DESIGN AND FABRICATION OF MINI COOLING TOWER

Submitted in partial fulfillment of the requirements
Of the degree of

BACHELOR OF TECHNOLOGY
IN
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This is to certify that the Research work titled **DESIGN AND FABRICATION OF MINI COOLING TOWER** that is being submitted by **AMBUJ KUMAR, LAXMAN KUMAR YADAV, RISHABH SINGH RAJPUT, ABHISHEK YADAV** is in partial fulfillment of the requirements for the award of **BACHELOR OF TECHNOLOGY**, is a record of bonafide work done under my guidance. The contents of this research work, in full or in parts, have neither been taken from any other source nor have been submitted to any other Institute or University for award of any degree or diploma.

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ABSTRACT

A cooling tower is a special type of heat exchanger in which water and air is circulated, and temperature of water is lowered by evaporative cooling method. In this as air and water are in contact some amount of water is evaporated and latent heat of vaporization is taken from water itself, which will result in decrease in water temperature. This method of cooling is most efficient and eco-friendly method. Importance of this cooling method is more particularly in are where water is not easily available from natural resource or there is some restriction imposed by government for use of natural resource. The temperature rage in which cooling tower can be operated and the performance of cooling tower is dominated by wind speed, ambient air temperature and humidity in atmospheric condition.

Now days most of chemical and mechanical industries uses large amount of water for b their cooling plants. However largest user of water are the power plant, in which low pressure steam from turbine is condensed in large condenser and then cooled in cooling tower for reuse.

TABLE OF CONTENT

List of abbreviations

1. NDCT — Natural draft cooling tower.
2. MDCT — Mechanical draft cooling tower.
3. IDCT — Induced draft cooling tower.
4. FDCT — Forced draft cooling tower.

List of figures

1

Introduction

1.1 Project background

Every power plant or larger industrial facility produces excessive heat that cannot be used further (due to the entropy rise). This heat has to be transferred to the environment if a breakdown of the process in the facility is not accepted (which is normally isn't). If there are water reservoir (sea, lake, rivers) nearby in which heat can be transferred without environment concerns, this is the cheapest and easiest way. But unfortunately, this is not often the case and so alternative cooling methods need to be invented and used. One especially well known is the cooling tower, because it is a land mark and is often mistaken for a chimney.

The general construction of a cooling tower is governed by different decisions. It is important to construct the tower in a way that it lives up to all the demands the different parties have towards it. I.e. environmental, design, function and price.

1.2 Research purpose and meaning

Purpose of research is to

1. Review the existing design of cooling tower.

2. Find the problem in existing design of cooling tower

3. To design a cooling tower which is most efficient and cost effective.

4. To enhance our understanding about cooling tower.

5. To enhance our understanding about various tool used in design and production of cooling tower.

2

Literature review

2.1 Introduction

Cooling tower originated in the 19th century through the development of condensers for the use with the steam engine. Condensers use relatively cool water, via various means, to condense the steam coming out of cylinder or turbines. However the condenser require an ample supply of cooling water, without which they are impractical. While water usage is not an issue with marine engines, it forms a significant limitation for many land-based systems. By the turn of the 20th century, several evaporative method of recycling cooling water were in use in areas lacking an established water supply, as well as in urban locations where municipal water mains may not be of sufficient supply. In areas with available land, the systems took the form of cooling ponds; in areas with limited land, such as city, they took the form of cooling towers. These early towers were positioned either on the rooftops of buildings or as free-standing structures, supplied with air by fans or relying on natural. An American engineering textbook from 1911 described one design as a circular or rectangular shell of light plate-in effect, a chimney stack much shortened vertical and very much enlarged laterally. At the top is a set of distributing troughs, to which the water from the condenser must be pumped from these.

A hyperboloid cooling tower was patented by the Dutch engineer Frederik van Iterson and Gerard Kuypers in 1918. The first hyperboloid cooling towers were built in 1918 near Heerlen. The first ones in the United Kingdom were built in 1924 at Lister Drive power station in Liverpool, England, to cool water used at a coal-fired electrical power plant

2.2 Reviews

Design of cooling tower by B. Bhavanisai, I. Swathik (2016)

They has delineate an in depth methodology of a evoked draft cooling system of counter flow kind throughout that its efficiency, effectiveness, characteristics area unit calculated. The technical info has been from a mechanical draft cooling system. Cooling towers are unit heat removal devices accustomed transfer methodology waste heat to the atmosphere. Cooling towers produce use of evaporation whereby variety of the water is vaporized into a moving air stream and later discharged into the atmosphere.

Performance analysis of Natural draft wet cooling tower at optimized injection height by lalok Singh, Sanjay Soni, R.S.Rana.

Cooling tower is associate integral a part of thermal power generation plant. Essentially cooling square measure heat rejection device accustomed transfer waste heat to the atmosphere. Investigation involves the two-dimensional process fluid dynamic model support actual reference condition. Temperature and humidness within the tower square measure having main influence on the performance of natural draft cooling tower.

Performance analysis of a low approach low temperature direct cooling tower for high temperature building cooling system by Mehdi Nasrabadi, DonalP.Finn.

For certain temperature climate varieties, cooling towers have potential to provide hot temperature chilled water, that when used in conjunction with bright and displacement cooling technologies, have prompted interest throughout technologies, have prompted approach for the acquisition of buildings. The feasibleness of the projected system depends principally, on achieving low approach water temperature at intervals.

Associated in nursing fittingly designed cooling system, at acceptable levels of energy performance.

Performance Evaluation of cooling tower in Thermal power plant – A Case study of RTPS Karnataka By Pushpa B. S, Vasant Vaze, P. T. Nimbalkar.

The site selected for this project is Raichur Thermal Power Station, at Shakthinagar, Karnataka. It is a coal-fired plant and contribute about 40% of total electricity generated in Karnataka. Data on air temperature, inlet/outlet water temperature, relative humidity, wind velocity, and power generation were collected from the project for calculation of rate of heat loss, sensitivity analysis and efficiency. From this study they conclude thathe rate of heat loss is affected by the atmospheric parameter like air temperature, water temperature, relative humidity and rate of heat loss.

The supply of fresh air, the size of droplets and the temperature of warm water will be governing the effectiveness of natural draft cooling tower.

