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A REVIEW ON PERFORMANCE ANALYSIS OF NATURAL AND INDUCED DRAFT COOLING TOWER IN SUMMER AND MONSOON SEASONS

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Abstract- Power plants, some other industries produce a large quantity of waste heat in the form of hot water. In the present scenario, in most of the places, the water supply is limited and thermal pollution is also a serious concern.Cooling tower is an integral part thermal power generation plant. A cooling system may be a heat rejection device that rejects waste heat to the atmosphere through the cooling of a water stream to a lower temperature. Cooling towers are used in all heat producing industries. Power plants, some other industries produce a large quantity of waste heat in the form of hot water.Temperature and humidity inside the tower are having main influence on the performance of natural draft cooling tower.

Keywords- Power Plant, Cooling Tower, Pump, Thermodynamic cycles, Heat transfer

I. INTRODUCTION

Water is the most usable part in the thermal power plants as it's used for the generation of the steams. The resources of water are easily available in plenty amount, but usage of water has to be done very carefully to from the environment point of view. In the thermal power plant large amount of water is used for the steam generation and it also re-circulated. For the continuous recirculation of water, it is necessary to cool it. For this purpose, cooling tower is used in the thermal power plant. The hot water cannot be thrown back to the water reservoir, like river. It is dangerous for the aquatic creature. If done so, the hot water would heat up the river water temperature and it will be harmful to survival of fishes and other aquatic creature. Water is also taken in limited amount because one receives the recirculation of water through cooling towers.

Cooling towers are devices used for transferring the heat. It facilitates the direct contact of water and air for heat transferring process. Within it, hot water sprays from the nozzle on to the large surface area called 'fill'. Fill is made up of PVC (Poly Vinyl Chloride); it is more durable and efficient for the temperature distribution. Fill area is a heat transfer zone and direct contacting zone of cold air and hot water. The heat transfer rate depends on the contact time of water & air in the fill area. A cooling tower consist drift eliminators, fill area, nozzle, fan as design demand procedure. The hot water comes from the condenser; by the help of pump it sprays on the large surface area of fill. Here, the cold air will be taken from atmosphere and it will be allowed to contact with the fill area for heat transfer. Cold air takes heat from hot water and gets heated. Then the hot air transfers its heat to the environment. Hot air may carry some liquid particles along, which will get separated by through the drift eliminator. Water particles carried by the Hot air will get condensed over the large surface of drift eliminator. This action restricts the occurrence of over-moisture in the outgoing air to the atmosphere.

Terms related with cooling tower

i. Wind age or Drift: - The reduction of water due to effect of wind. Some amount of water losses with the contact of water by direct contact. Temperature of both elements is different when heat is exchange than water is losses.
ii. Plumes: - It occurs because of mixing of water vapours with air which are released from the cooling towers.
iii. Induced fans: - In Induced drafts, cooling tower fans are an essential part. The induced fan cooled rapidly hot water.

Fig.1 Induced fan

iv. Motor: - For the running of fan motor give power to the fan.
v. Nozzle: - To spray the water on the fill area nozzle are used.

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Fig.2 Nozzle

vi. Blow down: - when the cooling tower is circulated by the water, some amount of water losses due to evaporation, Due to evaporation of water solid particles are increases in the running cooling water. To maintain the solid concentration in water are drain out, that phenomenon is known as blow down.

vii. Fill or Packing: - Fill area is an essential part of cooling tower. It is made up of plastic or PVC. It provides the time to contact hot water and cold air for maximum time. The hot water transfer heat to cold air in that region. It's structural are Zig-zag form and length about 1m. it is spread entire whole base area at a certain height.

Fig.3 PVC Fill material

viii. Riser: - Condenser water reaches to the Header of cooling tower by the riser.

Fig.4 Riser

Basin or Sump: - Bottom of the cooling tower where cold water is collect is known as Basin.

Performance Parameter of Cooling Tower

i. Range :- It is the differences among the inlet temperatures of hot water;

CT Range (°C) = [CW inlet temp (°C) - CW outlet temp (°C)]

ii. Approach :- It is the difference between cold water outlet temperature and WBT CT Approach (°C) = [CW outlet temp (°C) - Wet bulb temp (°C)]

iii. Wet Bulb Temperatures: - It is the temperature observed by the thermometers. These thermometers are completely enclosed in a cloth which is soaked in water and further air is passed through it. Upon reaching at the level of 100 percent humidity, dew bulb temperatures are approached by WBT.

iv. Dry Bulb Temperatures :- It the air's temperature which is calculated with the help of a freely hanging thermometer.

