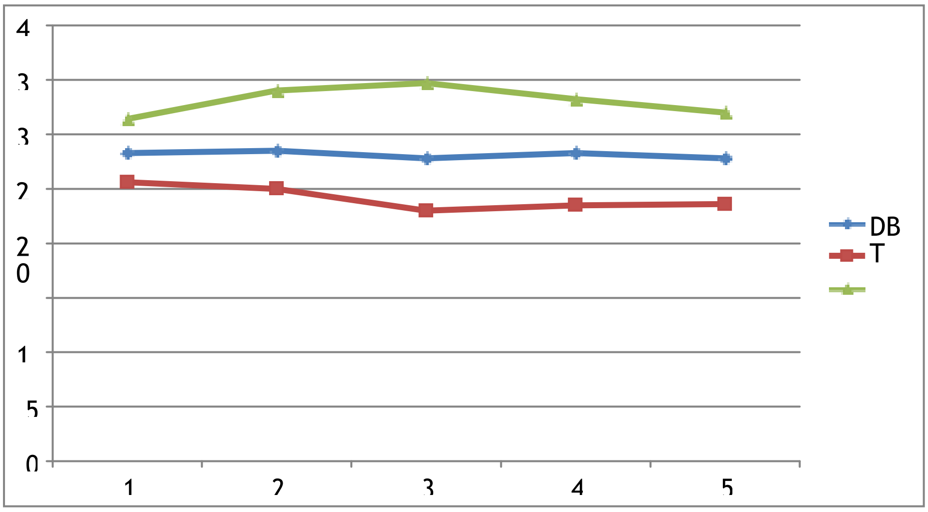
PADS	DBT	WBT	ODT
1	30	24.5	33.9
2	29	25.4	31.5
3	28	24	33.8
4	28.4	24	33
5	28.1	24	31.4

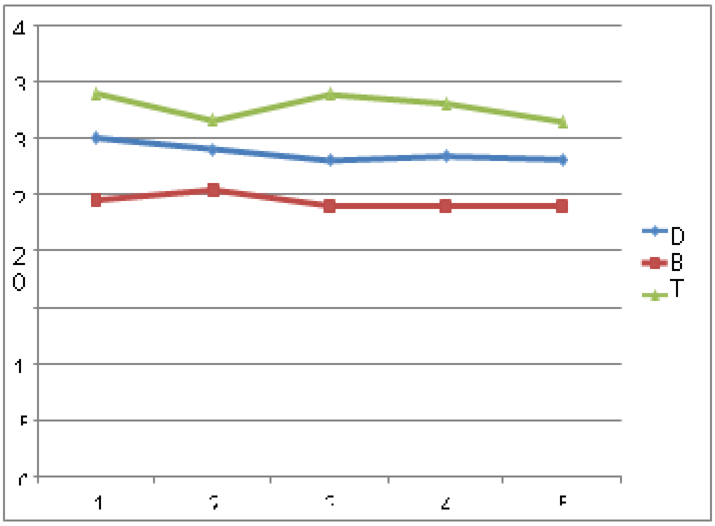


Reading with same panels and with different thickness panel-2:-

PADS	DBT	WBT	ODT
1	28.3	25.6	31.4
2	28.5	25	34
3	27.8	23	34.7
4	28.3	23.5	33.2
5	27.8	23.6	32







7. APPLICATIONS-

Use in our houses.

Uses in offices.

Uses in collages.

Uses in schools

Uses in industries.

8. CONCLUSION AND RESULT-

The cooling system we built ourselves was able to maintain a constant temperature of 24 °C. Air coolers lessen the use of power and not only save the cost of the users but also save the usage of power. It is no doubt a suitable alternative to compressor-based cooler. The setback of air cooler that it increases humidity can be met by using indirect evaporative cooling. Another drawback of air cooler regarding hygiene issues can also be dealt with. The users of the air coolers should maintain cleanliness of the air coolers and frequently change the water to avoid breeding of mosquitoes. The usage of air coolers has more benefits than its demerits. It is also energy and cost efficient.

Some important points:-

- Only the main issue is that, if all the 4-valve of the air cooler is open then moisture contain will increase, but it can be control or maintain by closing the respective valve.
- As we increases the thickness of panel, relative humidity ofair increases but after certain time relative humidity does not increase but there is a temperature drop.
- When the atmospheric temperature is increases, at the same time due to increase in thickness we get the optimum temperature drop.
- Relative humidity is continuously reducing.
- By increasing in thickness panels the cooling effect is reduced.
- We get the optimum cooling effect, when thickness of the panel is 1cm.
- But after increasing the panel thickness by 0.5cm we don’t get more cooling effect.
- We are getting the temperature drop up to a particular thickness.

9. FUTURE SCOPE-

- We can reduce the size of the cooler.
- We can also change the design.
- We can use different material for the construction of cooler.
- We can also use the honey comb pads, in presence of Khuskhus.
- We can also reduce or increase the number of panels.
- We can use these in any conditions.
- If the moisture contain is increase the with the help of valves we can control or we can reduce it.
- We can use in all the three seasons.
- We can also modify the cooler as much as possible for the better results.

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