Maintenance of a Natural draft cooling tower by Neet Singh Raghuvanci, Dr. Alok Singh (2014)

Cooling tower closing maintenance is extremely complicated and time intense. This drawback is happen once correct sequencing procedure isn’t employed in closing maintenance. Closing maintenance of cooling system is happens once the part of cooling system aren’t activity their functions properly causes the performance of cooling system reduces. Once we use the correct sequence of closing maintenance activity then we are able to cut back the quality in maintenance activity and reach the less time with minimum labor. Once these maintenance activities square measure unplanned then it will increase the overhauling value of cooling system in terms of labor value and time consumption.

3

Problem description

3.1 Problem description

After air water is most valuable and precious thing on earth for human life to survive. As we know that source of fresh water is decreasing continuously and population of human being increasing drastically, it will make water is more precious. Priorly water can be used for drinking and agriculture purpose. Secondary priority of water is for industries like power plant. In any power plant as we know water is required in very large amount to cool the condenser.

There are two type of cooling water system we can design or manufactured, first one is cooling once through and second one is cooling in close loop, The water requirement for close loop almost 90% less than that of cooling once. Cooling towers are considered to be effective while adopting the close-loop system. Main advantages of cooling tower is that, it can use almost same amount of water again and again, that makes it more economic as well as eco-friendly. Whenever there is a limited resource of water is available it is necessary to use close loop cooling tower.

Most of the cooling tower available in the market now days are costly and less efficient.

Larger industries like power plant can use these-tower but for small and medium scale industries initial investment is to high, that’s why they are unable to use cooling tower.

In our project we try to design a mini cooling tower which is efficient and cost effective too.

As we know that most of the cooling towers are made up of iron and in cooling tower there are always contact of air and water, this will lead to corrosion and ultimately leakage in tower and every time this type of leakage is ignored and this will make tower less efficient. This can be prevented by using that material which are non-corrosive in nature .In our project we used non-corrosive material like wood and grass in those component which are directly is in contact with air water, this will reduce the chance of corrosion and leakage of water and air, this will increase the effectiveness of tower.

4

The Cooling Tower

4.1 Introduction of cooling tower

Cooling towers are one of the important part of many chemical and mechanical industries. The main task of a cooling tower is to extract heat from any of the component which is continuously subjected to various heating process. They represent a relatively inexpensive and dependable means of removing low-grade heat from cooling water. While cooling some of water gets evaporated and to counter this we have to add some water known as make-up water and the source from which water is added is known as make-up water source. Hot water from heat exchanger is sent to the cooling tower through a pipe and after the cooling process the cold water is sent back to the exchanger or to other units for further cooling. Cooling towers are able to lower the water temperature more than device that use only air to reject heat, like the radiator in a car, and are therefore more cost-effective and energy efficient

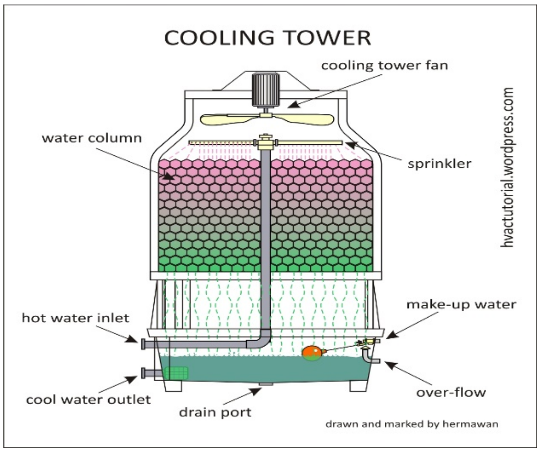


Fig. 01

4.2 Types of cooling tower

Categorization by air to water flow

1. Cross flow

This is a type of cooling tower in which contact of air and water takes place perpendicularly. Air flows enter through louver which is vertical and after the louver there is a fill material and water flow along the pours in fill material and air and water meets perpendicularly and filly a fan suck the air and thrown it in the environment.