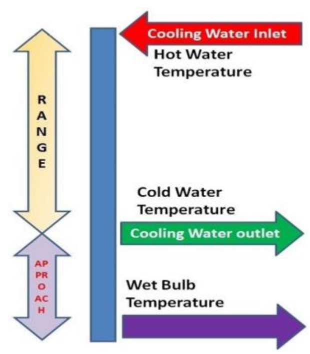

Fig. 5 Range approach line diagram

v. Cycles of concentration (C.O.C): It's the ratio formed among the dissolved solid in the makeup water to the dissolved solid in the circulating water. Its range is designed and works the range within 4 to 6.

vi. Liquid/Gas (L/G) ratio: it is a ratio formed among the mass flow rates of air and water.The towers established for cooling purposes have specific values in terms of their designs. However, with the change in the climate, it needs related adjustments and also the air and water flow tuning is needed for attaining the best possible efficiency from the tower. Through adjusting the angle of the blade or making changes in the loading of the water box, it is possible to make the adjustments.The rules of the thermodynamics also stated that the amount of heat removed from the water and amount of heat discharged to the atmosphere is exactly same. Thus, it can be expressed through the below mentioned expression:

$$L (T1 - T2) = G (h2 - h1)$$

$$L/G = (h2 - h1) / (T1 - T2)$$

Where: L/G = liquid to gas mass flow ratio (kg/kg)
T_1 = hot water temperature (°C)
T_2 = cold- water temperature (°C)
h_2 = enthalpy of air-water vapor mixture at exhaust wet bulb temperature (same units as above)
h_1 = enthalpy of air-water vapor mixture at inlet wet-bulb temperature.

vii. Capacity: - In reference to this study, it can be stated as the ability of a tower of cooling the maximum amount of water at specific humidity, particular range and WBT.

viii. Makeup:In reference to this study, it can be stated as the total quantity of water which is needed for covering up the losses which came in existence because of the evaporation, drift an blown down losses.

ix. Heat loads:In reference to this study, it can be stated as thequantity of heat to be removed from the circulating water in an hour is called as heat load of cooling tower. Heat load is equal to the rate of water flow per hour multiplied by range. It is defined as the total quantity of heat that needs to be removed in 1 hour.

x. Cooling tower efficiency: In reference to this study, it can be stated as the evaluation of the effectiveness of the tower of cooling which comprises of the method and range of the towers. This effectiveness is restricted by the ambient WBT. When considering the ideal scenario, the temperature of the cold water will be equivalent to the WBT and this cannot be attained on practical grounds. A huge tower is needed for attaining this and the outcome is drift loss or wind age in association with large amount of evaporation. It is not a practical solution.

Cooling Tower Efficiency = (Range) /{(Range + Approach)} x 100

Losses in cooling tower

1) Evaporation loss

Losses of water due to evaporation process. When hot water and cold air transferring heat with each other some amount of water evaporated. These losses are calculated as follow:

E = (0.00085) x (R) x (1.8) x (C)
E = Evaporation Loss (m3/hr) R= Range
C = Circulating Cooling Water (m3/hr)
(Reference: Perry's Chemical Engineers Hand Book)

2) Blow down

In the cooling tower water is evaporated dissolve solid particles are increases and cycle of concentration increases. To maintain the cycle of concentration blow down of water done and make up water mixed. Blow down is the function of cycle of concentration.

The calculation of the blow down is expressed below:

B = E / (COC-1)
B = Blow Down (m^3/hr)
E = Evaporation Loss (m^3/hr)
COC = Cycle of Concentration. Varies from 3.0 to 7.0 depending upon Manufactures Guidelines

3) Windage loss or Drift loss

The en-trained small droplets are gathered with the help of the air stream which is flowing in the upward direction inside the mist eliminators. Further, these droplets get accumulated for forming large size droplets which will at the end return towards the fills. Generally, in droplets forms, a very small amount of water is carried with the air. However, because of these droplets, water loss takes place. This loss is either termed as wind age loss or drift loss.

