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# DESIGN AND FABRICATION OF AN EVAPORATIVE COOLING SYSTEM

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***Abstract****-Civilizations throughout the ages have found ingenious ways to combat the heat in their region. Many years ago when people living in hot climates used to hang get wet clothes in their windows at night, knowing the evaporative air blowing through the window would help cool the house. In respect of our country evaporating cooling system is great important because of natural and energy efficient. Being so much less expensive than air conditioning and environmentally "safe", evaporating cooling system is used throughout the world. In evaporating cooling system there is a low horsepower motor which pumps the water from the floor of the cooler to the cooler pad, where it proceeds to fall down the sides along the cooler pad. A blower pulls air from the outside, and then pushes cool air into the hot room. In this cooling system, the cooler outlet temperature is reduced 3 to 5ºC from room temperature. The main objective of this paper is to design and fabrication of an evaporative cooling system.*

**Keywords:** Environmentally safe, Natural cooling, Energy efficient.

## 1. INTRODUCTION

Splash some cool water on your face on a hot day in the summer and you will immediately feel cooler .An evaporative cooler works on the same principle. Evaporative cooler also called "swamp coolers", because they add humidity to the air and maintained "wet bulb" temperature of the air. In low humidity areas, like Indian subcontinent especially Bangladesh, evaporating water into the air provides a natural and energy efficient means of cooling. The cooling process works on the principle of evaporation of moisture.

## 2. EVAPORATIVE COOLING PROCESS

Evaporative cooler is the main device of an evaporative cooling system. Evaporative cooler consists of a low horse power motor, a blower, porous filter pads or gunny bag, water reservoir, float valve, water distribution line and electric motor. The low horse power motor pumps the water from the floor of the cooler to the top of the cooler, where it proceeds to fall down the sides, along the cooler pad. A blower fan pushes cool air in the hot building or room. The significant cooling action is the water evaporating as the air passes through it, the water level is kept constant with the help of a float valve .This process will be continued. The evaporative cooling process is essentially an adiabatic saturation process. The evaporative cooling process, is commonly employed to reduce the dry bulb temperature of the air without refrigeration. It is a constant wet bulb process of reducing dry bulb temperature. The hardware used to achieve this process usually consists of the basic components of the adiabatic saturation chamber plus some type of device to amplify the interface surface area between the water reservoir and the air, such as wetted rick, matting, plates, spray etc. The fundamental governing process of evaporative cooling is heat and mass transfer due to the evaporation of water. This process is based on the conversion of sensible heat into latent heat. Sensible heat is heat associated with a change in temperature. While changes in sensible heat affect temperature, it does not change the physical state of water. Conversely, latent heat transfer only changes the physical state of a substance by evaporation or condensation [2]. As water evaporates, it changes from liquid to vapor. This change of phase requires latent heat to be absorbed from the surrounding air and the remaining liquid water. As a result, the air temperature decreases and the relative humidity of the air increases. The maximum cooling that can be achieved is a reduction in air temperature to the wet-bulb temperature (WBT) at which point the air would be completely saturated.

## 3. WORKING PRINCIPLE

The rudimentary basis for understanding any air conditioning, dehumidification and evaporative cooling is psychometrics. Psychometric consists of the interactions between heat, moisture and air. It is basically the study of air-water mixtures and is an essential foundation for understanding, how to change air from one condition to another. As air temperature rises, its capacity to hold moisture rises also; and warmer air becomes less dense. This makes moisture a very influential factor for heat gain, both for comfort and in calculations. 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.

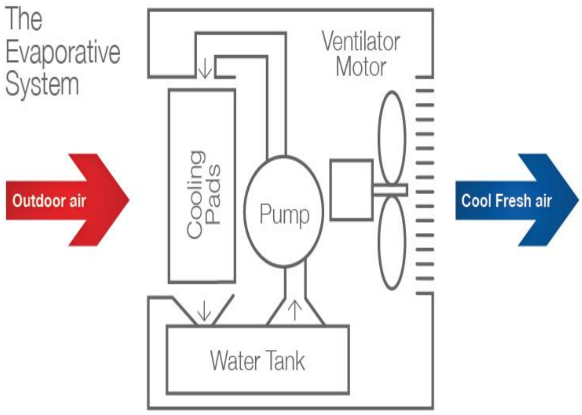



Fig 1: General evaporative cooling process

**3.1. Psychometric Chart**

The psychometric chart is a graphical representation that describes the relationships between the air temperature and relative humidity. Although complicated in appearance, this chart can be used to establish state points and is used to calculate specific humidity, dew point and vapor pressure.

