A Review on Experimental investigation and Analysis of cooling tower to enhance its efficiency by fin geometry

Karthik Sankararaman[1], Shumaila Sultan[2]
[1]ME Student,Thermal Science Engg., RKDF Institute of Technology, RGPV, Bhopal, India
[2]Asst. Professor, Mechanical Department, RKDF Institute of Technology, RGPV, Bhopal, India

Abstract: A cooling tower is an essential component of power plants, petrochemical plants, oil treatment facilities, semi-conductor plants, petroleum gas preparing plants, nourishment handling plants, and so on.. The significant capacity of a cooling tower is to discard of heat into the environment. The significant sorts of cooling towers are the mechanical draft (incited draft) and normal draft cooling towers. tubes having (fins) blades for increment surface zone of tube. Mechanical draft cooling towers utilize huge fans to suck or power air through coursed water overload.. The cascades downhill over the fill media, which expands the contact time between the air and the water, this augments heat move between them. The counter-stream and cross streams are two basic structures of incited (mechanical) cooling tower. It is notable that heat flow in counter stream is more compelling than heat flows in cross-stream or parallel stream. This paper is all about the developing a cooling tower that cools the hot water by using different types of tubes of same material. Tubes having different surface area that helps the heat dissipation. Tubes having fins for increase surface area of tubes.

Keywords: fin, fills, heat exchanger, mechanical draft

1. Introduction

Cooling tower is a heat rejection device. It is used to dissipate waste into atmosphere through the cooling of water steam to a lower temperature. Cooling tower may either use the evaporation of water to remove the process heat and cool the working fluid to near the wet bulb temperature. Cooling tower are one of the most widely equipment units used in cooling system, which also consist of a network of heat exchangers in closed circuit that consume water only to make up for the inherent losses in the process. Cooling tower constitute very important component of power generation system and also contribute to environment protection. Its role is to remove heat from a process, usually either a direct manufacturing process or from the condenser of a chillers. Cooling tower is a vital element of power plants, petrochemical plants, petroleum refineries, semi-conductor plants, natural gas processing plants and food processing plants.

Cooling tower is an essential part of power plants. The primary function of cooling tower is to discard heat into the environment. Hot water from condenser is sent to the cooling tower. The water exists the cooling tower is sent back to the boiler for further process. In Cooling tower, 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. Cooling tower is used to fulfil the purpose of cooling with minimum usage of fresh water. It circulates fresh water for cooling to the machine and uses least make up water that is lost due to evaporation. Cooling tower is heat and mass transfer device based on the evaporative cooling of water in contact with ambient air. Cooling tower reduces temperature of circulating water so that water may be reused in condenser and other heat exchange equipment's. The cool water absorbs heat from the condenser becomes warmer. The warm water then returns to the cooling tower. In cooling tower the warm water sprayed downward and air is blown upward. As the warm water droplets contact the air, some of the water droplets evaporate and the air absorb the heat released to atmosphere, thereby lowering the temperature of the remaining water. In cooling tower the ambient air is used to cool warm water which is coming from the condenser.

1.1 Experimental set up

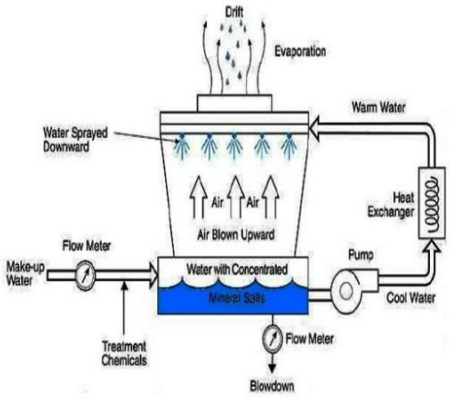

Fig. Experimental set-up

1.2 Principle of Operation

Cooling tower has simple working principle. It works on the principle of heat and mass transfer. 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. Atmospheric air is circulating by fan, convective.

Currents, and natural wind current or effective from sprays. A portion of the water absorbs heat to change from a liquid to a vapor at constant pressure. This heat of vaporization at atmospheric pressure is transfer from the water remaining in the liquid state into the airstream.

