Performance and Efficiency of Swamp Cooling System

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Abstract—Now days due to energy crisis and harmful effect to environment, there is a urgent need of energy saving in air conditioning and water cooling demands in mainly consideration of all the free cooling techniques. Among them evaporative cooling is well known technique from long time which gives good results and wide number of applications in residential, commercial, agricultural, and institutional buildings to industrial applications such as spot cooling in power plants, foundries, etc. So in this paper the evaporative cooling, it's potential, and different trends in evaporative cooling are studied, which are environment friendly as it uses only natural energy as latent heat of water. The efficiency and effectiveness of evaporative cooling depends on surrounding climatic conditions which are studied in this paper, faster the evaporation rate we gate maximum cooling effect.

Key words: Evaporative Cooling System (Swamp Cooling System); Ambient Conditions; Wick Material; Direct-Indirect Evaporative Cooling

I. Introduction

Evaporative coolers, often called "swamp coolers" , are cooling systems that use only water and a blower to circulate air. Conventional direct evaporative coolers consist of a large water reservoir, a pump that draws water from the reservoir and discharges it through spray nozzles directly into air stream or through cooling pads. Evaporative cooling has been in use for many decades in India for cooling water and for providing thermal comfort in hot and dry regions. Evaporative air conditioning systems offer an attractive alternative to the conventional summer air conditioning systems in places, which are hot and dry. Evaporative air conditioning systems also find applications in hot industrial environments. In addition, evaporative cooling systems are more environmentally friendly as they consume less energy and their performance improves as air temperature increases and humidity decreases.

A. Classification of Evaporative Cooling

The principle of evaporative cooling can be used in different ways. Evaporative cooling can be further classified as follows-

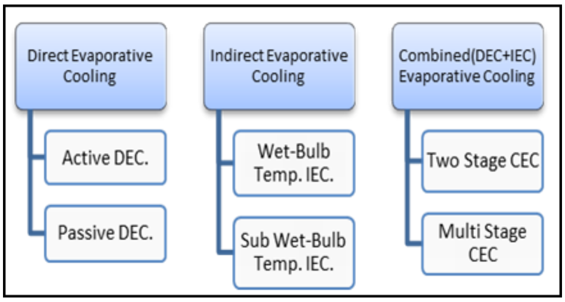


Fig. 1: Classification of Evaporative Cooling

1) Direct Evaporative Cooling (open circuit)

Direct evaporative cooling introduces water directly into the supply airstream (usually with a spray or some sort of wetted media). As the water absorbs heat from the air, it evaporates and cools the air. In direct evaporative cooling the dry bulb temperature is lowered but the wet bulb temperature remains unchanged. The efficiency of direct cooling depends on the pad media.

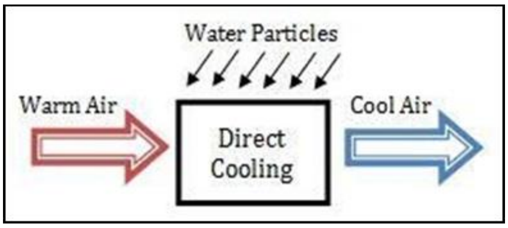


Fig. 2: Direct Evaporative Cooling

2) Indirect Evaporative Cooling (closed circuit)

Indirect evaporative cooling lowers the temperature of air via some type of heat exchanger arrangement, in which a secondary airstream is cooled by water and which in turn cools the primary airstream. The cooled air never comes in direct contact with water or environment. In indirect evaporative cooling system both the dry bulb and wet bulb temperatures are reduced. Indirect evaporative coolers do not add humidity to the air, but cost more than direct coolers and operate at a lower efficiency.