**3.2. Dry Bulb Temperature**

The Dry Bulb Temperature refers to the ambient air temperature measured using a normal thermometer freely exposed to the air but shielded from radiation and moisture. It is called "Dry Bulb" because the air temperature is indicated by a thermometer not affected by the moisture of the air.The dry bulb temperature is usually given inSI unit is Kelvin (K). Zero Kelvin equals to – 273ºC.

**3.3. Wet Bulb Temperature**

The Wet Bulb temperature is the temperature measured by using a thermometer whose glass bulb is covered by a wet wick/cloth

**3.4. Humidity**

It is the mass of water vapor present in one kg of dry air, and is generally expressed in terms of gm. per kg of dry air. It is also called specific humidity or humidity ratio.

**3.5. Absolute Humidity**

It is the mass of water vapor present in 1 $m^3$ of dry air, and is generally expressed in terms of gram per cubic meter of dry air ($g/m^3$ of dry air).

**3.6. Relative Humidity**

It is the actual mass of water vapor in a given volume of moist air to the mass of water vapor in the same volume of saturated air at the same temperature and pressure. It is briefly written as RH.When air has 50 percent relative humidity, we say it is 50 percent saturated (the terms are numerically so close that we use them interchangeably)..Relative humidity is determined by comparing the "wet-bulb" and "dry-bulb" temperature readings. Dry bulb and wet bulb temperatures are taken simultaneously and then plotted on a psychometric chart. Relative humidity is determined by the value at the intersection of two temperature lines.

**3.7. Dew Point**

The Dew Point is the temperature at which water vapor starts to condense out of the air and becomes completely saturated. Above this temperature the moisture will stay in the air. The dew point temperature is an indicator of the actual amount of moisture in air.The Dew Point is the temperature at which water vapor starts to condense out of the air and becomes completely saturated. The dew point temperature is an indicator of the actual amount of moisture in air.

**3.8. Sensible Heat**

The heat used to change the temperature of the air. Sensible heat will always cause a change in the temperature of the substance.

**3.9. Latent Heat**

Latent heat is the heat energy involved in the phase change of water. The heat will only change the structure or phase of the material without change to temperature.

## 4. DESIGN AND FABRICATION

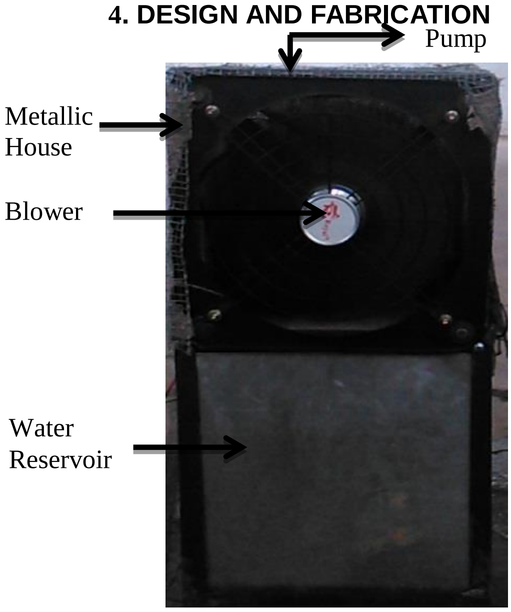



Fig 2: Evaporative cooler

**4.1 Cooler Size**

Dimension of the room**: 3.5m * 3 m * 3 m**

So we have 10.5 square meter room with 3 meter high ceilings.