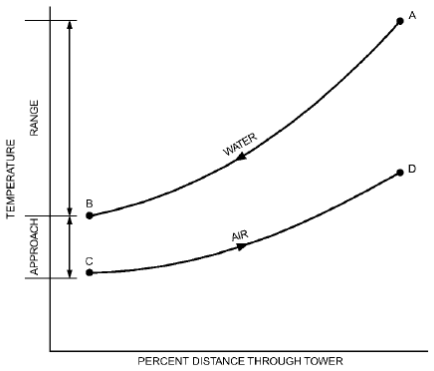

Fig. 1.2 Temperature Relationship Between Water and Air in Counter Flow Cooling Tower

Figure 1.1. Shows the temperature relationship between water and air as they passed through a counter flow cooling tower. The curve indicates the drop in water temperature (A to B) and the rise in the air wet bulb temperature (C to D) in their respective passage through the tower. The temperature difference between the water entering and leaving the cooling tower (A minus B) is the range. For a steady-state system, the range is same as the water temperature rise through the load heat exchanger, provided the flow rate through the cooling tower and heat exchanger are the same. Accordingly the range is determined by the heat load and water flow rate, not by the size or thermal capability of cooling tower.

2. Problem Definition

"To determine the effectiveness, efficiency of cooling tower consisting various types of fins. As well as provide the comparison for above said. "

3. Objective

This project consists following points that should be considered as problem statement.

1. To fabricate the cooling tower containing different types of tubes.

2. Determination of effectiveness of coils.

3. To find the value of cooling tower efficiency.

4. Analysis of cooling tower using ANSYS software.

5. Comparison of efficiency for different types of tubes.
6. Result validation with CFD Analysis.

4. Scope

1. Model is created for testing purpose.

2. To make scholar understand about cooling tower.

3. To analyze cooling tower performance.

5. Literature review

Manas M. Patil et al. explain 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. 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. **[1]**

Ali Ayoub et al. explain a model of a natural draft wet type cooling tower, which is based on the conservation laws of thermodynamics. The model assesses the cooling abilities of a tower, the evaporation rate, and the amount of required make-up water, all represented as a function of the atmospheric conditions. The purpose of the model is to estimate the effects of extreme weather conditions on the thermodynamic efficiency of a natural draft wet type cooling tower. World climate is changing and average temperatures are anticipated to rise in the near future, thus affecting the electrical energy generation. To that aim, we study the climate change effects on the ability of natural draft wet type cooling towers to reject heat. **[2]**

Xiao Li et al. explain an ESC based cooling tower control scheme which can minimize the combined power consumption of cooling tower fan and chiller compressor. The ESC strategy is tested on a dynamic simulation model of the chiller-tower

system .The inner loop controls of superheat and chilled water temperature are implemented, by regulating the flow area of valve and slide-valve opening, respectively. Simulation study was performed for a fixed condition and then for two varying conditions in which ramp changes are introduced to the evaporator inlet water temperature and the ambient air condition, respectively**[3]**

Wenjie Liu et al. explain a novel approach is used for underground commercial building to solve series environmental problems caused by cooling tower (CT) By setting packing materials above the underground pool, a new type heat and mass transfer device was developed to replace the traditional one. The pool can be served as thermal storage tank to optimize the cooling system. Such a design was applied in a small underground commercial building, and an experimental study was conducted. Results suggest that the approach can fulfill the requirements of cooling system, the volume of the packing materials can be reduced to an economical size, and water in the pool can be cooled down 4°during the recharging process of thermal store**[4]**

Donald Kasten and Michael R. Muller explain the efficiency of a tower is based on the original design conditions as well as the type of tower (evaporative, draft driven). Efficiency can reduced due to under or over sizing, controls that are not properly functioning, and basic lack of maintenance that can create fouling of the exchangers. This paper present the efficiency relationship between the tower and the chiller, but more specifically develops a methodology to measure and estimate this efficiency on a short one or two day assessment. This paper includes information about how to determine the appropriate design conditions for the tower, its temporal performance, as well as tips from major tower manufactures on design, performance, and maintenance**[5]**

Ramkumar Ramkrishnan and Ragupathy Arumugam explain deterioration of the packing material is a major problem in cooling towers. In this experimental study ceramic tiles were used as a packing material. The packing material is a long life burnt clay, which is normally used as a roofing material. It prevents a cooling tower resulting from corrosion and water quality of the tower. In this study, we investigate the use of three different types of ceramic packing's and evaluate their heat and mass transfer coefficients. A simple comparison of packing behavior is performed with all three types of packing materials. The experimental study was conducted in a forced draft cooling tower. The variations in many variables, which affect the tower efficiency, are described. **[6]**

