Modified Air Cooler With Split Unit For Humidity Control

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***Abstract* - Energy consumption all over the world is increasing rapidly and there is pressing need to develop ways to conserve energy for future generation. The conventional refrigeration system consumes very large amount of power (about 1.5 KW). Also for cooling, Evaporative coolers are the better option. The cost of Evaporative coolers is low and also it consumes less power than that of AC. The main drawback of Evaporative cooler is that the air supplies by it has very large amount of Humidity. Due to which when an individual sits in the air of evaporative coolers, he fills stickiness on his body which is not comfortable condition. So this project works involves the manufacturing and design of the split unit which will not increase the humidity of air. It will maintain the room at comfort conditions by re-circulating the air in the room through split unit.**

***Keywords*: - Evaporative cooler, Humidity etc.**

INTRODUCTION

The evaporative cooler was the subject of numerous U.S. patents in the twentieth century; many of these, starting in 1906, suggested or assumed the use of excelsior (wood wool) pads as the elements to bring a large volume of water in contact with moving air to allow evaporation to occur. A typical design, as shown in a 1945 patent, includes a water reservoir (usually with level controlled by a float valve), a pump to circulate water over the excelsior pads and a squirrel-cage fan to draw air through the pads and into the house. This design and this material remain dominant in evaporative coolers in the American Southwest, where they are also used to increase humidity. Energy consumption all over the world is increasing rapidly and there is a pressing need to develop ways to conserve energy for future generations. Researchers are forced to look for renewable sources of energy and ways to use available sources of energy in a more efficient way. Conventional refrigeration based vapour compression air conditioning systems consume a large portion of electrical energy produced mostly by fossil fuel. India's energy demands are expected to be more than double by 2030, and there is a pressing need to develop ways to conserve energy for future generations. This implies that we have to look for renewable sources of energy and use available sources of energy in a more efficient way. Thus energy consumption can be reduced drastically by using energy efficient appliances. In India, the Union ministry of power's research pointed out that about 20-25% of the total electricity utilized in government a building in India is wasted due to unproductive design, resulting in an annual energy related financial loss of about Rs 1.5 billion. Conventional heating ventilation and air conditioning systems consume approximately 50% of the building energy. Conventional refrigeration based vapour compression air conditioning systems consume a large portion of electrical energy produced mostly by fossil fuel. This type of air conditioning is therefore neither eco- friendly nor sustainable.

1.1 BASIC PRINCIPLES

Evaporative cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it. Latent heat, the amount of heat that is needed to evaporate the liquid, is drawn from the air. When considering water evaporating into air, the wet-bulb temperature, as compared to the air's dry-bulb temperature is a measure of the potential for evaporative cooling. The greater the difference between the two temperatures the greater the evaporative cooling effect. When the temperatures are the same, no net evaporation of water in air occurs, thus there is no cooling effect.

A simple example of natural evaporative cooling is perspiration, or sweat, which the body secretes in order to cool itself. The amount of heat transfer depends on the evaporation rate, however for each kilogram of water vaporized 2257 kJ of energy are transferred. The evaporation rate in turn depends on the humidity of the air and its temperature, which is why one's sweat accumulates more on hot, humid days: the perspiration cannot evaporate.

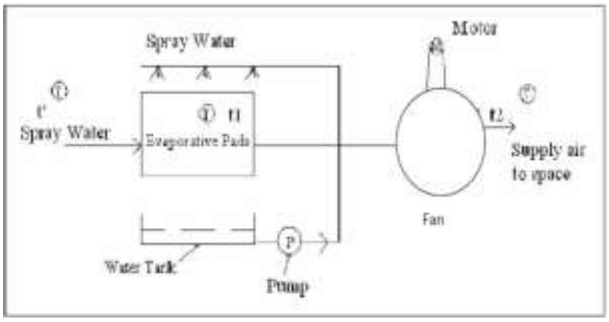

Figure 1.1 Basic process of evaporative cooling

Evaporative cooling is not the same principle as that used by Vapour-compression refrigeration units, although that process also requires evaporation (although the evaporation is contained within the system). In a vapour-compression cycle, after the refrigerant evaporates inside the evaporator coils, the refrigerant gas is compressed and cooled, causing it to return to its liquid state. In contrast evaporative coolers water is only evaporated once. In a space-cooling unit the evaporated water is introduced into the space along with the now-cooled air; in an evaporative tower the evaporated water is carried off in the airflow. Key evaporative cooling performance descriptors include saturation effectiveness and unit efficiency.