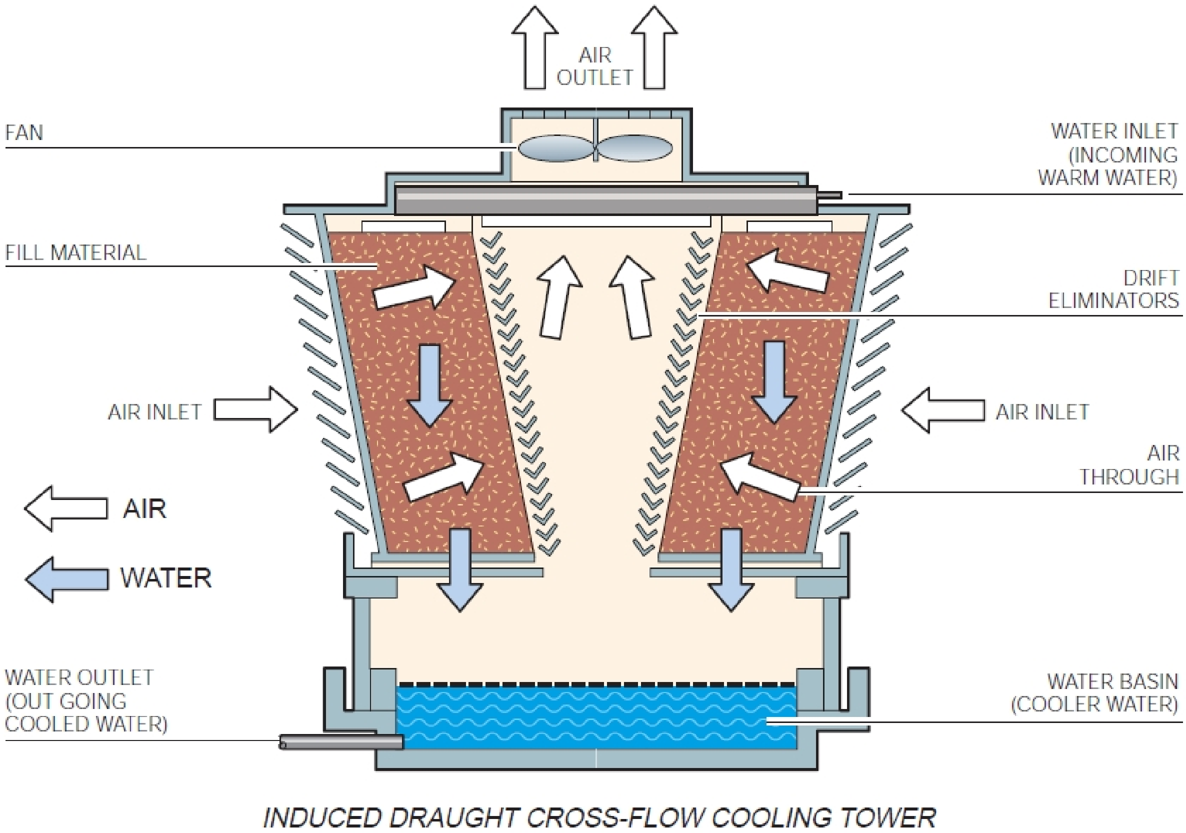


Fig.02

2. Counter flow

In this type of cooling tower the flow of air and water occur parallel but opposite in direction. Air flow occur through a louver and after with the help of a fan it is sucked or forced vertically upward. The water is sprayed through pressurized nozzles near top of tower in vertically downward direction and in this way contact of air and water takes place .

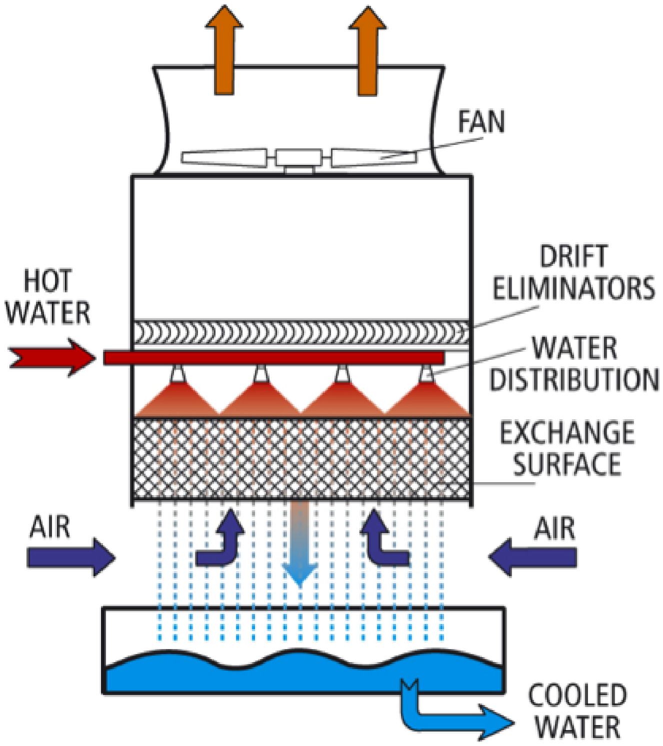


Fig. 03

Categorization by Air flow generation method

1. Natural Draft Cooling Tower (NDCT)

In natural draft cooling tower we use a principle according to which when we heat up some fluid its density decreases and that's why it start flowing in upward direction. As hot air moves upwards through the tower, fresh cool air is drawn into the tower through an air inlet at the bottom. To counter the pressure issue the design of tower is hyperbolic that's why it is also known as hyperbolic tower. Due to the layout of the tower, no fan is required and there is almost no circulation of hot air that could affect the performance. Concrete is used for the tower shell with a height of up to 200m. These cooling towers are mostly only for large heat duties because large concrete structure are expansive.

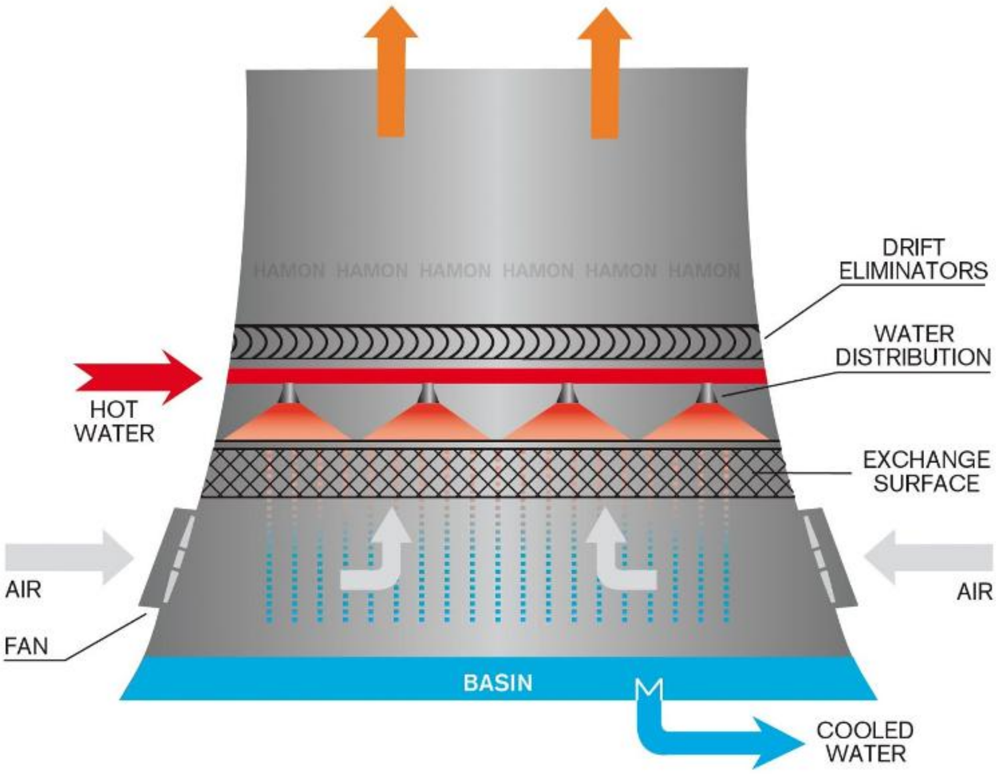


Fig. 04 NDCT

2. Mechanical draft cooling tower (MDCT)

In this type of tower movement of air is done by some mechanical means like use of fan that's why this is known as mechanical draft cooling tower. The water falls downwards over fill surface, which help increase the contact time between the water and air, this helps maximize heat transfer between the two. Cooling rates of mechanical draft towers depend upon various parameters such as fan diameter and speed of operation, fill for system resistance etc.

