International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 05 Issue: 02 | Feb-2018 www.irjet.net p-ISSN: 2395-0072

Design and Analysis of Cooling Tower

Manas M. Patil[1], Sanket J. Patil[2], Prashant S. Patil[3], Suneet J. Mehta[4]

[1,2,3] *Student, Dept. of Mechanical Engineering, VIVA Institute of Technology*
[4] *Asst. Professor, Dept. of Mechanical Engineering, VIVA Institute of Technology, Virar, Maharashtra, India*

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Abstract - *A cooling tower is a vital element of power plants, petrochemical plants, petroleum refineries, semi-conductor plants, natural gas processing plants, food processing plants, etc. The major function of a cooling tower is to discard heat into the environment. The major types of cooling towers are the mechanical draft (induced draft) and natural draft cooling towers. Very large concrete chimneys are used by the natural draft cooling tower to introduce air through the media. They are usually used for high water flow rates, i.e. above 45,000 m3/hr., due to the large size of these natural draft cooling towers. These types of natural draft cooling towers are used only by utility power stations. Mechanical draft cooling towers use large fans to suck or force air through circulated water overfill. The waterfalls downhill over the fill media, which helps to increase the contact time between the air and the water, this helps to maximize heat transfer between them. The counter-flow and cross flows are two elementary designs of induced (mechanical) cooling tower. It is well known that heat exchange in counter flow is more effective than heat exchange in cross-flow or parallel flow.*

This paper includes the performance study, working principle, and analysis of induced draft cooling tower, which is one of the deciding factors used for increasing the power plant efficiency. A setup is fabricated and various parameters of cooling tower are observed and calculated i.e. effectiveness, range, approach, and evaporation loss.

Key Words*: *Mechanical, Thermal, Cooling Tower, DBT (dry bulb temperature), WBT (wet bulb temperature), effectiveness, evaporation loss, experiment, numerical, natural draft, induced draft.

1. INTRODUCTION

1.1 Introduction

Cooling towers are an essential part of Power plants. The primary job of a cooling tower is to discard heat into the environment. Hot water from Condenser is sent to the cooling tower. The water exits the cooling tower and is sent back to the boiler for further process. In cooling towers, air is passed alongside or counter at present with water. The heat gained by air is the heat lost by water. The effectiveness of cooling tower depends on water and air flow rates and working temperatures.

In the chemical industries, utilities play an important role in plant tasks. Two types of utilities are used in industries, i.e. heating utilities and cooling utilities. Cold water is required for condenser, reactors, heat exchangers and other cooling purposes. Cooling towers are used to cool the water for its various applications. The high-temperature water used for various applications can be cooled and reused. Various types of cooling towers include Natural draft, forced draft, and induced draft cooling towers. Various researchers have carried out studies and investigation on various characteristics of the cooling tower which impact the effectiveness and functioning of the cooling tower.

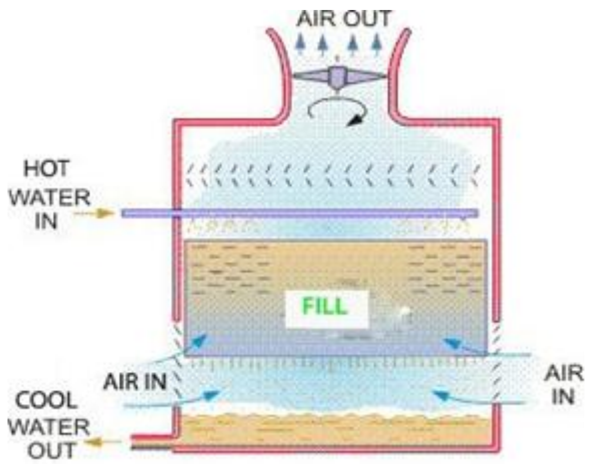

Fig -1: Cooling tower

1.2 Components of Cooling Tower

The basic components of an evaporative tower are:

Fill: Most towers use fills to facilitate heat transfer by increasing water and air contact. Fills are of two types, i.e. splash or film type. With splash fill, waterfalls over successive layers of horizontal splash bars, continuously breaking into smaller droplets, while also wetting the fill surface. Plastic splash fill promotes improved heat transfer than the wood splash fill. 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.

