Available online www.ejaet.com

European Journal of Advances in Engineering and Technology, 2016, 3(11): 10-14

Research Article ISSN: 2394 - 658X

Performance Improvement of Mechanical Induced Draft Cooling Tower by Using Aluminum as Fill Medium

Syed Amjad Ahmad, Anas Ahmad, Ahmed Butt and Taimoor Waqas

Department of Mechanical Engineering, Institute of Engineering and Fertilizers Research, Faisalabad, Pakistan
anasimcbian44@gmail.com

ABSTRACT

The objective of this research is to study the performance of the cooling towers and the factors affecting this performance and hence improving its efficiency by applying various methods the conducted research dealt with measuring performance parameters like temperature and flow rates of air and water in and out of the tower during a specific period. Then these measured parameters were evaluated and compared to ideal design data. Various methods were studied for performance improvement such as using rotating type aluminium packing, introducing water spraying louvers, using ceramic type packing etc. Declination in the efficiency is attributed to many reasons. Some of these reasons are due to negligence of routine cleaning and maintenance, dusty conditions, formation of deposits, failure of any mechanical parts... etc. Many suggestions have been presented in this study to improve the situation and hence the efficiency of the cooling towers which hopefully is expected to increase the performance of the cooling tower.

Key words: Aluminium, cooling tower, Ceramic, Efficiency, Performance, rotating plates

INTRODUCTION

Cooling towers are the devices that are referred as heat exchanging devices used to remove heat from hot water coming from condenser or any other hot water source. Cooling towers are used high water amount in number of industries where water is needed to cool down such as chemical industry, cement industry and power plants. The working principle of cooling tower if defined by a single term that would be “evaporating cooling” in which hot water comes in contact with ambient air and thus removes heat energy from water. The packing material or the contacting surface which is known as fills are placed in the working volume of cooling tower to increase the time of contact between two phases. The type of packing applied in cooling tower plays an important role in the performance of cooling tower indeed. Many types of packing that can be used in cooling towers are splash type packing, ceramic tile type packing [1], plastic packing and redwood packing. Many researchers have studied various packing effects with the help of experiments and different types of analyses.

The theories of cooling towers are studied by various researchers in depth. First of all, the Merkel work in 1925 [2]. He proposed simple and very accurate mathematical form of heat and mass transfer phenomena in cooling towers. Simpson and Sherwood [3] studied the effect of wood packing on the performance of cooling towers using 1.05m of height of wood. Kelly and Swenson [4] explained the heat transfer and pressure disorder in cooling tower using splash type packing they have observed relation between cooling tower characteristics with water/air mass flow ratio and concluded that factors effecting cooling tower characteristics were founded Water/Air ratio, packing height, geometry and inlet water temperature they also postulated that cooling towers characteristics at constant water/air ratio is independent of wet bulb temperature and air load. Bedeker et al [5] experimentally studied the performance of counter flow cooling tower with bed packed with film type packing and presented result in terms of towers characteristics outlet temperature and efficiency as a function of water/air flow ratio. The main conclusion of its work was that tower performance decreases with increase in liquid/gas ratio. More recently Kloppers and Kroger [6] explained the loss coefficient for wet cooling towers fills. They have used three types of fills trickles, splash and film type in cooling tower with tested area of about 1.5m x 1.5m and proposed new form of empirical equation that can correlate fill loss coefficient as function of water/air ratio. They have proposed another model VGA type packing [7]. This type of packing was proposed for mass transfer process between gas and liquid and not being used in cooling towers which have direct contact between water and air. This V.G.A type packing was later used by Lemouari and Boumaza [8-9]. This packing consists of vertical grids disposed in wall in the form of zigzag working on the principle that when water passes through that zigzag grids it gets contact with air traveling in opposite to it and heat removal take place.

The main purpose of this paper is to carry out the experimental investigation on the performance of cooling tower by using Aluminium fills and rotating water louvers.