Mechanical draft cooling tower further classified into two categories

1. Forced draft cooling tower

2. induced draft cooling tower

Forced draft cooling tower (FDCT)

When a fan or blower is used at inlet of tower to force the air through it then it is forced draft tower. The fan pressurized air into cooling tower which will increase the velocity of air at inlet and due to friction velocity of air at exit will decrease which will increase the chance of recirculation of air. With the fan on the air intake, the fan is more susceptible to complications due to freezing condition. Another disadvantage is that a forced draft design typically requires more motor horsepower than an equivalent induced draft design. The benefit of the forced draft design is its ability to work with high static pressure. Such setups can be installed in more-confined space and even in some indoor situations. Advantage of forced draft is that in forced draft fan is more near to ground which will decrease the vibration.

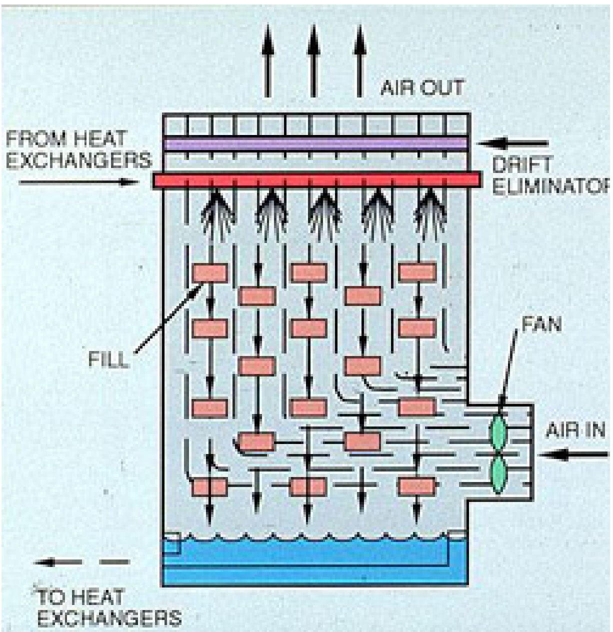


Fig. 05 FDCT

Induced draft cooling tower (IDCT)

In this type of cooling tower fan is placed at the top of cooling tower which will create a negative pressure inside the tower due to which air flows occur inside the tower. This produces low entering and high exiting air velocity, reducing the possibility of recirculation in which discharge air flows back into the air intake. The fan arrangement is also known as draw-through. In this fan is placed at the top of tower which will increase the vibration problem.

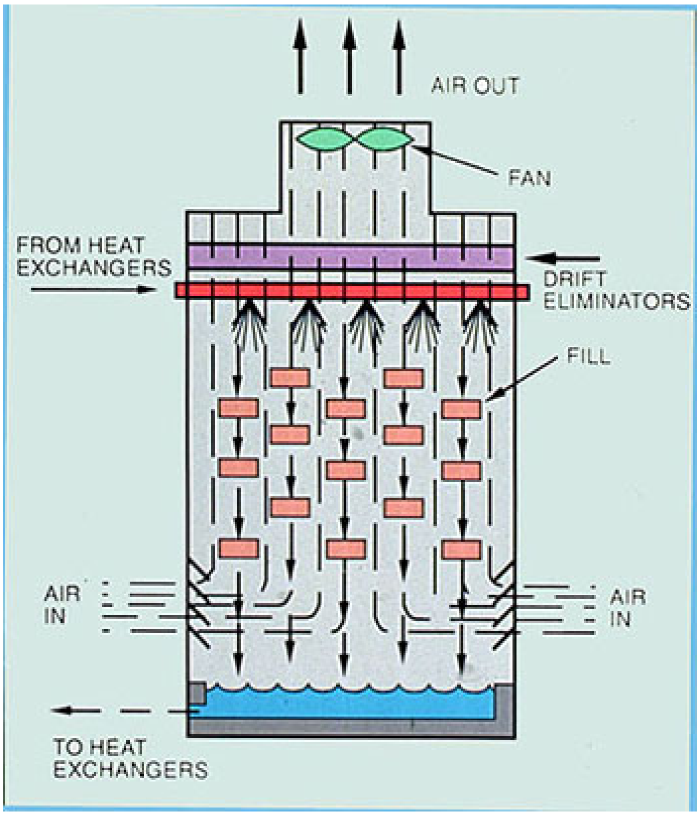


Fig. 06 IDCT

Categorization by open and close circuit

1. Open circuit cooling tower

In this type of cooling tower there is a direct contact between air and water in order to lower the temperature of air. Due to direct contact between air and water the cooling of water occur due to both type of heat transfer sensible heat transfer as well as latent heat transfer. When there is large reduction in temperature is required this type of cooling tower is used

2. Closed circuit cooling tower

In this type of cooling tower there is no direct contact between the air and water.

In this type of cooling tower heat transfer occur through only one means, sensible heat transfer. When large reduction in water temperature is required this type of cooling tower cannot be used.