M. Goodarzi, and S. Moradi Maryamnegari explain a new natural draft dry cooling tower with better cooling efficiency during the windy condition has been introduced. A numerical method has been used to simulate and predict the thermo hydraulic performance of the proposed cooling tower in comparison to the usual cooling tower. The details of the flow field and also outlet water temperature have been presented comparatively. A new geometry with different arrangement of the radiator sectors has been proposed to improve the cooling efficiency of the natural draft dry cooling tower**[07]**

T. Jagadeesh and Dr. K. Subba Reddy explain we use a natural draft counter flow cooling tower in investigating the performance of cooling tower in different seasons. The humidity is defined as water particles present in air. The humidity is the major factor in the atmosphere, it depends upon ambient temperature. Humidity is high in winter season and low in summer season. The performance of the natural draft cooling tower is dominated by wind speed, ambient air temperatures and humidity in the atmospheric conditions. When the humidity is high in atmosphere, large quantity of water is required for cooling condensate. When humidity is low in atmosphere, small quantity of water is required for cooling condensate. The value of relative humidity in the atmosphere varies from place to place and season. The different losses in the cooling tower such as drift losses, evaporation losses and blow down losses can be calculated. The maintenance of cooling tower in the form of removal of scale or corrosion plays important role in the performance of the tower**[08]**

B Bhavani Sai et al. explain detailed methodology of an Induced draft cooling tower of counter flow type in which its efficiency, effectiveness, characteristics are calculated. The technical data has been taken from a mechanical draft cooling tower. Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly. **[09]**

Stephen A. Leeper explain a survey of wet cooling tower literature was performed to develop a simplified method of cooling tower design and simulation for use in power plant cycle optimization**[10]**

6. Methodology

The focus of this study is to investigation and analysis of cooling tower having fins of varying

shape and material. For the theoretical methodology to developed a test set up for experiment. For experiment performance test and trial will conduct by using cooling tower tubes with fin and varying Material of tube. Set up runs to find out different parameters like effectiveness of coils, cooling tower efficiency etc and then do result Analysis using **ANSYS** software.
Also, similar test will conduct by using cooling tower tubes without fin and varying Material of tube and find out above mention parameters. Finally Analysis of result after all the trials and testing is carried out and comparison with standard values.

Flow-chart of methodology

Fig. 6.1 Flowchart of progress

Phase-I:-This phase involves the detail study of heat transfer enhancement techniques of cooling tower tubes and other active parts with particular attention towards mechanical draft cooling tower heat transfer enhancement techniques with fin. Effect of fins on heat transfer enhancement will be further analyzed in this phase. Additionally idea behind the installing fins on the surface of tube to form the more effective heat enhancement structure will also be studied.
Phase-II:-On the basis of the concluding remarks from the literature review it is decided to proceed in the same direction towards the investigation of thermal performance of cooling tower coils with fins. Accordingly the experimental system will be designed and manufactured to investigate the proposed
title
Phase III:-Additionally to evaluate the accuracy of the measurements, experimental system is to be tested and validated with and without fins before running the experiments.
Phase IV:-This phase aims to prepare the fin of required size and shape with varying material of cooling tube surface. The characterization of fin will also be done in this phase only.
Phase V:-By using the prepared fin in the above phase, experimentation will be carried out on proposed system with variation in inlet water flow rate with different material cooling tube The corresponding observations will be noted in the respective conditions which will be further utilized to draw conclusions.
Phase VI:-In this phase the effect of the parameters on thermal performance of the cross flow heat exchanger will be represented graphically to see the variation and come out with some results.
Predicted Flow of work is going in following way as,

A. Design
A roadmap or a strategic approach for someone to achieve unique expectations. It defines the specifications, plans, parameters, costs, activities, processes and what and how to do within legal, political, social, safety and economic constraints in achieving that objective.
B. Material selection Selection of material is main part of design. The material should have good thermal properties as well as it should be easy for manufacturing processes.
C. Validation On the basis of selected material it is necessary to validate that material is according to the design process. Selected material should satisfy our design outputs.
D. Fabrication After all the design and analysis we have to fabricate the project model of cooling tower. In fabrication brazing, soldering and welding processes carried out.
E. Testing We will test cooling tower efficiency and effectiveness of final result.