10.5 * 3 = 31.5 cubic meter

CMM = 31.5/2 = 15.75

The cubic meter per minute of air that the cooler can blow into room = 15.75

**4.2 Selections of Fan**

From the continuity equation, Q= A * V

Where A = area of the cooler

V = velocity of air

=≫ 15.75 = 0.365 m * 0.365 m * V

$\Rightarrow\gg$ V = 118.221 m / min

**4.3 Cooling Pad Material**

There is transfer of heat from the pad material during evaporation and during this process water is been evaporated. The cooling capacity of a system is independent on the amount of air flow and its saturation which in turn depends on the characteristics of the pad, air velocity through the pad and the water flow rate. Evaporation from the wetted pad affected by some factors which are wind, temperature, surface area, humidity, air velocity, water flow rate and thickness. The amount of water that the air can evaporate from the pad depends on the rate of saturation and the temperature of the air [3]. The lower the relative humidity the higher the rate of evaporation and thus the more the cooling takes place. Various materials have been used as pad ranging from, palm tree leaves, hessian cloths, ,aspen wood, jute, cotton materials, perforated clay blocks mad some other materials based on the functionality, costing and availability. Olosunde tested three materials namely jute, hessian and cotton waste and after series of experiment, jute pad also had the highest efficiency [3].

## 5. MODIFICATION

In general Evaporative cooler the pump is situated between the blower and cooler pad. The pump is produced a small quantity of heat that affects the experimental data and it becomes a big problem for the long running period of the cooler. The blower cannot suck the humidified air properly due middle position of the pump between the blower and cooler pad. To solve this problem in this evaporative cooler the pump is separated from blower and cooler pad and took the pump at the top of the cooler that is covered by iron net. As a result it does not greater influence to the experimental data. Finally evaporator outlet air temperature is lower than the general evaporator. So it is more beneficial.

## 6. METHODES OF EVAPORATIVE COOLING

Rusten, 1985 specified that there are two main methods of evaporative cooling namely:

(1) Direct evaporative cooling, (2) Indirect evaporative cooling

(2)

**6.1 Direct Evaporative Cooling**

This is a method by which air is passed through a media that is flooded with water .The latent heat associated with the vaporizing of the water cools and humidifies the air streams which now allows the moist and cool air to move to its intended direction. (Sellers, 2004) Sanjeev, (2008) disclosed that direct evaporative cooling has the following major limitations:

1) The increase in humidity of air may be undesirable.

2) The lowest temperature obtainable is the wet-bulb temperature of the outside air,

3) The high concentration and precipitation of salts in water deposit on the pads and the other parts, which causes blockage, and corrosion, and requires frequent cleaning, replacement, and servicing [6].

**6.2 Indirect Evaporative Cooling**

A heat exchanger is combined with an evaporative cooler and the common approach used is the passes return/exhaust air through an evaporative cooling process and then to an air-to air heat exchanger which in turn cools the air, another approach is the use of a cooling tower to evaporative cool a water circuit through a coil to a cool air stream (Sellers, 2004).Sanjeev, (2008) also said indirect cooling differs from direct cooling in the sense that in indirect cooling the process air cools by the evaporation of water. But there is no direct contact of water and process air. Instead a secondary airstream is used for evaporation of water. So the moisture content of process air remains the same [6].

## 7. TYPES OF EVAPORATIVE COOLER

Evaporative coolers can be classified according to the position of the cooler in relation to the building. Generally, there are three types: (a) down-draft (roof mounted), (b) side draft (typically eave or window mounted), and (c) updraft (ground mounted). Roof mounted' down-draft coolers (a) are sometimes preferred since they can usually be more readily connected to duct systems and are out of the way on the roof. However, eave mounted (b) or ground mounted (c) units can be more easily and safely serviced since the person doing the maintenance does not have to use a ladder to inspect or repair the system.

## 8. HOW THE UNIT WORKS

The main reservoir of the unit is connected to the main water supply line of the place. Water flows continuously to the reservoir and the float valve controls the flow rate. The float valve allows exactly that amount of water to enter the reservoir which is evaporated in to the air. The two foams are placed in such a way that one face of the foam is always in direct contact with the water in the main reservoir. Water evaporates from the wet foams when air (which is brought in by the fan from outside) flows around them As the water evaporates, the dry bulb temperature of the air is reduced and this cooled air is supplied to the room. The rate of evaporation is less than the rate of water flow; the excess water is draining out properly by a piping system. An added benefit of evaporative cooling is that it works best in the hottest time of the day' as the temperature outside increases as the sun climbs, the humidity normally drops. In the early morning, for example, the temperature may be 70 degrees, with a relative humidity of 60 percent' By mid-afternoon, when the temperature has climbed to 90degrees, the humidity may well have dropped to 30 percent conditions that make evaporative cooling work more effectively.