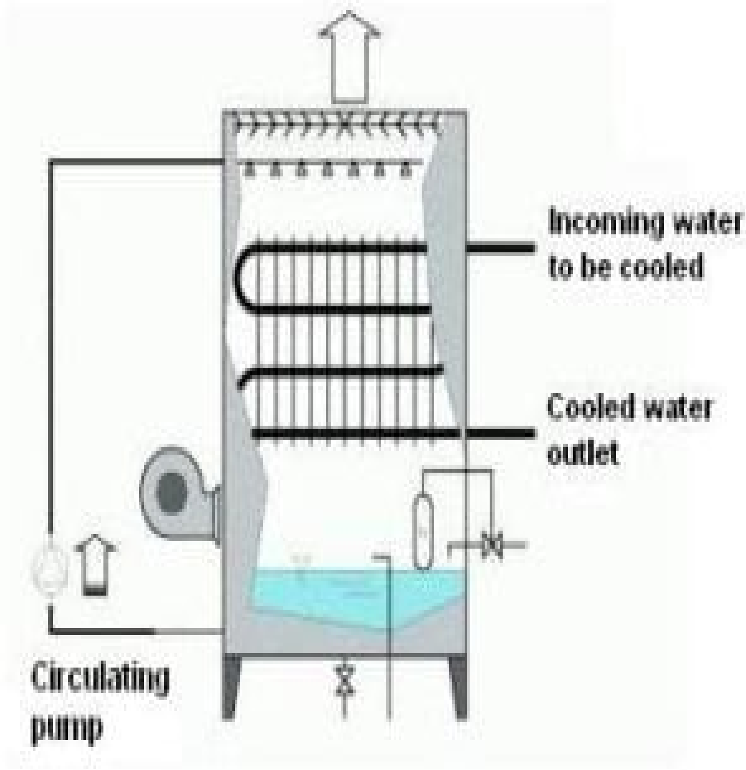


Fig. 07 Closed circuit

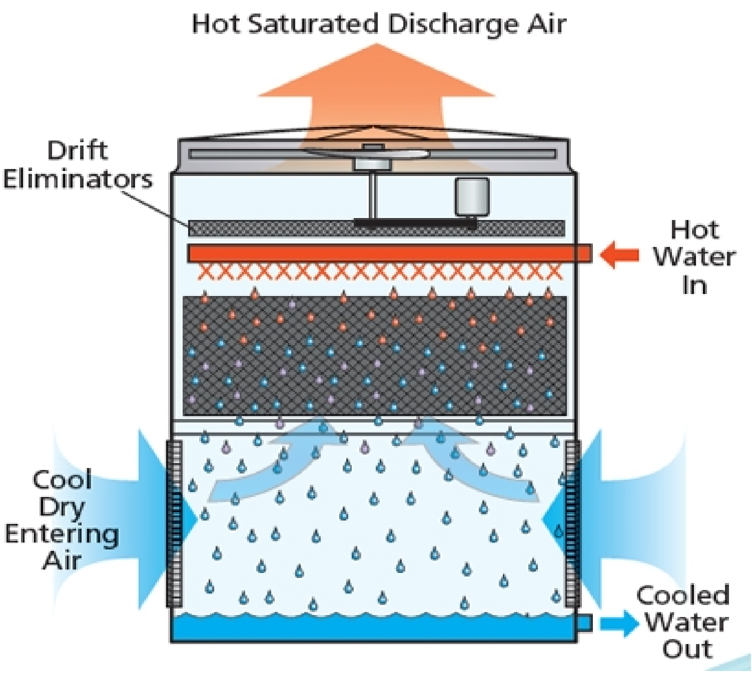


Fig. 08 Open circuit

3. Hybrid Tower

In above both type of tower we studied have their own advantages and disadvantages. In order to design a tower which have both type of characteristics we design a cooling tower which can work on either sensible heat transfer mode or sensible and latent heat transfer mode this kind of cooling tower is known as hybrid tower. When required only sensible heat mode is on but when this mode is no sufficient we have to switch on latent heat mode. This will increase the efficiency of cooling tower. In now days in almost every industry hybrid cooling tower is used.

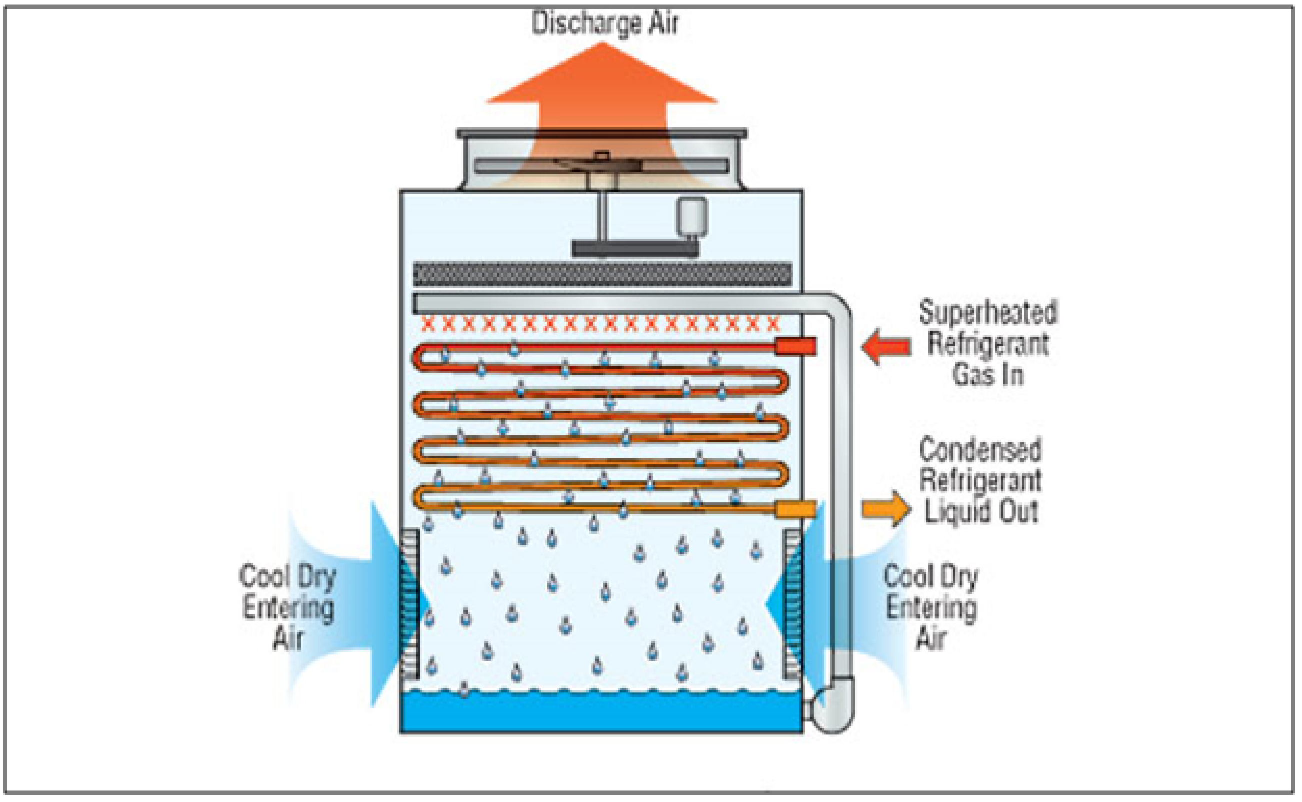


Fig. 09 Hybrid tower

4.3 Components of cooling tower

The basic component of cooling tower is as follows.