Effectiveness is defined as:

$$\varepsilon = \frac{t_{db} - t_s}{t_{db} - t_{ws}} \qquad \text{.... equation 1}$$

Where,

ε = Effectiveness (%)
t_{db} = Outdoor dry bulb temperature
t_{wb} = Outdoor wet bulb temperature
ts = Supply dry bulb temperature

In contrast to vapour compression air conditioners, which generally dehumidify indoor air, evaporative coolers add moisture to the supply air stream.

1.2 SYSTEM TYPES

The evaporative cooling is done in various stages is mentioned as follows:

Single Stage Systems

Single-stage (direct) evaporative coolers generally combine a blower, a pump, an absorbent evaporative pad, and other components in a metal, fibreglass, or polymer cabinet that has an air intake and a supply air outlet. Water is circulated by the pump from a sump in the bottom of the cabinet over the evaporative pad, and the blower draws in outside air, passing it through the moist pad and into the building to be cooled. Water lost through evaporation is replaced by the operation of a float valve (or a solenoid valve and float switch) that feeds in fresh water from a water supply. The direct evaporative cooling process is illustrated in Figure 1(Direct (single-stage) Evaporative Cooler Airflow Path). Some single stage coolers do not use a pump but rotate the evaporative pads through a water bath. Rarely, a cooling pad is not used and the air is passed through a water spray.

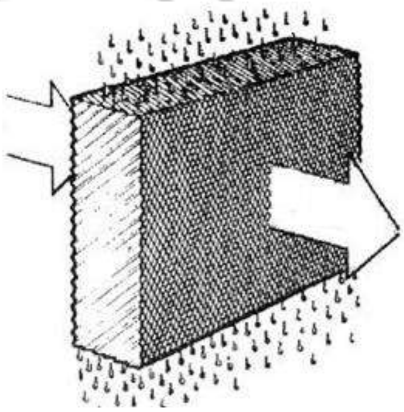

Figure 1.2 Direct (single-stage) Evaporative Cooler Airflow Path

There are other variations on this theme, but the principal of operation is the same. Because the continuous evaporation of water concentrates minerals in the sump water, some method of removing the minerals must be used. This is typically accomplished by either bleeding off a small percentage of the water that leaves the pump to a drain, or by periodically completely emptying the sump using a separate pump or electrically operated drain valve.

Two-Stage Systems

Indirect/Direct (two-stage) evaporative cooler designs add an indirect cooling stage upstream of the direct stage. The indirect stage, most commonly a plastic plate air-to-air heat exchanger, cools the outdoor air evaporatively, but without adding moisture (Figure 2 Indirect- Direct(Two-Stage) Evaporative Cooler Airflow Paths). The downstream direct stage further cools the air, in some cases to a temperature below the outdoor wet bulb temperature, resulting in an overall effectiveness greater than 100%. Two stage systems deliver cooler and drier supply air than can be achieved with a single-stage cooler, but at the expense of some added fan and pump energy. Indirect-only evaporative coolers are sometimes used to pre-cool make-up air for larger commercial buildings, but are not addressed by this proposed standard. There are currently two, two-stage products on the market. Performance of two-stage systems can be characterized either by their indirect and direct effectiveness or by an overall evaporative effectiveness for the two stages. Overall effectiveness can be used to compare single and two-stage systems and is a preferred metric for standards purposes.

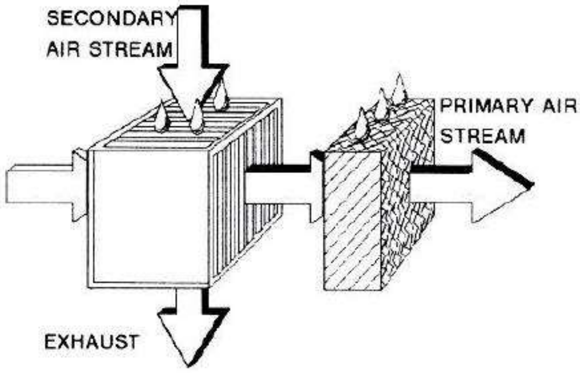

Figure 1.3 Indirect- Direct (Two-Stage) Evaporative Cooler Airflow Paths

Several manufacturers offer portable or spot coolers that are designed to deliver cool air directly on the work area. These do not connect to an outside air supply and therefore are not appropriate for general building cooling since they would eventually add moisture until indoor air reaches saturation. The proposed standard would not apply to these products.