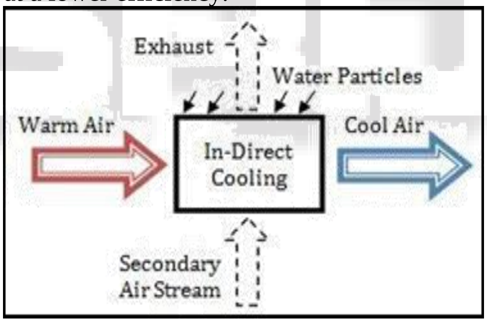


Fig. 3: Indirect Evaporative Cooling

3) Combined Evaporative Cooling

This type of evaporative coolers combines both direct and indirect evaporative cooling. This is accomplished by passing air inside a heat exchanger that is cooled by evaporation on the outside.In the second stage the pre cooled air is passes through a water soaked pad and picks up humidity as it cools.Because the air supply to the second stage evaporator is pre cooled less humidity is added to the air whose affinity for moisture is directly related to temperature. In many cases the two stage systems provide better comfort.

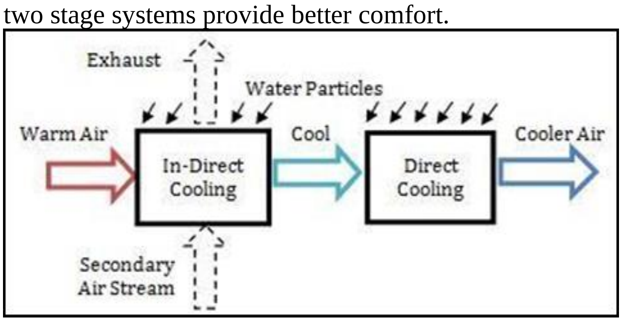


Fig. 4: Combined Evaporative Cooling

B. Working Principle:

Evaporative cooling system is based on the principle that when moist but unsaturated air comes in contact with a wetted surface whose temperature is higher than the dew point temperature of air, some water from the wetted surface evaporates into air. The latent heat of evaporation is taken from water, air or both of them. In this process, the air loses sensible heat but gains latent heat due to transfer of water vapor. Thus the air gets cooled and humidified. The cooled and humidified air can be used for providing thermal comfort.

II. OBJECTIVES

- To utilise a heat exchanger for two stage evaporative cooling system.
- Testing the performance of the two stage evaporative cooling system and comparing it with conventional cooling media.
- To evaluate the performance study of an evaporative cooling system such as dry bulb temperature, wet bulb temperature, and relative humidity.
- Evaluating the performance of cooler by combining three different cooling pads.
- Evaluate the economics of evaporative cooling system.

III. MATERIALS AND METHODOLOGY

A water supply system that intermittently sprays water into the air flowing over the cooling pad.

- A coarse fabric cooling pad fitted across the air flow onto the condenser. The water is sprayed onto this to keep it wet. The surface area of the cooling pad needs to be as large as possible to make the system effective in lowering the air temperature.
- Water can be controlled either by a sensor measuring machine. To prevent corrosion problems, you should fit non-metallic sprays.

A. AHU (Air Handling unit)

- It is a device used to regulate and circulate air as part of a HVAC system.
- An air handler is usually a large metal box containing a blower, heating or cooling elements etc.
- The AHU used in our experiment made up of galvanized steel and aluminium die cast corner.

Fig. 5: AHU Box

B. Tank with support for Heat Exchanger

- Tank is made up of SS 304 sheet, which is made leak proof.
- Provisions are given for water inlet, overflow and drain.
- Tank is designed in a way to ensure the complete drain of water in order to avoid water stagnation.

Fig. 6: Tank with support for heat exchanger

C. Main blower and motor

- The Blower-Motor is assembled on aluminum blower rails which are assembled in perpendicular directions.
- The blower is fixed on one set of rails and the motor on second set which is fixed perpendicular to it.
- Capacity, Blower: 675 CFM,
- Motor : 0.55 kW

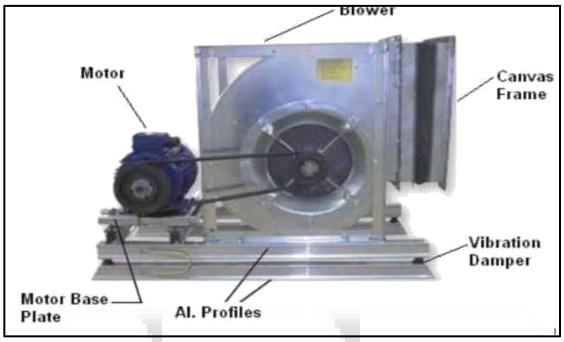


Fig. 7: Main Blower and Motor

D. Sensible Heat Exchanger

- Individual pumps lifts water from the tank to the top surface of both the heat exchangers.
- Monoblock pumps are used for recirculation of water from the tank continuously thereby wetting the heat exchangers.
- The water flow is controlled by gate valves so as to maintain the required wetness of the heat exchangers.