1. Frame and casing

All of engineering structure having frame and casing. The basic work of frame and casing to support the structure and house various equipment of component. As we know the frame takes all load of component this the most critical part.

2. Fill

Fills are a way to increase the contact time between air and water in order to get maximum heat transfer. It is generally made of plastic or iron. It is porous in nature. But in our design we used fill made up of grass.

There are two types of fill:

A. Splash fill

Water falls over the multiple layer of horizontal splash bar. After hitting the bar water drop divided in more small of water. Generally fills made up of plastic are better than fills made up of wood and iron.

B. Film fill:

consists of thin, closely spaced plastic surfaces over which the water spreads, forming a thin film in contact with the air. These surfaces may be flat, corrugated, honeycombed, or other patterns. The film type of fill is the more efficient and provides same heat transfer in a smaller volume than the splash fill.

3. Cold-water basin

The cold water basin or storage tank are fitted at the bottom of tank, water after passing through fill and getting cooled down, stored in this storage tank. The basin usually has a sump or low point for the cold-water discharge connection. In many cooling tower size of storage tank is equal as size of fill. In some forced draft counter flow design, however, the water at the bottom of the fill is channeled to a perimeter trough that functions as the cold-water basin. Propeller fans are mounted beneath the fill to blow the air up through the tower. With this design, the tower is mounted on legs, providing easy access to the fans and their motors.

4. Drift eliminators

Some of water droplets are entrapped by air and fly out of the tower and also some amount is also deposited on fan blade, This will cause a problem of corrosion in blade. To eliminate this a drift eliminator is placed just below the fan and just above the pipe circuit.

5. Air inlet

Air inlet is designed in such a way that optimum amount of air is always supplied to the tower. Some times it will equal as frame of tower and some time lower than that as per requirement.

6. Louvers

The purpose of use of louver is to clean the air and to optimized the air coming in the fill. Generally it is fitted at the air inlet.

7. Nozzles

The one of the important component of cooling tower is nozzles. The uniform spray of water at the top of fill is necessary to this job we use nozzle. Nozzles used in cooling tower is either of fixed type or flexible. Nozzle may spray water in square for oe circular form as per requirement.

8. Fans

Fans are used in mechanical draft cooling tower. Along with fan an automatic on-off circuit is used with multiple sensor. When temperature of air is lower than requirement than fan is automatically. Fan used can be either of centrifugal type or propeller type.

4.4 Material used

In ancient time cooling tower are generally constructed by using wood. Almost every component of tower like frame, louver, cold water basin are made up of concrete or wood.

In now days various type of material is available for construction of cooling tower. Designer have different criteria to design a cooling tower like it should be light weight, low cost, durable, Non- corrosive etc.

For different component different material is used as per requirement.

1. Frame and casing

Wooden towers are still available, but many components are made of different materials, such as the casing around the wooden framework of glass fiber, the inlet air louvers of glass fiber, the fill of plastic and the cold-water basin of steel. Many towers (casings and basins) are constructed of galvanized steel or, where a corrosive atmosphere is a problem, the tower and/or the basis are made of stainless steel. Larger towers sometimes are made of concrete. Glass fiber is also widely used for cooling tower casings and basins, because they extend the life of the cooling tower and provide protection against harmful chemicals.

2. Fill

Plastics are widely used for fill, including PVC, polypropylene, and other polymers. When water conditions require the use of splash fill, treated wood splash fill is still used in wooden towers, but plastic splash fill is also widely used. Because of greater heat transfer efficiency, film fill is chosen for applications where the circulating water is generally free of debris that could block the fill passageways.

3. Nozzle

Generally nozzles are made up of steel but now days plastic are also used to construct a nozzle. For nozzle now days PVC, ABS, Glass-filled nylon is used.

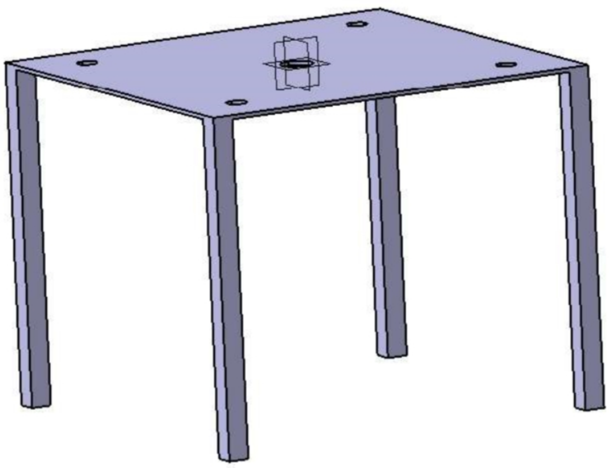
4. Fans

Fans are generally made up off aluminium, plastic, steel, cast iron.