If it is not available it may be assumed as :
For Natural Draft Cooling Tower D = {(0.3 to 1.0) * C }/100
For Induced Draft Cooling Tower D = {(0.1 to 0.3) * C} /100
For Cooling Tower with Drift Eliminator D = {(0.01) * C} /100 (Where C = Cycle of concentration)

II. Literature Review

Ajeet kumar et al in "analysis of performance of natural draft cooling tower at optimized injection height" the effectiveness of cooling tower generally depend on the distribution, initial water droplet diameters, humidity with the temperatures of the ambient air, flow rate of the water, height of the tower's inlet, depth of the fill and operating parameters in the rain zone. Author designed a natural cooling tower in modelling software and analyses in CFD technique above parameters taking constant and Different injection height has been taken for optimizing the height of the injection and analysing its effect over the natural draft cooling tower's performance. [1]

Pushkar R. Chitale,, et al made a novel design for the cooling tower's counter flow. This is made on the basis of the parameters of the input process with keeping various kinds of probable losses in consideration. After that, the researcher modelled the presented design which the help of the software known as Solidworks 2012. The performance and efficiency of the model is observed with the help of the CFD software. The observance of the variance in the angle of the inlet of the air is made with the cooling tower efficiency with the help of the ANSYS. The researcher then concluded that when the angle of the inlet of the air increases, there will be an increase in the temperature of the outlet water. There the efficiency of cooling will get reduced. [2]

Vishnu s kumar et al had perform analysis and optimized on cooling tower with water mass' different rate of flow inlet water temperature, air influences on the counter flow induced draft cooling tower. Design is created in SOLIDWORKS and analyses in CFD technique and it found that enhancement in the cooling tower performance can be made by increasing the air's mass flow rate. All the parameters (like characteristic ratio of the tower, efficiency, range of water cooling) established for calculating the performances have hiked. A hike of 20% can be made in the cooling tower's efficiency through L/G ratio optimization. The effect of water mass flow rate also seen that through optimization of the mass flow rate of both air and water the efficiency can be hiked. 3]

Umakanta et al study on IDCT performances and analysis in captive power plant, Taken consideration flow rate of water, fill area material, atmospheric condition and analytically calculate losses, range, approach, heat losses. He elaborated types of cooling tower, needs, and functions. They concluded that an efficient prediction by the model is made when a stack of cooling tower shaped rectangular is considered. This prediction is related to the temperature of water and air outlet, perquisites of fan control, stream rates of water mass as well as gulf air and requirements of water. [4]

Rahul et al Effectiveness of cooling tower mostly depends on the WBT, DBT, humidity of atmosphere. He works on the mechanical draft cooling tower (Forced draft cooling tower) and also computed material balanced and packed height of column. He conclude that efficiency of the cooling tower tends to 65% and observe that leakage of water and blow down of water reasons for the lower efficient. [5]

Yagnesh S. Anchan et al works on the different literature survey and determine the new type of cooling tower which is more durable, less noisy, less water polluted. He observed that the characteristics along with the various kinds of generation of losses and designs of the cooling towers are in close relations with each other. Two very significant parameters for assessing the cooling tower's performances are efficiency and evaporation loss. Its performances rise when the rate of flow of the air rises and the characteristics reduces. It also depends over the rise of the ratio of the water to air. In comparison to the "Horizontal Orientation Wire-Mesh", a better performance is attained with using "Vertical Orientation Wire-Mesh Packing". [6]

PoojaRai et al works on the cooling tower, it's main focused on the different area like as Fill Area Performance, Heat and Mass Transfer (hmt) Analysis, Evaporation Loss, Scaling and Fouling Phenomenon in CT, Climate Condition performance. She conclude that Scaling and fouling deposited in condenser tube and fill area can be prevented by using Chemical dosing, CIO2 generator, side stream filter.[7]

Ajit Prasad Dash et al works on mechanical draft cooling tower and calculates thermal efficiency. He taken a standard data and specification and according to these data using psychometric chart calculate effectiveness. The author made an analysis over the distributions of water through the plane area and made an adjustment of the water quantity for suiting the conditions of the air flow. This remains uninfluenced from the "natural draft cooling towers". When the water was distributed optimally, a static temperature for water outlet was attained. This decreased the exergy loss and the generation of the entropy from the cooling towers. [8]