Evaporative Media

Cooler effectiveness depends largely on the capability of the evaporative pads or "media" to provide a high wetted surface area and minimal airflow resistance. Many materials have been used for media, including natural and synthetic fabrics.

Type	Media
Synthetic	Expanded paper, and woven plastic.
Natural	wood excelsior; rigid cellulose media; aspen pads
Metallic	copper, bronze or galvanized screening; vermiculite, perlite,

Table1.1 Evaporative Media

Prior to the advent of rigid cellulose media, "aspen pads" were the standard for production coolers. This material is made from aspen wood excelsior from young trees grown at altitudes above about 10,000 feet to avoid a fungus commonly found at lower altitudes. Aspen pads generally cool supply air to lower temperatures than competing materials, but have a short service life due to sagging, clogging and decay. A woven, expanded paper product has gained popularity as a replacement for aspen wood pads in many markets. This media has a longer useful life than aspen wood, but does not cool air as effectively. Developed in the 1960's, rigid media proved to be a landmark breakthrough due to its high performance and comparative durability. This cellulose or fiberglass content material is bonded in a cross-fluted design that induces turbulent mixing of air and water for improved heat and moisture transfer and self-cleaning. First introduced in large commercial and industrial applications, in recent years the material has been adopted by leading cooler manufacturers for use in premium quality products.

1.3 APPLICATIONS

Evaporative coolers are used in residential, commercial, agricultural, and industrial applications where higher indoor humidity is acceptable and low operating cost is important. They can provide comfort equivalent to vapour compression cooling systems in dry climates, but during periods of hot, humid weather they may produce indoor conditions that are outside the ASHRAE "comfort zone" shown in Figure.

Common mounting locations for single-stage units include walls, roofs, windows, and ground equipment pads. They will not function properly if the building is not supplied with a means of relieving indoor air to the outside. The preferred method of relief is to install barometric dampers in the ceiling or walls. Open windows or doors are frequently used for relief with low cost wall/window-mounted systems, and agricultural/industrial systems. Ceiling-mounted relief dampers in houses with attics have the advantage of cooling the attic as well as the house, reducing ceiling heat gain.