System Design

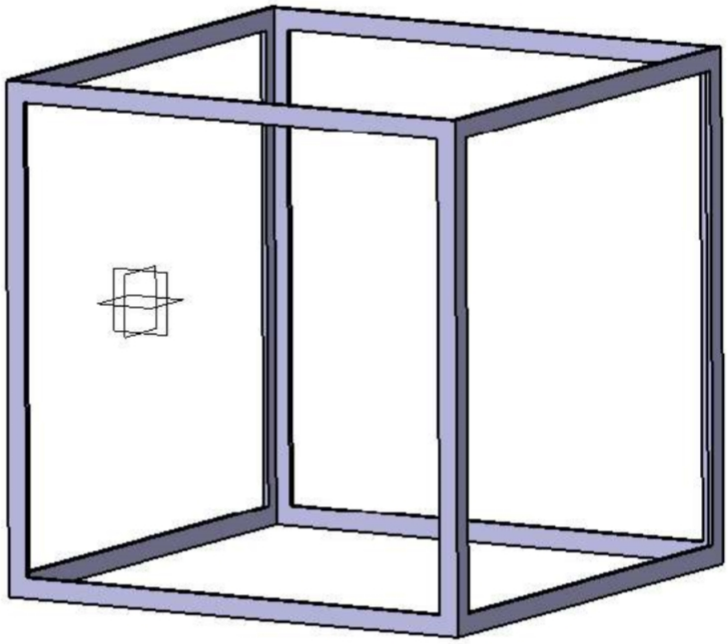
5.1 Component Design

1. Base



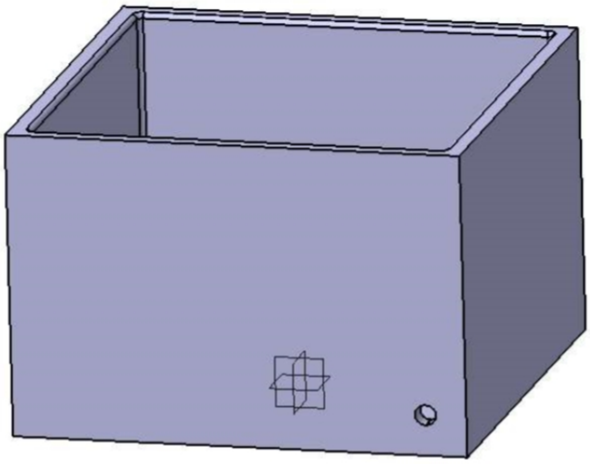
Dimension: 40*40*50 cm

2. Frame



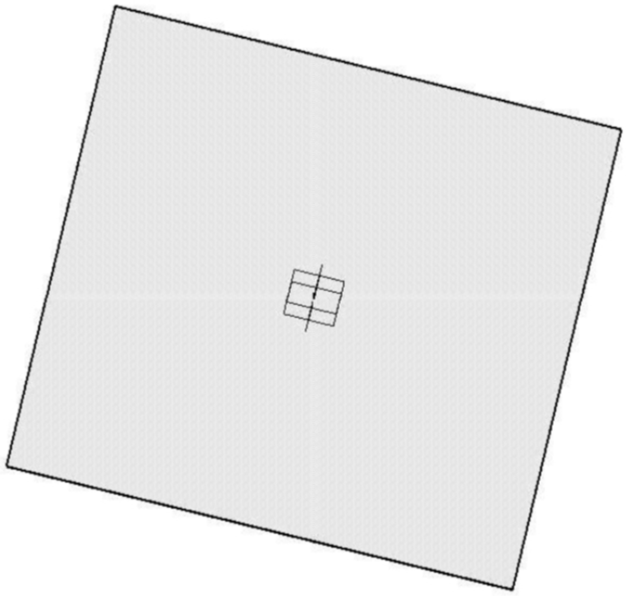
Dimension: 40*40*50

3. Storage tank



Dimension: 40*40*30

4. Louvers and pipe network



5.2 Assembly

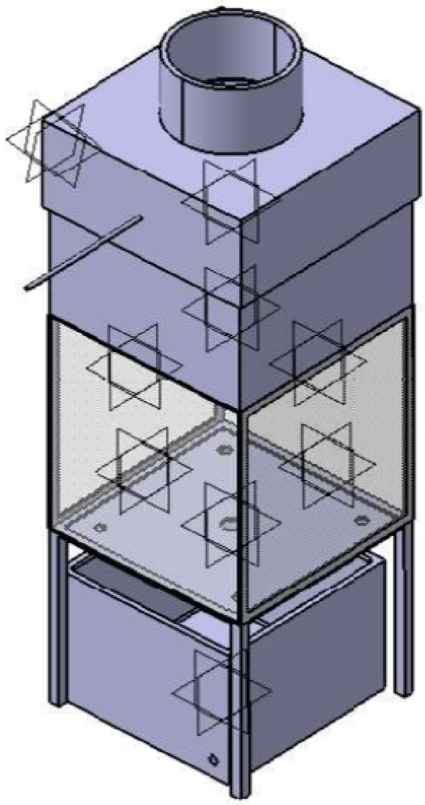


Fig.

6

Working principle and performance

6.1 Working principle

It works on same principle as a heat exchanger in this to different liquid or gas are comes in contact with each other and heat from one liquid to other liquid is transferred and temperature of a liquid decreases. But in cooling tower while to air or water are in contact some amount of water is vaporized and heat required for this vaporization is taken from liquid itself this will reduce the temperature of liquid by large amount. This process in known as evaporative cooling.

The hot water generally comes from condenser of any power plant or from the process in which heat rejection takes place. That water is pumped through pipes into the cooling tower. In cooling tower there is a nozzle which spray the water on fil l uniformally. The water is exposed to air as it flows-down through the fill. The air is being pulled by an motor-driven electric “cooling tower fan”.

When the air and water come together, a small volume of water evaporates and heat required for evaporation is taken by water itself. That’s how temperature of water decreases. The cold water coming out from tower is sent back to the plant for reuse. It repeats the loop over and over again to constantly cool down the heated equipment or condensers.

A cooling tower cools water by a combination of heat and mass transfer. Water to be cooled is distributed in the tower by spray nozzles, splash bars, or film-type fill, which exposes a very large water surface area to atmospheric air.