Cold water basin: The cold water basin, located at or near the bottom of the tower, receives the cooled water that flows down through the tower and fills. The basin usually has a sump or low point for the cold water discharge connection.

In many tower designs, the cold water basin is beneath the entire fill. In some forced draft counter flow design, however, the water at the bottom of the fill is channelled 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.

Drift eliminators**:** These capture water droplets entrapped in the air stream that otherwise would be lost to the atmosphere.

Air inlet**:** This is the point of entry for the air entering a tower. The inlet may take up an entire side of a tower–cross flow design– or be located low on the side or the bottom of counter flow designs.

Louvers**:** Generally, cross-flow towers have inlet louvers. The purpose of louvers is to equalize air flow into the fill and retain the water within the tower. Many counter flow tower designs do not require louvers.

Nozzles**:** These provide the water sprays to wet the fill. Uniform water distribution at the top of the fill is essential to achieve proper wetting of the entire fill surface. Nozzles can either be fixed in place and have either square or round spray patterns or can be part of a rotating assembly as found in some circular cross-section towers.

Fans**:** Centrifugal fan is used in towers. Generally, propeller fans are used in induced draft towers and both propeller and centrifugal fans are found in forced draft towers. Depending upon their size, propeller fans can either be the variable or fixed pitch. A fan having non-automatic adjustable pitch blades permits the same fan to be used over a wide range of kW with the fan adjusted to deliver the desired air flow at the lowest power consumption. Automatic variable pitch blades can vary air flow in response to changing load conditions.

Digital Thermometer**:** 2 Digital thermometer are used to detect the inlet water temperature to the cooling tower and outlet water temperature out of the cooling tower.

Fig -2: Digital Thermometer

Pump**:** Pump is used to lift the water from heating basin to the inlet of the cooling tower.

Fig-3: Pump

1.3 Tower Materials

In early days, towers were constructed primarily of wood. Wooden components included the wooden plates, casing, fill, and often use chilled water basin. The basin was of concrete. Nowadays, tower manufacturers design towers. Tower components from a variety of different materials. Often several materials are used for corrosion resistance, reduce maintenance, increase reliability and more service life. Galvanized steel, various grades of iron and stainless steel, and concrete are widely used in tower construction. Plastic, fiber, and aluminium also use for other components. The inlet air louvers made from glass fiber, the fill made from plastic, and the cold water basin made from steel. Bigger towers are made of concrete Galvanized tower made from stainless steel basin.

Glass fiber is widely used for cooling tower basin and casting, they give long life, protection from the harmful effects of many chemicals. Plastics material widely used for fill. Film fill use because it offers greater heat transfer efficiency. Plastics also find wide use in nozzle materials. Many nozzles are being from, ABS, polypropylene, PVC and glass-filled nylon. For fan material Aluminium, glass fiber, and hot-dipped galvanized steel are used. Centrifugal fans are made from galvanized steel. Propeller fans made from galvanized, aluminium or glass fiber reinforced plastic.

1.4 Problem Statement

The general construction of a cooling tower it has been governed by different decisions. Not only cooling towers are used in nuclear power plants but also they are used in many other conventional power plants to remove excess process heat from the system. It is most important to construct the tower in a way that it must live up to all the demands the different parties have towards it. Cooling towers are divided into two different kinds:

1) Natural Draught Cooling Towers (NDCT) and
2) Mechanical Draught Cooling Towers (MDCT).

Dry cooling towers are a radiator like most of every car or truck uses one. The hot water is pumped through an array of pipes with attached metal plates then radiate the heat to air that flows in the cooling tower. Mechanical Draught is just indicated that the convection in the tower is not natural but also induced by a fan. From the movement of air and water is the reason for another classification which divides them into the cross flow and counters flow towers. And if one considers the mechanism of the cooling in the tower they can be divided into wet, wet-dry and dry cooling towers.