F. Result Analysis Analysis of result after all the trials and testing is carried out and comparison with standard values.

References

1. M. M. Patil, S. J. Patil, P. S. Patil, and S. J. Mehta, "Design and Analysis of Cooling Tower,", pp. 05–11, 2018.
2. A. Ayoub, G. Sansavini, and G. Sansavini, "Accepted Manuscript,", pp. 15–17, 2018.
3. J. Lee, "Evaluation of impacts of cooling tower design properties on the near- field environment," Nucl. Eng. Des., vol. 326, no. April 2017, pp. 65–78, 2018.
4. W. Wang, H. Zhang, Q. Liu, G. Yue, and W. Ni, "Energy & Buildings , A performance enhancement of a natural draft dry cooling tower in cross wind via inlet flow field reconstruction," Energy Build., vol. 164, pp. 121–130, 2018.
5. M. Goodarzi and S. M. Maryamnegari, "A new natural draft dry cooling tower with improved thermal performance during windy condition," Appl. Therm. Eng., 2018, pp. 03–06
6. B. Bhavani. Sai, I. Swathi, K. S. L. Prasanna, and K. S. Rao, "design of cooling tower," vol. 4, no. 5, pp. 1560–1563, 2013.
7. Ben Costelloe, Donal Finn, "Experimental Energy Performance Of Open Cooling Towers Used Under Low And Variable Approach Conditions For Indirect Evaporative Cooling Of Buildings", Building Serv. Eng. Res. Technol., vol.24, no.3, pp.163-177,2003.
8. D. K. Baniya, A. C. Kurup, and A. Varghese, "Design and Fabrication of Cooling Tower," International Journal of Latest Engineering Research and Applications (IJLERA) Volume – 02, Issue – 05, , PP – 27-37, May – 2017.
9. Mohammed Nsaif Abbas, "Study The Performance Of Different Packing In Open Cooling Towers", Journal Of Engineering And Development, vol. 16, no.2, pp.193-210, June 2012.
10. P. Ajit, P. Dash, K. K. Panda, A. K. Yadav, and V. Sharma, "Design of mechanical draft cooling tower and determination of thermal efficiency," IJSDR,Volume 1, Issue, pp. 191–197,April 2016.
11. M. Rahmati and A. Sedaghat, "Thermal performance of natural draft wet cooling towers under cross-wind conditions based on experimental data and regression analysis," 6th Conference on Thermal Power Plants, CTPP , Iran University of Science and Technology, pp. 1–5, 2016.
12. R. K. Singla and R. Das, "Retrieval of Controlling Parameter in Induced Draft Cooling Tower Using Inverse Method, 2nd International Conference on Control Science and Systems Engineering (ICCSSE)" pp. 223–226, 2016.
13. C. Ionescu, and D. Gogoa, "Improving the Efficiency of Natural Draft Wet Cooling Towers by Using Smart Metering Systems, International Conference on Optimization of Electrical and Electronic Equipment" pp. 134–139, 2017.
14. S. J. Kulkarni and A. K. Goswami, "Studies and Experimentation on Cooling Towers : A Review," IJRTS,pp. 279–282, 2015.
15. K. S. Vishwakarma, A. S. Bhoyar, S. K. Larokar, V. Vaibhav, and S. Bhudhbaware, "Study the factors on which efficiency of cooling tower can be critically acclaimed (A case Study)," vol. 5, no. 4, pp. 73–79, 2015.
16. J. H. Alsuwaidi, O. R. Al Hamdan, and M. M. I. Hammad, "Natural Draft Cooling Tower Performance Evaluation," vol. 6, no. 4, pp. 1499–1512, 2015.
17. N. D. Towers, "Experimental Study of Effects of Cross Wind on Flow in Existing experimental studies, Applied Thermal Engineering" vol. 3, no. 2, pp. 955–958, 1998.
18. P. H. Margen, B. S. Eng, and A. Member, "the economic selection of cooling towers, IEEE-Part A: Power Engineering pp.22-26, 1955.
19. R. Mcelveen, K. Lyles, B. Martin, and W. Wasserman, "A new more reliable solution for cooling tower drives, IEEE Industry Applications Magazine · August 2017" pp. 1–8,2006.
20. H. Xie and L. Liu, "Performance Estimation of Cooling Towers Using Adaptive Neuro-Fuzzy Inference", Fourth International Conference on Natural Computation, china ,pp. 250–254, 2008.