## 9. APPLICATIONS

**9.1 Comfort Cooling**

“Human comfort” depends on a variety of factors ranging from temperature, humidity and air movement to clothing and culture. What is comfortable for one person in one society may be entirely uncomfortable for another. Someone who has long lived without refrigerated air conditioning may find an artificially air-conditioned environment uncomfortable, whereas people who take refrigerated air conditioning for granted in their homes and workplaces may avoid being outside during hot weather all together [5].

### 9.2 Residential

Residential applications of evaporative cooling are common throughout the hot and dry areas in the southwest. Residential EAC's are typically smaller than commercial units but the basic components of a supply fan, water sump, sump pump, water distribution header and both pad and rigid wetted media are very similar. Many residences use direct evaporative coolers, but the addition of indirect coolers are becoming more accepted by users who want lower discharge temperatures and more available cooling hours. The Evaporative Cooling Institute reports that "in New Mexico, 90% of residential and around 40% of commercial installations use evaporative coolers [5]. It was also reported that if only a small amount of water is placed on the roof, the evaporation is highly accelerated as compared to what would be if the roof surface was flooded [4].

### 9.3 Commercial

Evaporative cooling is a well-recognized method of cooling 40% of New Mexico offices, shops, warehouses, laundries, kitchens and institutional facilities. Most new facilities use commercially available units that have 12" thick rigid media. Some have also include an indirect evaporative cooler section for better cooling performance. These units are often controlled with thermostats to further increase energy savings. Facilities that require tight temperature control and use refrigerated air can add an indirect EAC to precool the air upstream of the refrigeration air coil. Another widespread use of the evaporative effect in the commercial sector is evaporative cooling towers and evaporative condensers, which are used to reject heat from refrigeration chiller. The latent heat of vaporization will drastically increase the heat transfer rate of these heat rejection devices [5].Using the cooler, pumpkins were stored 60 hours instead of 12 hours without cooling and tomatoes lasted for 93 hours compared to 32 hours [1].

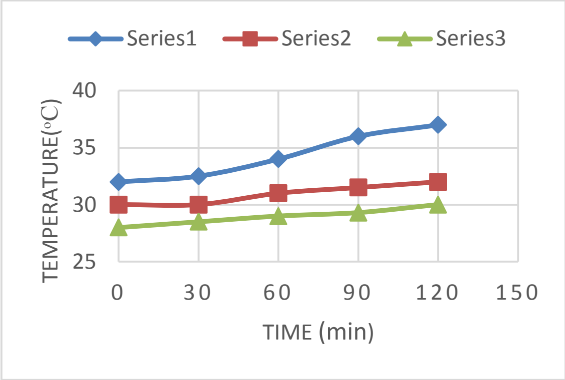
## 10. RESULTS

### 10.1 Results Obtained

After completion of my fabrication of the cooler we take experimental data from 10:00 am to 3:30 pm in one day. We take

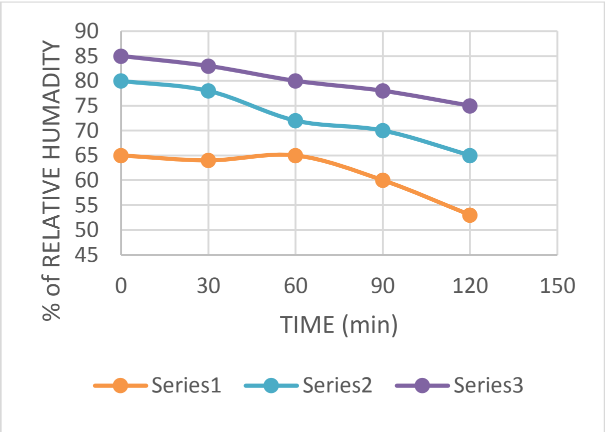
1. Evaporator outlet temperature
2. Ambient temperature
3. Room temperature
4. Air velocity
5. Evaporator outlet Relative Humidity
6. Relative Humidity of the room
7. Ambient Relative Humidity

We take these data from 10:00 am to 12 am at 30 minutes interval, closing all the windows and doors and 1:00 pm to 3:30 pm at 30 minutes interval, with open windows and doors. The various curve obtained are given below,