The most disadvantage is that its cooling capacity is below from the other two designs. The water in the cooling circuit is not evaporated and hence there are problems with mineral deposits can be avoided. In the Wet cooling tower uses parts of the hot water that must need to be cooled to evaporate and to support the cooling effect of air by adding extra evaporation cooling to the process. The advantage of the wet cooling tower is its simplicity and low cost, but its disadvantage is it has just that what makes it so effective. The water that evaporates has must be refilled since evaporating water does not take it is dissolved minerals within it, the water deposits its minerals in the pipes and then the tower if the mineral level is not controlled.

When wet and dry cooling towers combine the disadvantages of both other designs is they are using part of the water to evaporate and cool the water itself plus water that is being pumped through pipes in so called as the filling of the cooling tower. This generates, on the one hand, less steam and therefore there is lost water, on the other hand, is the mineral deposit problem still present in it, it is expensive to build and the cooling effectiveness is not good as that purely wet cooling tower.

We are going to make a lab model of Test rig of the cooling tower and we are going to do the design and analysis of induced mechanical draft cooling tower. We are going to predict the air flow velocity and temperature at the exit of the cooling tower. The cooling tower efficiency can be increased by increasing heat transfer area with fins and these will result in an increase in the heat transfer rate of the cooling tower. Results of this study are expected to be useful for future work on the development of cooling towers.

1.5 Methodology

The selection of cooling tower depends on the many factors and application. An improperly selected cooling tower will cause a loss of production, increase in energy consumption. Properly designed cooling towers that require minimum maintenance. For selecting proper cooling tower many choices and decisions are required. The required cooling tower size and performance depends on:

- The mass flow rate of water.
- Hot water temperature.
- Cold water temperature.
- Cooling range.
- Wet bulb temperature.
- Tower type.
- Materials use for construction.
- Total heat rejection.
- Water quality.
- Airflow rate.
- Wet bulb temperature.
- Fill media.

There are 2 types of cooling tower-:

1) Natural

2) Mechanical-:

i) Induced draft cooling tower

ii) ii) Forced draft cooling tower

We are studying about mechanical induced draught cooling tower.

Mechanical draught which is used for the power-driven motor to force or draw air through the tower is known as induce draught cooling tower.

This fan is located near the bottom and on the side. This fan forces air from bottom to top. An eliminator is a use in the cooling tower to prevent loss of water droplets along forced air.

In this fan induce hot moist air out from the discharge. This produces low entering and high exiting air velocity and reduces the possibility of circulation in which discharge air flow back into the air intake. The main purpose of this is improving the efficiency of the cooling tower by reducing energy consumption.

The efficiency of the cooling tower can be improved by following points-:

1) Check cooling water pumps regularly.
2) Optimize cooling tower fan blade angle on seasonal or load basis.

3) Replace splash bar with self-extinguishing PVC cellular film fin.

4) Install a nozzle that sprays in a more uniform wear pattern.

5) Correct excessive or uneven fan blade tip clearance and poor fan balance.

6) Consider COC improvement measure for water saving.

7) Clean plugged cooling tower distribution nozzle regularly.

8) Clean plugged cooling tower distribution nozzles regularly.

9) Balance flow to cooling tower hot water basins.

10) Restricts flow through a large load to design values.

11) Cover hot water basins to minimize algae growth that contributes to fouling.

12) Optimize blow down flow rate taking into account into account the cycles of concentration limit.

13) Consider energy efficient fibre reinforced plastic blade adoption for fan energy saving.

14) Control cooling tower fan based on exit water temperature especially in small units.

15)In old counter flow cooling tower, replace old spray type nozzle with new spray nozzle that do not clog.