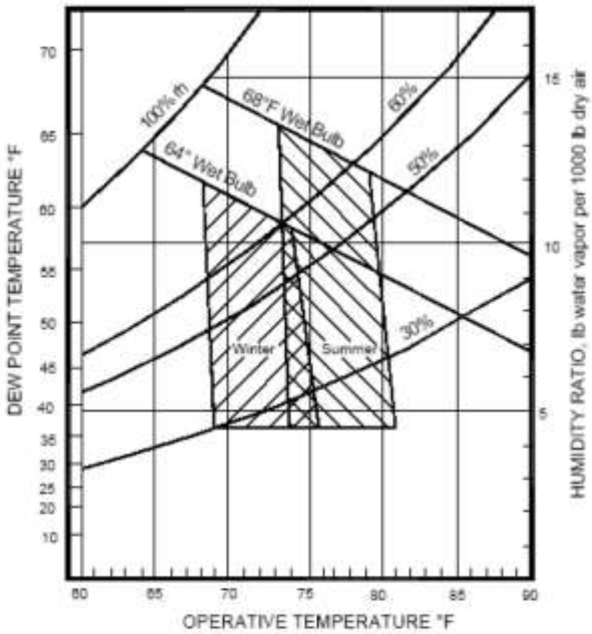

Figure 1.4 ASHRAE comfort zone chart

Manufacturers generally tend to oversimplify sizing methods by specifying airflow Rate that corresponds to a particular location or design wet bulb temperature. More accurate techniques calculate building cooling load exclusive of latent and infiltration loads, and specify a system that will deliver a sufficient volume of air to meet the design load based on the corresponding design supply air temperature and the desired indoor air temperature. The supply air temperature is calculated from the system effectiveness and the design wet bulb temperature as indicated in Equation 1. Latent cooling load can be ignored because all air is exhausted; infiltration load can be ignored because the evaporative cooler pressurizes the building. Evaporative coolers are typically controlled using manual switches, timers, and thermostats. Their low operating cost and relatively low cooling capacity favor the use of low cost controls rather than the setback thermostats used with vapor compression cooling systems. Some evaporative coolers have two fan speeds or fully variable fan speed control, allowing the user to control the temperature to some extent via the supply airflow, making the capacity of these units variable.
Some of the important applications of Evaporative cooling are explained as under:

• COOLING:
Two common applications of evaporative cooling are:
1) To improve the environment for people, animals or processes, without attempting to Control ambient temperature or humidity.
2) To improve ambient condition in a space.
• HUMIDIFICATION:
1) Using re circulated water without prior treatment of the air.
2) Pre-heating the air and treating it with re-circulated water
3) Using heated water
• DEHUMIDIFICATION AND OOLING:
Evaporative coolers are also used to cool and dehumidify air. Heat and moisture are removed from the air. For this, the temperature of water be lower than DPT of the Entering air.
• AIR CLEANING:
Evaporative coolers of all types perform some air cleaning. The dust removal efficiency of evaporative coolers depends largely on size and density of dust. They are ineffective in removing smoke.
• MAKEUP AIR:
In most industrial plants and in all confined spaces, makeup air is required to replace the large volumes of air that must be exhausted to provide the required conditions for personal comfort, safety, process operations and to maintain high indoor air quality. Evaporative cooling is useful for that.
• COMMERCIAL COOLING:
In dry climate, evaporative cooling is effective with lower velocities that are required in humid climates. This makes it suitable for use in applications where low air velocity is desirable.

INDUSTRIAL APPLICATIONS:
a) In a factory having a larger internal heat load, it is difficult to approach outdoor conditions during the summer without using an extremely large quantity of outside air. Evaporative cooling can alleviate this heat load problems and contribute to worker efficiency.

b) Area Cooling: Evaporative cooling of industrial buildings may be accomplished on an area basis or by spot cooling.
c) Spot Cooling: Spot Cooling yields to more efficient use of equipment when the personnel are relatively stationery. It is applicable in hot areas where individual cooling is needed such as chemical plants, pig and ingot casting, die casting shops, glass forming machines etc.
d) Laundry: One of the most difficult or severest applications of evaporative cooling is laundries, since heat is also produced by the processing equipment. A properly designed evaporative cooling system reduced the temperature in a laundry from 30ºC to 60ºC below outside temperature.
e) Cooling of large motors: The rating of electrical generators and motors is generally based on a maximum ambient temperature of 400ºC. For a temperature higher than this, excessive temperature will develop in the electrical windings unless the load is reduced. An air supplied to the motor/generator is through evaporative cooler, they are operated safely without load reduction.
f) Gas turbine operation: gas turbines require a large quantity of clean cool air (generally 360-40 kg /kW hr).Evaporative cooling is useful in serving this purpose.
g) Process cooling: In the tobacco, textile, spray coating and other Industries where manufacturing requires accurate humidities, comfort cooling is also obtainable by evaporative coolers. High relative humidities are required in cigar plants, textile etc. and evaporative cooling will provide the solution.
h) Mine cooling: in mine evaporative cooling with mechanical refrigeration is used to produce desirable conditions.
i) Fruit and Vegetables: Evaporative cooling as it is applied to fruits and vegetables is to provide an effective yet inexpensive means of improving common storage. Evaporative cooling is used as a supplement to refrigeration in the storage. Evaporative cooling can be used effectively to store Potatoes, Apples, Oranges, and Lemons etc.

1.4 ADVANTAGES AND DISADVANTAGES OF EVAPORATIVE COOLERS

ADVANTAGES

1) Its initial and running cost is low.
2) Unlike air conditioners, air coolers do not require refrigerants and hence eco-friendly.
3) It is comparatively less bulky.
4) Its maintenance cost is low.
5) No separate electrical connections are required for installing an air cooler. It can work at normal voltage and frequency.
6) Power consumption is low.
7) Danger of leakage of toxic refrigerant is not present.
8) The expensive insulation for the walls, ceiling etc. is not required.
9) Desert coolers can be conventionally placed in open space such as corridors, balcony, verandas, etc.
10) Tightness of doors and windows are not required while using desert coolers.