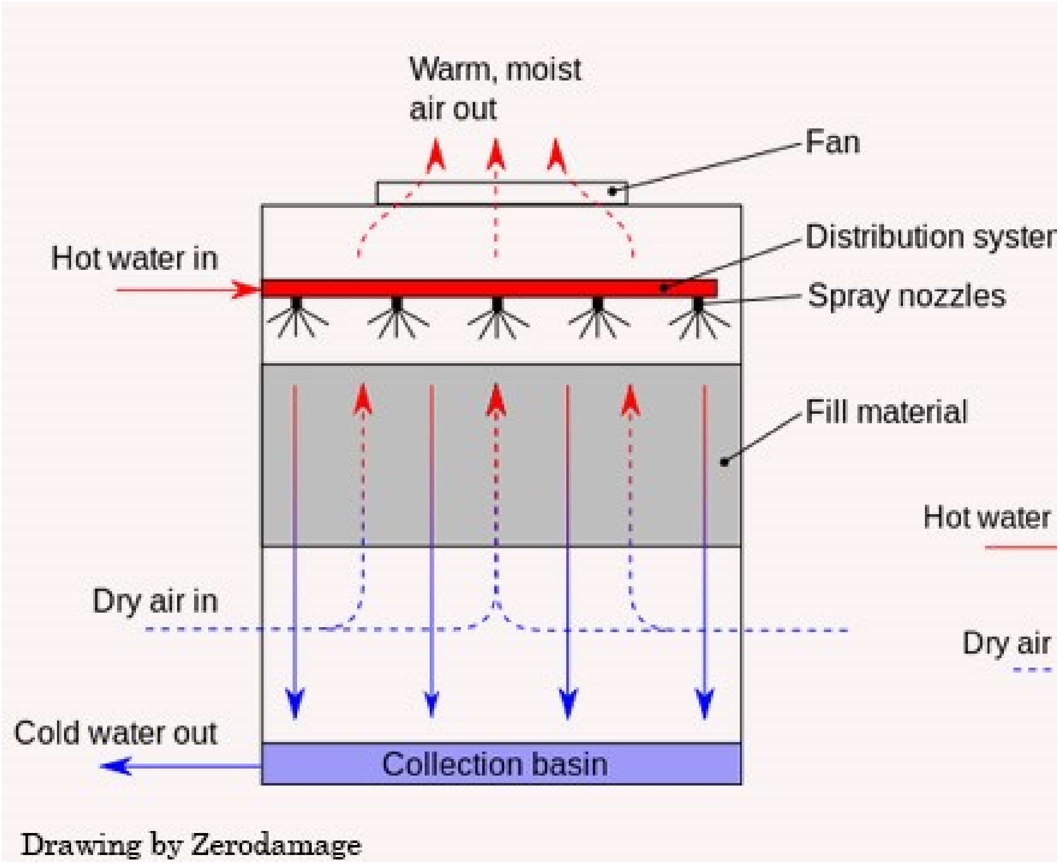


Fig.

6.2 Performance analysis

1. Range

Range of cooling tower means the minimum temperature at which cooling tower can supply the water. Mathematically is defined the difference between temperature at inlet and temperature at exit. If range of cooling tower is high it means cooling tower can be used in various industries.

The formula is:

(°) = (°)− (°)

2. Approach

Approach means the temperature difference with which air is approaching the tower. Mathematically it is defined as the temperature difference between exiting cold water temperature and wet bulb temperature of air entering. The lower the approach the better the cooling tower performance. Even though the range and approach both should be checked frequently but approach is a better indicator of performance.

The formula for approach is given by

(°) = (°)− (°)

3. Effectiveness

Up to what percent of their efficiency a cooling tower is working is measured by effectiveness. Mathematically it is defined as the ratio of temperature difference from inlet temperature to up to which temperature it is cooling actually and up to what it should be cooled.

The formula for effectiveness is given as follows

(%) =(–) /(�

� –)

×

4. Cooling Capacity

Cooling Capacity is measurement of rate at which heat is removed from water. The unit of cooling capacity is ton. One ton is defined as the rate of heat transfer at which heat transfer required to melt 1 ton of water in one day when initial temperature of ice is 32 degree.

5. Evaporation loss

While cooling some of water get evaporated and this is accounted as evaporation loss. Water required to counter this loss is known as make-up water and is supplied from a natural resources.

. The following formula can be used

$$(\quad) = \; . \quad \times \; . \quad (\quad) \times (\quad - \quad)$$

T1 - T2 = temperature difference between inlet and outlet water

6. Cycles of concentration (C.O.C)

This is the measurement of what amount of solid gets stuck in cooling tower or evaporator. Mathematically it is defined as reciprocal of ratio of dissolved solid in make-up water to the dissolved solid in circulating water.

.

7. Blow down loss

Depend upon cycles of concentration and the evaporation losses and is given by formula.

$$= e \quad / (\; . \; . \; . - \;)$$

8. Liquid/Gas ratio

The L/G ratio of a cooling tower is mathematically defined as the ratio of mass flow rate of air to the mass flow rate of water. Cooling towers there have some fixed value of L/G ration, but seasonal variations require adjustment and tuning of water and air flow rates to get the best cooling tower effectiveness. Adjustments can be made by water box loading changes or blade angle adjustments. From the first law of thermodynamic heat removed from the water must be equal to the heat deposited in the surrounding air.

Therefor the following formulae can be used:

$$(\quad - \quad) = \; (\quad - \quad)$$

L/G = liquid to gas mass flow ratio (kg/kg)

T1 = hot water temperature (°C)

T2 = cold-water temperature (°C)

h2 = enthalpy of air-water vapor mixture at exhaust wet-bulb temperature

h1 = enthalpy of air-water vapor mixture at inlet wet-bulb temperature

6.3 Factor affecting performance

1. Capacity

Capacity is measurement of rate at which heat is removed from water. Capacity is measured in ton of refrigeration. Capacity of cooling tower is great influence of cooling tower, as capacity of cooling tower is increases the effectiveness of cooling tower is decreases. Capacity also affects the range of cooling tower.

2. Heat load

Heat load of cooling tower have great influence on the performance of cooling tower. Heat load is determined by the process in which cooling tower is used. Heat load is also measurement of Heat energy wasted by system. As heat load increases effectiveness and range of cooling tower is decreases. Performance of cooling tower is maximum at some optimum heat load. The degree of cooling is depends on desirable operating temperature. In most of the case low desirable temperature will leads to be more efficiency as desirable temperature increase efficiency decreases.

3. Wet Bulb Temp

Wet Bulb temperature of air is most important factor in determining the performance of cooling tower. As we know that cooling towers based on evaporative cooling system and amount of water can evaporate depends on wet bulb temperature of air, Because the water which will evaporate have to mix with air and amount of vapor can mix with water depends on saturation level of air and saturation level is measured by wet bulb temperature. As wet bulb temperature decreases the range of tower also decreases. Atmospheric condition also affect the performance of cooling tower if humidity in atmosphere is high means wet bulb temperature of air is high means low range of tower.

4. Size of tower

If heat load, range, approach and wet-bulb temperature are held constant, changing the fourth will affect the tower size.

7

Conclusion

7.1 Conclusion

In this paper we described the different type of cooling tower their application and various parameter to evaluate the performance of cooling tower. Our design of cooling tower is small in size that's why this can be used in small scale industries.

Even though due to lock down we have not tested our design but we can say our design of cooling tower is of optimum size and effectiveness of tower will be sufficiently high.

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