2. PRELIMINARY ANALYSIS OF COOLING TOWER

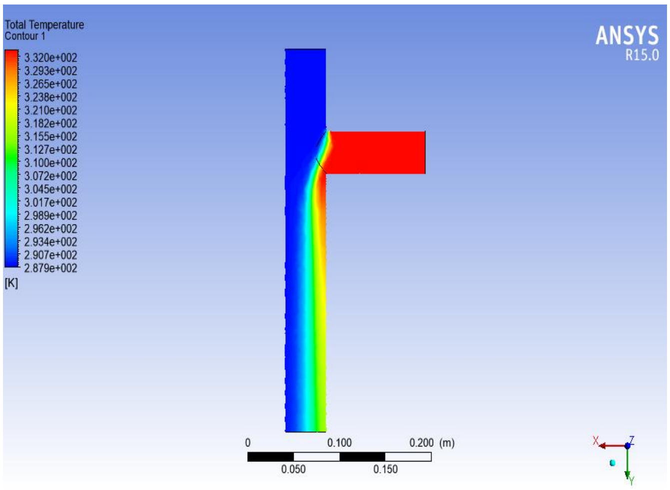

Fig -4: Temperature Analysis of water in tower

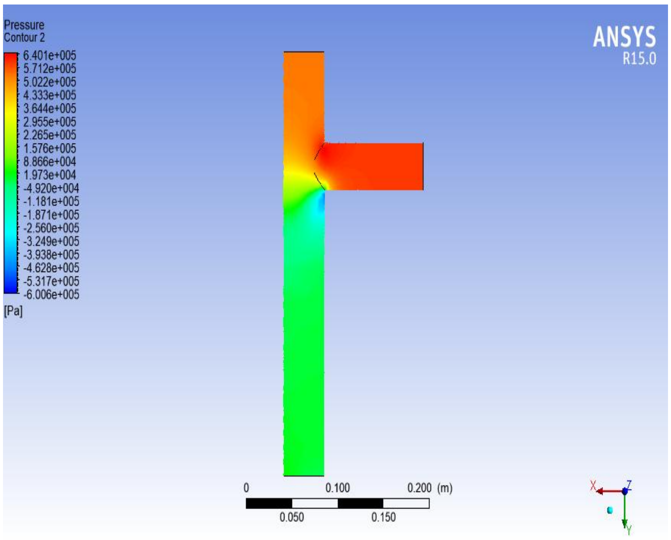

Fig -5: Pressure Analysis of water in tower

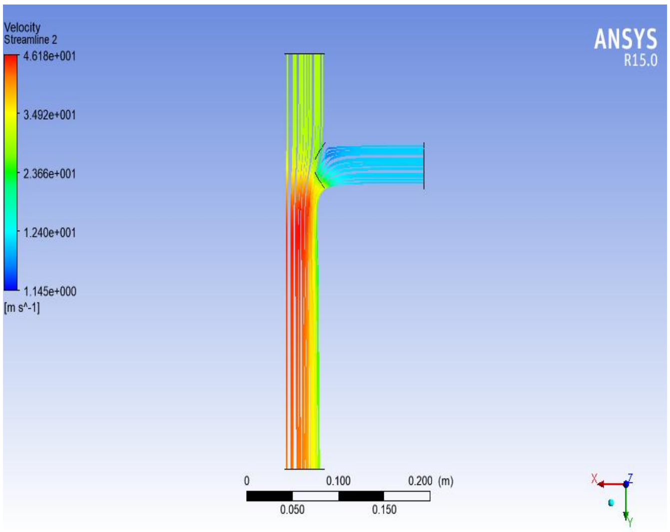

Fig -6: Velocity Analysis of water in tower

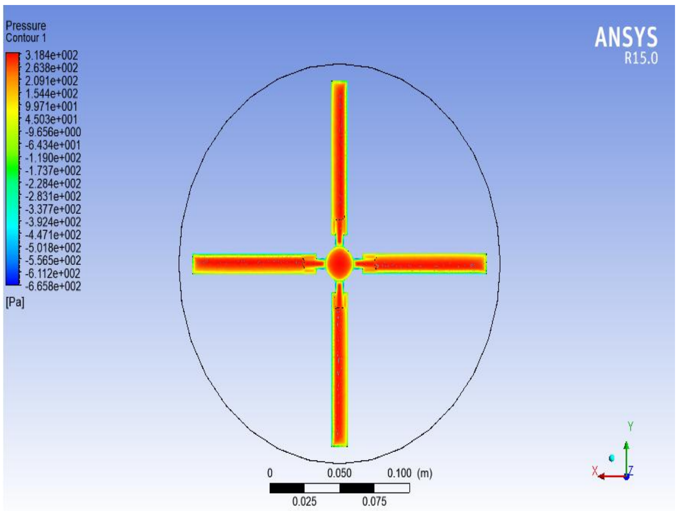

Fig -7: Pressure Analysis in fan

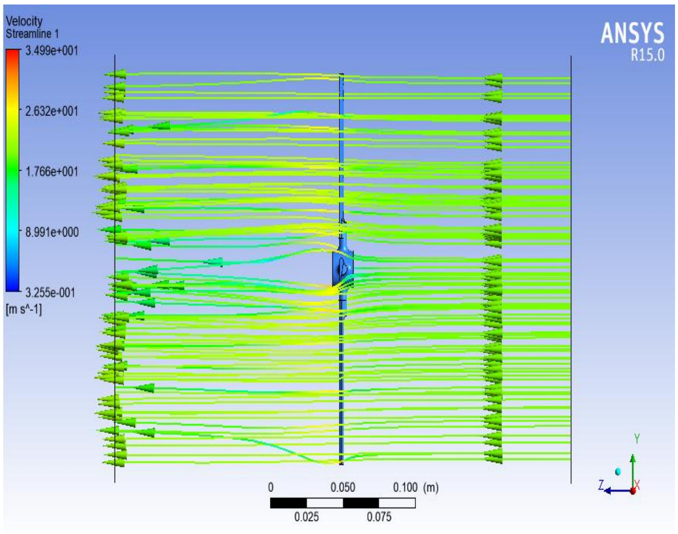

Fig -8: Velocity Analysis of air in fan

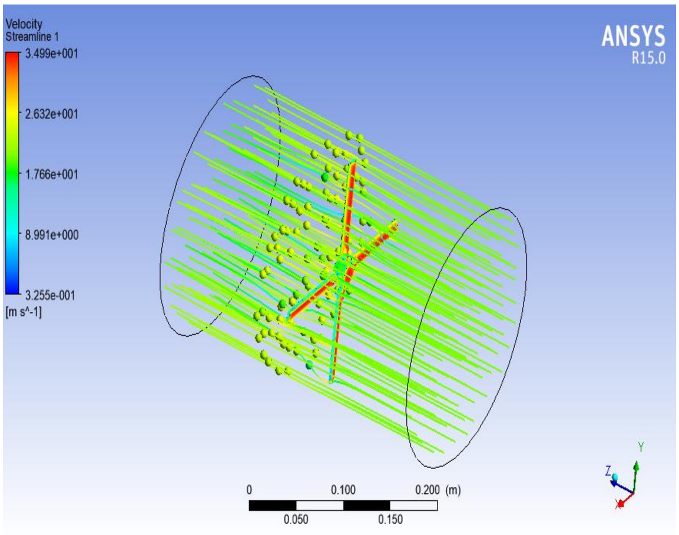

Fig -9: Velocity Analysis of air in fan

3. CONCLUSIONS

We have studied the way of increasing the efficiency of the cooling tower by enabling more volume of air to pass through the tower and hence more heat will be dissipated. The zigzag water flow pattern has made the water movement to slow down and longer time of water exposure to air is achieved.

The importance of a cooling tower in industries has motivated us to study its performance and look for possible ways to increase its efficiency.

ACKNOWLEDGMENT

It gives us immense pleasure to express our sense of gratitude and sincere thanks to our respected guide prof. Suneet Mehta, Mechanical department, VIVA Institute of Technology, Virar, for his valuable guidance.

We would also like to thank Dr. Arun Kumar, Principal, wholehearted support. We also wish to express our sincere thanks to prof. Niyati Raut, HOD Mechanical department, for her kind, hearted support.

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