DISADVANTAGES

1) Humidity control is not possible.
2) It cannot be used effectively in regions with high humidity.
3) It may not be suitable for people suffering from Arthritis, Bronchitis, Asthma, etc.
4) After regular intervals, the cooling pads have to be changed and the tank has to be cleaned.
5) The parts coming in contact with humid air may corrode. Though the disadvantages cannot be neglected, but the advantages overcome
these disadvantages and make them so popular now-a-days.

1.5 COMPARISON OF EVAPORATIVE COOLING TO AIR CONDITIONING

Advantages

Less expensive to install

Estimated cost for installation is about half that of central refrigerated air conditioning.

Less expensive to operate

Estimated cost of operation is 1/4 that of refrigerated air.

Power consumption is limited to the fan and water pump vs. compressors, pumps and blowers.

Ease of Maintenance

The only two mechanical parts in most basic evaporative coolers are the fan motor and the water pump, both of which can be repaired at low cost and often by a mechanically inclined homeowner.

Ventilation air

The constant and high volumetric flow rate of air through the building reduces the age-of-air in the building dramatically.

Evaporative cooling increases humidity, which, in dry climates, may improve the breathability of the air.

The pad itself acts as a rather effective air filter when properly maintained; it is capable of removing a variety of contaminants in air, including urban ozone caused by pollution, regardless of very dry weather. Refrigeration-based cooling systems lose this ability whenever there is not enough humidity in the air to keep the evaporator wet while providing a constant trickle of condensate that washes out dissolved impurities removed from the air.

Disadvantages

Performance

High dew point (humidity) conditions decrease the cooling capability of the evaporative cooler.

No dehumidification. Traditional air conditioners remove moisture from the air, except in very dry locations where recirculation can lead to a build-up of humidity. Evaporative cooling adds moisture, and in dry climates, dryness may improve thermal comfort at higher temperatures.

Comfort

The air supplied by the evaporative cooler is typically 80–90% relative humidity; very humid air reduces the evaporation rate of moisture from the skin, nose, lungs, and eyes.

High humidity in air accelerates corrosion, particularly in the presence of dust. This can considerably shorten the life of electronic and other equipment.

High humidity in air may cause condensation. This can be a problem for some situations (e.g., electrical equipment, computers, paper/books, old wood).

Water

Evaporative coolers require a constant supply of water to wet the pads.

Water high in mineral content will leave mineral deposits on the pads and interior of the cooler. Bleed-off and refill (purge pump) systems may reduce this problem.

The water supply line may need protection against freeze bursting during off-season, winter temperatures. The cooler itself needs to be drained too, as well as cleaned periodically and the pads replaced.

Miscellaneous

Odours and other outdoor contaminants may be blown into the building unless sufficient filtering is in place.

Asthma patients may need to avoid poorly maintained evaporative cooled environments.

A sacrificial anode may be required to prevent excessive evaporative cooler corrosion.

Wood wool of dry cooler pads can catch fire even by small sparks.

1.6 SCOPE OF WORK

The evaporative cooler cools air by evaporative action, but the main drawback of evaporative cooler is that it increases the humidity of incoming air. Humidity of air is net content of water in dry air. This humidity causes stickiness on the body of individual which makes him uncomfortable when anyone sits in the environment for long time; this is the main problem of evaporative cooler. To overcome the problem people move to an air conditioner, but the AC is very expensive and it consumes large amount of power (about 1.5 KW). Thus it is not affordable to the common man.

The goal of this project is to reduce to amount of humidity in the outlet air of evaporative cooler so that the air will be comfortable to individuals who are in the vicinity of the air. Also to supply the air in less cost so that common man can also afford the cooler. This goal can be achieved by constructing a duct in which three heat exchangers will be placed and water from evaporative cooler will be supplied to them.

The air will be supplied through this duct to room. Thus the target of reducing humidity of air will be achieved. This unit requires two fans, three pumps; with total consumption of 130W thus the unit is affordable to common man.