EXPERIMENTAL FACILITY AND PROCEDURE

Fig. 1 represents a schematic of the experimental setup utilized in this study. This experimental setup includes a mechanical cooling tower which has several parts. The hot water is pumped out of water basin, which contains of two electric heaters, by water pump and is passed through a flow meter, which can adjust the flow rate of water the flow rate of water is kept constant throughout experiment. Above the basin there was aluminium fills having area of 36 inches x 8 inches which behaves as Contacting surface providing water and air the contact so to remove heat from hot water. Showering mechanism is used to spray water over the fills. For uniform distribution of water over the fills water showering louvers are used which moves to and fro with the help of H-bridge circuit. By using this system water is directly distributed over the ceramic packing, and the films of falling water were uniform across the whole surface of the packing. 9 Inches diameter centrifugal fan is used to induce the air inside the cooling tower. The air enters the tower at bottom and passing through rain zone, fill zone, spray zone and then leaves the tower with high humidity and high outlet velocity Centrifugal pump is used to circulate the water inside cooling tower. The air inlet and outlet velocities are measured by anemometer. The chromel alumel thermocouples are used to measure the inlet and outlet temperature of water this thermocouple was connected to 24 points digital display.in this experimental work, the factors which effect the performance of wet cooling towers were studied. These parameters and their ranges are given in the table 1.

The experimental procedure is described below as follows: At first the water at the basin is heated with the help of electrical heaters so inlet waters reach the temperature up to 50-55 ^{o}C. Water circulation system starts at the right time the air is started blown inside the tower from bottom so that hot water and ambient air gets contact at the aluminium surface to remove heat from water. Thus the water temperature is decreased and relative humidity of air is increased this cool water is then collected in the cold water basin. Because the air is highly humid so it cannot be directly discharged into the atmosphere that's why this air is subjected to the drift eliminators due to which the water droplets which air contaminate are then sticks to the drift eliminators and thus the humidity of air is relatively decreased. The air pressure at the contacting surface is measured by manometer by calculating pressure difference. The wet bulb temperature of inlet water is calculated by the psychometric calculators knowing relative humidity and inlet temperature. The relative humidity of air at inlet and outlet was measured by digital psych meter. The experiments are performed many times by changing the inlet temperature and observed change in temperature range.

Table-1 Cooling Tower Parameters and Measuring Device Specification

Parameter	Instrument Type	Range
Water temperature [°C]	Chromel-alumel thermocouples	0–70
Air temperature(WB) [°C]	Sling psychomotor	0–60
Flow rat of water [lts/hr]	Flow meter	0–1000
Air velocity [m/s]	Vane type anemometer	0–50

Performance Characteristics of the Cooling Tower:

In this work our main aim was to determine the tower characteristics with new packing experimentally. The performance of cooling tower depends on parameters like cold water temperature, range of cooling tower heat rejection from water and cooling tower characteristics. The cooling tower characteristics are also known as NTU.

Number of transfer units NTU of the system which is a dimensionless parameter. The cooling tower effectiveness is the ratio of range and ideal range.

$$Effectiveness\ (\mathcal{E}) = \frac{Range\ (R)}{Range(R) - Approach(A)} = \frac{(\mathbf{T_1 - T_2})}{(\mathbf{T_1 - Tw})}$$

The outlet temperature of cooling tower is the temperature of water after leaving packing surface and heat removal by air. The range is defined as the difference of inlet and outlet temperature of cooling tower.

$$\text{Range} = \Delta T = T1 - T2$$

The main parameter of cooling tower is the estimated amount of heat rejected from water expressed by the following expression:

$$\text{Heat rejected} = Q = mCp\ (T_1 - T_2)$$

Where Q is amount of heat rejected, m is the mass flow rate of water and Cp is specific heat of water. This equation includes the convective and evaporating heat rejection.

Heat and Mass Balance Equation

The schematic of wet cooling towers showing the important states of water and air is presented in Fig. 2. Calculating the energy balance between air and water in experimental cooling tower assuming that the tower is completely insulated and amount of heat rejected from water is the same the amount of heat gained by air so applying principal of conservation of energy.

$$Q\ a = Q\ w$$
$$Q\ w = Q\ cv + Q\ eV$$
$$mCp\ (T_1 - T_2) = G(H_1 - H_2)$$

COOLING TOWER THEORY

When ambient air is passed through the wet aluminium fills there is transfer of heat in the form of sensible and latent heat. When there is a difference between the temperature of water and air then transfer of heat takes place in other case when there is difference in partial pressure in the vapours present in air then mass transfer will occur. When mass transfer occurs then water evaporates which means heat is rejected from water in the form of latent heat. The rate of heat transfer in cooling towers is the difference between the enthalpies of air. The total heat transfer rate per unit volume of the packing is the sum of sensible heat and latent heat.