Sunil J. Kulkarni et al conducted a study to increase the power saving and effectiveness of the cooling towers for making it better on the basis of efficiency and economy. He finds out the losses in cooling tower which is main crucial role for efficiency. He observed that a hike in the efficiency can be attained if the tower is provided with appropriated distribution of water. One of the most important issues is the degradation of the materials used for filling. When efficient strategies for shut down are applied, it will reduce the manpower. One more observation was made according to which temperature of water as well as air inlet, rate of flow of water at inlet and performances increase with packing's vertical orientation. With the help of this study, a conclusion can be made that appropriate distribution of water, strategies related to the shut down and packing are significant for optimizing the cooling tower. [9]

Jasem H. ALsuwaidi et al researched on natural draft cooling tower by two different method. First Merkel and then the approach for analysing "e-number-of-transfer-units" (e-NTU) is used over various ambient and operating conditions. The author first made an observation and then made a prediction according to which the rates of evaporation of water is always comparatively higher in accordance of the approach of e-NTU in comparison to the approach of Merkel. [10]

PriyankV.Dave et al performed analysis on NDCT using CFD by varying throat height of cooling tower. He taken some different height and various thermal operating parameters consider constant and the author concluded that when the range of the cooling hikes and there is a reduction in the approaches, these 2 parameters comes in direct relation with the effectiveness of cooling as cooling range increases and approach decreases this two parameters are directly related with cooling efficiency present at the throat height at specific effectiveness of cooling which is higher by 10-20% in comparison the real throat heights. This validated the fact that enhancement in the parameters for operation of the cooling towers for evaluating the performances. [11]

ShashankTiwari et al analysis of counter flow induced draft cooling tower byTaguchi Method. It is a logetharim method analysis. The outlet water temperature optimized by the different method i.e. Prediction by Taguchi method and by MATLAB regression modelling and relate with actual experiment values. [12]

Syed Amjad et al had performed an analysis to increase the cooling tower with using aluminium in fill area instead of plastic wood and PVC. They conclude that being an elemental of aluminium solids are free from corrosions and in addition they are highly capable of carrying it i.e. they are good conductors of heat. Aluminium's specific heat is of 900J/kg°C. This permits the air for removing the heat of the water when brought in touch with plates made up of aluminium. The author concluded one fact which states that the performance of the cooling tower becomes more efficient at the time of winter in comparison to the summer because of the drop in the level of the humidity. This increases the performance of the cooling tower. [13]

Krishna et al study a case the comparison of some calculations regarding the cooling tower. He observed that several things to improve efficiency of cooling tower. The author also optimized the angles of the fan blade of the cooling towers based upon the load or/and season. In addition, the author replaced the splash bars with the cellular film fills capable of self-extinguishing. Balanced flows are provided for the hot water basin of the cooling towers. Occasionally, cleaned plugged cooling tower distribution nozzles. Replaced slat type drift eliminators with low pressure drop, self-extinguishing, PVC cellular unit. Monitor approach, effectiveness and cooling capacity for continuous optimisation efforts, as per seasonal variations as well as load side variations. [5]

Pushpa B. S et al studied a case of thermal power plant and observed the rate of heat loss is affected by the atmospheric parameters such as 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 efficiency of the natural draft cooling tower.[14]

RandhireMayur research for improvement of cooling tower efficiency by several points and determine that, The result is lower outlet water temperature from the cooling tower and, thus, from the condenser, which results in greater efficiency of the power plant.[15]

T.Jagadeesh et al research on the efficiency evaluation of the cooling tower at different season, as summer season and winter season. He taking all the thermal parameter regarding cooling tower that is WBT, DBT, Relative humidity, COC and soon. Author observed that in the winter season efficiency of cooling tower is more comparatively summer season. [16]

III. Conclusion

A review study is carried out to investigate different types of cooling towers, their application, performance, usage and working principles, which can be useful in the field of power plants as well as other energy stations. A number of investigations have been considered to reveal differences between the NDCT and IDCT carried out to examine major contours and flow field around the cooling tower. The climatic conditions like air dry bulb and wet bulb temperature, relative humidity will affect the performance of the cooling tower.

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