1.7 PROBLEM DEFINITION

The humidity in the air of evaporative cooler makes the cooling space uncomfortable. This humidity makes evaporative cooler useless in humid regions. So to make the air of evaporative cooler comfortable following two processes must be done on it

Cooling and Humidification Cooling it already does so important factor is dehumidification

1.8 SPLIT COOLING UNIT

Split Cooling Unit consists of two heat exchangers. The temperature of water of the Evaporative cooler decreases gradually after starting the cooler. This cooled water is supplied to the Split Cooling Unit. When the air passes through the heat exchanger, it loses its heat and cooled air of 25ºC is supplied to the room without increasing its humidity. This unit can be used in non-coastal region.

METHODOLOGY

2.1 Selection of Evaporative Cooler

The Cooler buyer finds it difficult to select the right cooler to suit his requirement because of his inadequate knowledge about coolers. At present, the market is flooded with different brands of coolers, each one promising something new with large difference in prices. This further adds the confusion in the minds of buyer .Therefore the purchase is lastly made on the outer finish and manufacturer's recommendations. Except a few, most manufacturers themselves are not aware of the cooler technique and the coolers are manufactured with thumb-rule occupied with minor changes.

The following points should be kept in mind by the purchaser.

1) He should select the proper size of the cooler depending on the room volume to be cooled. The thumb rule is that the cooling capacity of the cooler should be equal to the room volume. If the room size is 3m X 4m X 3m = 36 m^3, then the fan capacity should be 36 m^3 / min. This indicated one air change per minute. There must be cross ventilation whenever the cooler is fixed. The fixing of the cooler outside the window is best. One air change per minutes is only with cross-ventilation;

otherwise the cooler kept inside the room will increase the humidity in the room after some time and will make the room more uncomfortable.

2) The cooler fan and pump should be of correct specifications. Mostly substandard
Fan and pump are used for earning higher profits and even sold at lower price by the road side manufacturers.

3) Check the internal fitting of cooler fan and pump. The fan blades should be properly centred in the front panel opening and should be mounted flush with front panel – for effective cooling.

4) Check the water spray system on the pads. The water droplets should fall on the pads uniformly for proper wetting of pads. The water should not fall towards the inner surface of the pad-as in this position, it is likely that the cooler fan will suck the water droplets and will throw them with the air in the room and will spoil the carpet etc. The motor of the cooler fan and pump may burn due to constant water spray

5) The louvers (air inlets) openings should be maximum possible – to avoid obstruction in sucking of air. This reduces the pressure loss and power consumption.

6) The body of the cooler should of proper size to match the air delivery of the cooler fan. In smaller size body the air will be sucked at higher speed through the pads and will have less time in contact with the water and will not be properly cooled. The higher air delivery in smaller cooler body is therefore meaningless. The body of the air cooler should be made of proper gauge of steel to avoid vibration and noise.

7) Check the proper earthling of the fan motor and pump motor before putting the point avoids the shock.

2.2 Design of split unit

The Split cooling unit consist of two heat exchangers equally spaced in which chilled water is supplied from the Evaporative cooler by using a high pressure submersible water pump of 40W. A fan of 18 W is fitted between the first and second heat exchanger, as shown in figure. One common rail is attached at the inlet of split unit which supplies the water to all two heat exchanger at equal pressure while another common rail is attached at the outlet of heat exchanger which collects the water from the heat exchanger and supplies to the water tank of Evaporative cooler.

Assumption:

1) Internal diameter of the tube is 5mm (As per available in market)
2) Gap between heat exchanger is 13cm.
3) Ambient temperature is 42°C.
4) Water temperature at starting of unit is 32°C.

Figure 2.1 Split unit

Figure 2.2 Heat Exchanger

MANUFACTURING PLAN

3.1 THEORETICAL ANALYSIS

3.1.1 INTRODUCTION

To study the various parameters of split unit over the wide range of DBT, WBT & RH for inside and outside conditions.