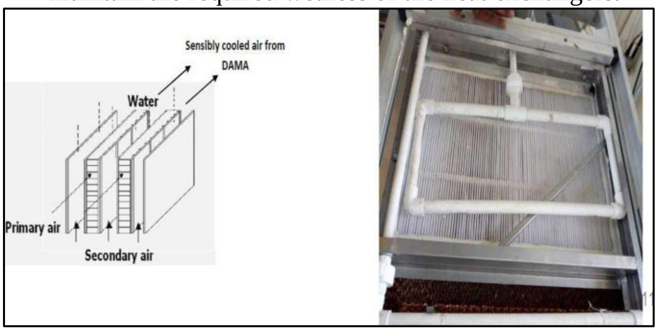


Fig. 8: Sensible heat exchanger

E. Adiabatic Heat Exchanger

- The cellulose cooling pad is constantly kept wet with a water sprinkler.
- The air coming from the sensible heat exchanger further moves through this cellulose pad section.
  Provides maximum cooling by volume expansion humidification of the conditioned air.
- Highly efficient evaporative cooling media.

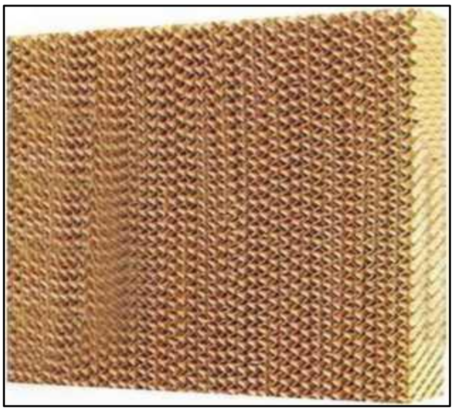


Fig. 9: Adiabatic Heat Exchanger

F. Filters

- It comprises of a high quality synthetic media made of High-Density Polyethylene pleated with Aluminum mesh.
- The entire set is housed in G.I casing which filters the incoming air.
- The filtered air then passes to heat exchangers after which it flows through the outlet.

Fig. 10: Filters

By using this 2 equipments we can find the humidity and air velocity of system

1) Sling Psychrometer
2) Digital anemometer

G. Sling Psychrometer

Sling Psychrometer is used to measure both the dry bulb and wet bulb temperatures at time. These temperatures are a measure of humidity content in air.