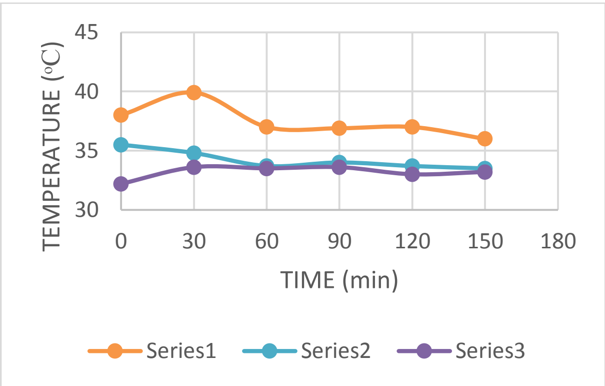

Series 1- Ambient temperature
Series 2- Room temperature
Series 3- Cooler outlet temperature

Fig 3: Temperature curve obtained from 10:00 am to 12:00 am at 30 minutes interval, closing all the windows and doors.



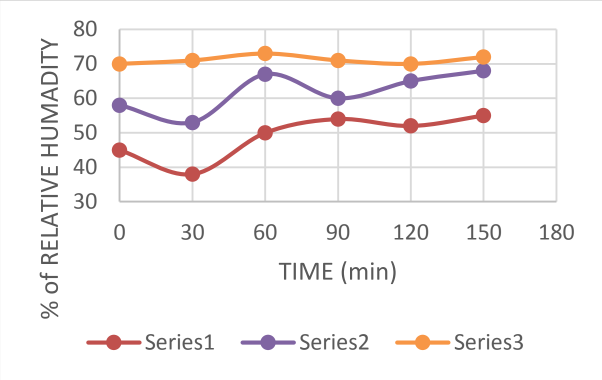

Series 1- Ambient Relative Humidity
Series 2- Relative Humidity of the Room
Series 3-RelativeHumidityof the evaporator outlet

Fig 4: Relative Humidity curve obtained from 10:00 am to 12 am at 30 minutes interval, closing all the windows and doors.




Series 1- Ambient temperature
Series 2- Room temperature
Series 3- Evaporator outlet temperature

Fig 5: Temperature curve obtained from 1:00 pm to 3:30 am at 30 minutes interval, opening all the windows and doors.




Series1- Ambient Relative Humidity,
Series2-Relative Humidity of the room,
Series3-Relative Humidity of the evaporator outlet.

Figu 6: Relative Humidity curve obtained from 1:00 pm to 3:30 pm at 30 minutes interval, opening all the windows and doors.

## 11. DISCUSSION

Fabrication of an evaporative cooler needs a careful engineering analysis. Some differences were found between the design or expected data and the experimental data. But such deviation was not unexpected as the cooler was not tested under ideal condition for which it has been designed. Evaporative coolers do not use compressors, condenser, chiller coils, cooling towers or heavily insulated piping. So it is needed less power and1/3 rd. operation cost than the refrigerated air conditioning. In this cooling system, the cooler outlet temperature is reduced 3 to 5ºC from room temperature. But in an ideal condition and very hot climates where relative humidity is low the cooler will able to achieve cooling 8ºC below the room temperature. That's why evaporative cooling is more suited in Bangladesh.

## 12. CONCLUSION

The evaporative cooling system shows its best performance during the month of March and April of the year when there is a high dry bulb temperature together with a low humidity. Evaporative cooling system do not provide complete air-conditioning, they can provide a great deal of relief from the high dry bulb temperature of desert type climates. So this type of cooler is perfect for the area where the dry bulb temperature is high and humidity is low. In our country ambient humidity is maximum time high. So in our country it can be used in two or three months in some areas as north side of our country. The fabrication cost is very low comparative to air conditioning. Thus the average people of our country can use it for some comfort during very high temperature.

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## NOMENCLATURE

| Symbol | Meaning | Unit |
|---|---|---|
| *T* | Temperature | (ºC) |
| *Q* | Volume flow rate | ($m^3$/min) |
| *A* | Area | ($m^2$) |
| *V* | Velocity | (m/min) |
| *RH* | Relative humidity | [-] |