3.1.2 SIMPLE THEORETICAL ANALYSIS

The cooling efficiency of evaporative air cooling is measured by the saturation effectiveness or the evaporative saturation efficiency (η) (ASHRAE Standard, ANSI/ASHRAE Standard 133–2001). It is determined primarily by the measured temperatures of the air entering and exiting the rigid media using the following equation:

$\eta = 100X\ (T_{d1}-T_{d2}/T_{d1}-T_{wb})$ ….equation 1

Where,

T_{d1} = inlet dry-bulb temperature (°C).

T_{d2} = outlet dry-bulb temperature (°C).

T_{wb}= thermodynamic wet-bulb temperature of the inlet air(°C);

η =evaporative saturation efficiency (%).

The coefficient of performance of split unit and the evaporative cooler is given by

$$COP = h_1 - h_2/w$$

Where

h_1=heat of air at inlet

h_2= heat of air at outlet

w= work done

It should be noted that the above equations consider the water vapour and not the water liquid. The solid media can be considered to simulate a heat exchanger.

Consequently the heat or mass transfer coefficient can be calculated with log mean temperature difference ΔT or density difference of water vapour $\Delta\rho_v$ to proxy q and in m_e Equations (4) and (5) we obtain

$$. h = q / As\Delta T$$

Where,

h = heat transfer coefficient (W /m^{2}K)

As= total wetted surface area of rigid media (m^2); and

ΔT= the log mean temperature difference for a constant water temperature in the heat exchanger, which is assumed to equal the wet-bulb temperature.

3.2 EXPERIMENTAL SETUP

The new design is as shown in figure, it consist of following components

- The conventional evaporative cooler.
- A duct consisting of three heat exchangers and a fan to supply air.
- Two submersible pumps

The heat exchangers are supplied with the cooled water from the Evaporative cooler by using high pressure submersible pump of 40W via flexible pipes. Outlet water from all heat exchangers is connected to the common rail and it collected in the water tank of Evaporative cooler. This water cools Evaporativaly in the Evaporative cooler.

Fan

There are two fans used in the modified system. One in split unit and the other in the evaporative cooler .The function of the Fan in Desert Cooler is to provide air with sufficiently high velocity to give desired air motion and effect to the human occupants.

Figure 3.1 Fan

Specification of Fan

Exhaust Fan:-152.4 mm

1500 rpm, 1 phase, 4 pole

Electric type fan:- 220/240V,50Hz, AC
Power- 50W.

Submersible Pump

The pump is used to circulate water through the pads of Desert.

Specification of Pump

Power Consumption:-15W
Voltage:-AC 220V
Outlet Nozzle Size:-½"
Maximum Head:-1.5m (5 Ft.)

Figure 3.2 Pump

Tank

Tank is used to hold sufficient quantities of water to enable the pump to circulate the desired amount of cooling water. It is large enough to hold a good quantity of water. The capacity of tank may range from 80 to 120 litres. The water being circulated after every cycle falls back in to the tank and constant circulation is maintained. As the water goes on evaporating slowly and slowly the water content in the tank goes on decreasing. Hence the tank should be refilled with water after a definite quantity of time, which depends on the no. of hours of cooler use. More is the use, quicker the tank gets empty. The tank is generally made of galvanized sheet metal but it is not at all compulsory to use this kind. Even the cement tanks can be used. A drain valve should be necessarily present in the tank so as to facilitate the cleaning and maintenance operations.

Pads

The function of pads is to assists in the evaporation of water by capillary action and thus provides the cooling effect. The pads are fixed in the body of Desert Cooler and exposed to the atmosphere on the outer side, so that the air keeps on flowing through them. The pads in use today are generally Aspen Wood Pad, which are easily available with the cooler dealers. Generally three pads are used in the cooler. The pads under the action of dust and dirt particles lose their efficiency with use; hence they should be replaced every year. They are not very costly and cost around 50-100 rupees per pad, depending on the quality.

Piping

Their function is to carry the circulating water the pump and distribute the water evenly above all the pads to produce uniform cooling. The pipes used now-a-days are of plastic so as to avoid corrosion and long life. Holes are provided in the pipes above the pads, so as to allow the water to fall over the pads from the holes. These holes should be regularly checked to ensure a proper flow of water over the pads. If they get clotted under the action of dust and dirt, they should be cleaned properly. Also the other piping is used for circulating the coolant through split unit.