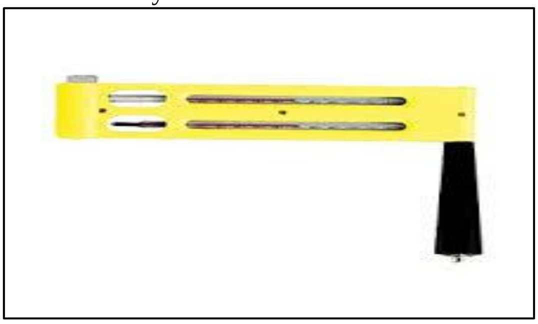


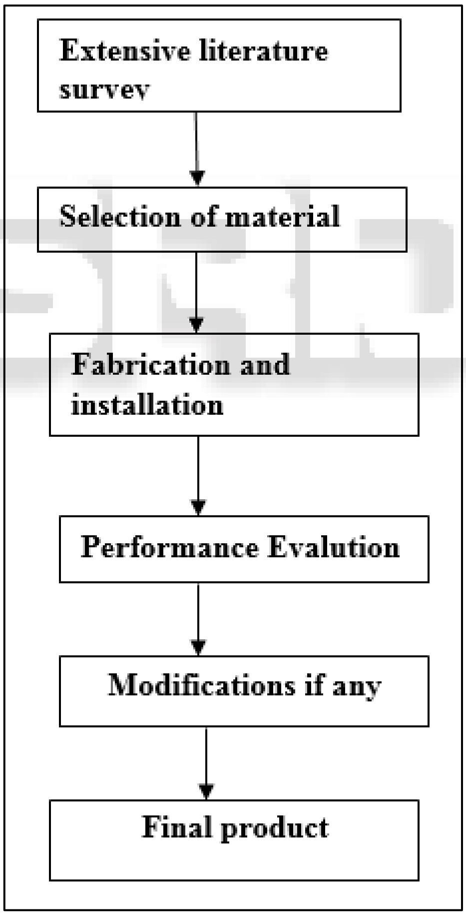
Fig. 11: Sling Thermometer

H. Digital Anemometer

The digital Anemometer is a device used for measuring the air velocity of the air and the speed of air from the Evaporative Cooling System

Fig. 12: Digital Anemometer

IV. METHODOLOGY



V. WORKING MODEL OF AN EVAPORATIVE COOLING SYSTEM

Fig. 13: Working model of an Evaporative Cooling System

VI. RESULTS AND DISCUSSION

Ambient Temperature in ºc	Inlet DBT in ºc	Inlet WBT in ºc	Outlet DBT in ºc	Outlet WBT in ºc
28.5	28.5	24.5	26	23.5
28	28	22.5	23.5	22

A. *Case 1*

Ambient temperature Ta: 28.5°C
Condition 1: Indirect evaporative cooling.

– Inlet Condition
  DBT: 28.5°C WBT: 24.5°C
– Outlet Condition
  DBT: 26°C WBT: 23.5°C
  Efficiency,

ϵ = .$\boldsymbol{db - To.db/Ti.db - Ti.wb}$ *100

– Ti.db : inlet dry bulb temperature
– To.db : outlet dry bulb temperature
– Ti.wb : inlet wet bulb temperature
  Efficiency,
– ϵ =28.5 − 26 /28.5 − 24.5∗ 100
– ϵ = 62.5%

B. *Case 2*

Ambient temperature Ta: 28°C
Condition 2: Indirect and direct evaporative cooling

– Inlet Condition
  DBT: 28°C WBT: 22.5°C
– Outlet Condition
  DBT: 23.5°C WBT: 22°C
  Efficiency,
  ϵ =28.5 − 26/ 28.5 -24.5*100
  ϵ = **81.8**%

The result obtained shows us that the Efficiency of a two stage evaporative cooling (Direct and indirect) is more when compared to that of a single stage Evaporative cooling (Indirect Evaporative cooling).

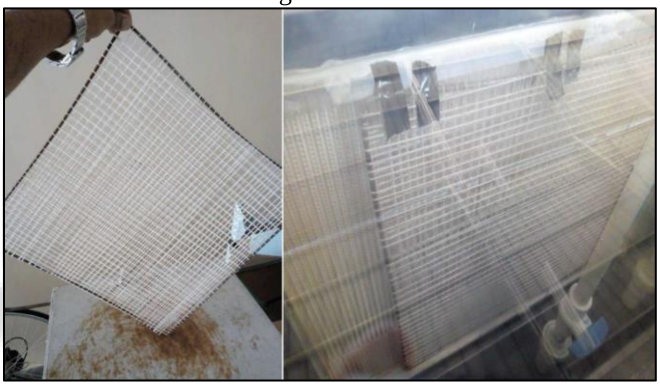
VII. CONCLUSION

– New type of sensible heat exchanger was tested successfully
– It provides higher DBT difference due to cross flow heat exchange
– Efficiency of two stage evaporator with sensible heat exchanger is higher than single stage indirect method.
– Cost of this type of evaporator is higher than the split AC
– Energy consumption of this evaporator is lower than the split AC
– As the water temperature increases, the performance of evaporative cooling system decreases.

VIII. FUTURE SCOPE

Using nano-particle embedded media

– As seen earlier, nano-sized $A1_2O3$ particles can be used as a media in addition to the existing setup.
– A simple experiment conducted with mesh made of cotton fibre embedded with nano-Al_2O_3 particles.
– The mesh were positioned at the inlet portion behind the sensible heat exchanger and at the outlet portion after the adiabatic heat exchanger.



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