Outer Body

The outer body can be made from different materials depending on the cost and convenience. They can be either made of Wood or can be fabricated from sheet metal. Now-a-days the the Plastic body cooler are also widely manufactured by some companies due to advantages like Low weight, corrosion free and easy maintenance.

Figure 3.3 Outer Body of Cooler

Front Cover

The Front Cover present in front of the Fan serves a no. of purposes. Firstly, they give a good and pleasing appearance to the cooler. Secondly, they act as a safety device, so as to keep human organs away from the fan. The louvers present in the Cover are also used to direct the flow in the desired direction.

Temperature and Humidity measuring device

Figure3.4 Temperature and Humidity measuring device

WORKING AND OBSERVATIONS

4.1 WORKING

Firstly the cooled water from water tank of Evaporative cooler is supplied to the heat exchangers via common rail. The temperature of water at inlet is 24ºC for all heat exchangers.

When air comes in contact with the heat exchangers, it loses its heat.

Then cooled air is supplied to the room without increasing its humidity.

The water at the outlet of heat exchangers is collected in the water tank of Evaporative cooler.

This cooler recirculates the air from the room so its cooling effect will go on increasing and it can maintain room temperature up to 27°C. Total power consumption of the unit is just 130W.

4.2 OBSERVATIONS

Table4.1 Observations

S. NO.	TIME	TEMPERATURE AT THE END OF THE SPLIT UNIT	AMBIENT TEMPERATURE
1	2PM	33	36

2	3PM	31	38
3	4PM	31	37
4	5PM	30	36
5	6PM	29	35
6	7PM	28	31
7	8PM	28	28
8	9PM	27	27

4.3 CALCULATION

1) Saturation Effectiveness

$\eta=100X\ (Td_1-T_{d2}/T_{d1}-T_{wb})$

Where,

T_{d1} = dry bulb temperature(°C)= 38

T_{d2} = outlet temperature(°C)= 27

T_{wb} = thermodynamic wet bulb temperature= 22

η = saturation effectiveness (%)

η =100X (38-27/38-22)

η =68.75%

2) Coefficient of Performance

COP= Energy supplied/ Energy used

COP= ms. $(h_1 - h_2)$/ W

Where,

ms = Mass flow rate of air in Kg/sec

h_1 = Initial Enthalpy of air in KJ/Kg

h_2 = Final Enthalpy of air in KJ/Kg

W= Power consumption in watt

COP = 0.1666 x (70-48)/ 130= 2.7

COP = 2.7

3) Heat transfer Co-efficient

$q=hA_s\Delta T$

Where,

h = heat transfer coefficient (W $m^{-2}K^{-1}$);

As = total wetted surface area of rigid media (m^2); and

ΔT is usually taken to be the log mean temperature difference for a constant water temperature in the heat exchanger, which is assumed to equal the wet-bulb temperature.

q = W/As

Where, W= Power consumption in watt

q = Heat flux in watt/ m^2

q =131/ 0.025908 = 50.56 w/ m^2

h= $q/A_s\Delta T$

h= 50.56/(0.025908 x (42-25))

= 114.795(W $m^{-2}K^{-1}$)

RESULTS AND DISCUSSIONS

5.1 RESULTS

The results are as follows:

The Split unit able to maintain the temperature of up to 27°C.

The COP of the system is 2.7.

The total power consumption of unit is 130 watt.

The split unit does not increase the humidity of air.

5.2 CONCLUSION

The experimental investigation above confirmed that split unit demonstrated reasonable potential for use as a wetted media in evaporative cooling systems. Consequently, it creates the possibility of new sustainable engineering systems where either cooling or humidifying is required. As the unit maintain the temperature 27°C and it has low cost than AC so it will be good replacement for AC.

5.3 FUTURE SCOPE

For the future modifications, if the density of the split unit is reduced then we can achieve better performance than that achieved. Also we can increase the thickness of the pad to achieve good performance.

Abbreviations and Acronyms

1 DBT- Dry bulb temperature
2 WBT-Wet bulb temperature
3 COP- Coefficient of performance
4 AC – Air conditioning
5 RH –Relative humidity
6 ASHRAE- American Society of Heating, Refrigerating and Air conditioning Engineers
7 ANSI-American National Standards Institute

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