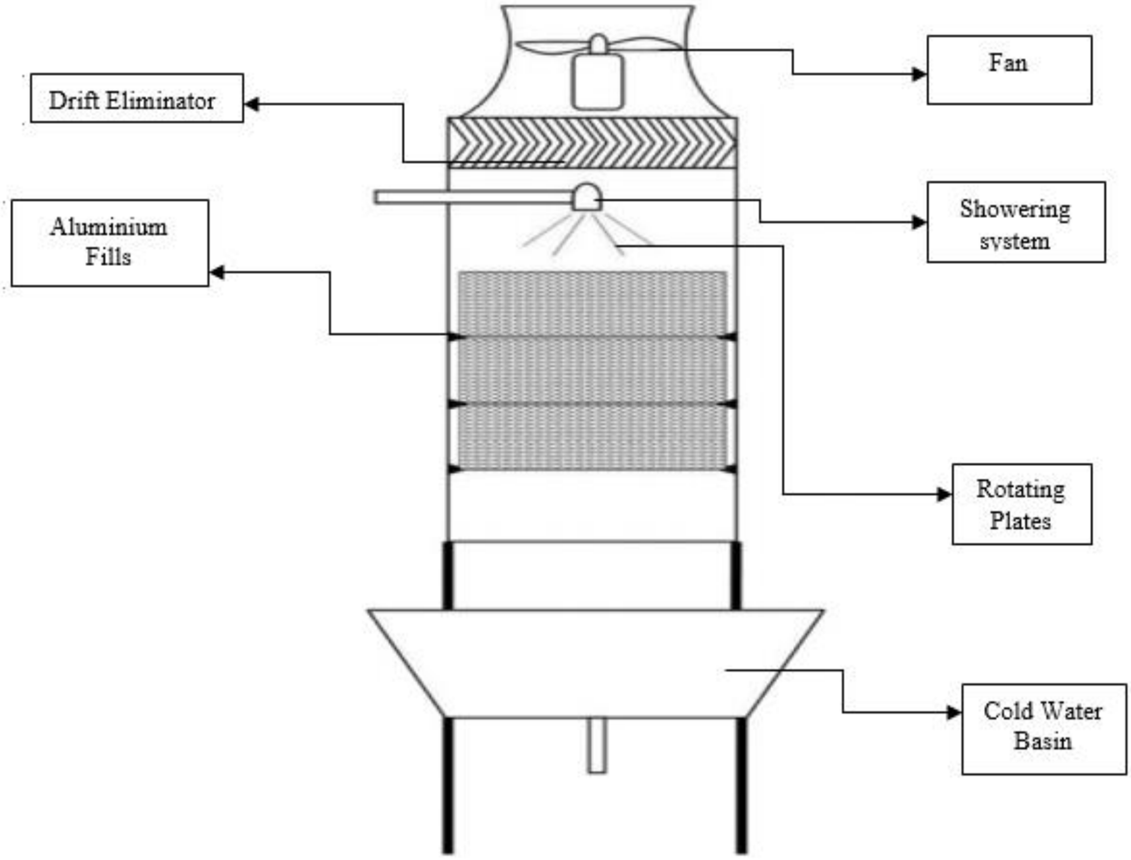

Fig.1 Experimental Setup

EXPERIMENTAL RESULTS AND DISCUSSION

Experiments are performed on our set up as result of which various conclusions are made and important parameters are measured just like Inlet Temperature, Outlet Temperature, wet bulb temperature and then efficiency, effectiveness and Cooling Capacity and hence observed the effect of Range on efficiency and Range on Cooling capacity, effect of Inlet temperature on efficiency Effect of approach on efficiency. The result and relations are given below Table 2.

when compared the cooling tower range with heat load it is founded that both has direct relation shown in Fig. 3 (a) which indicates that when contact between the air and water increases heat removal from hot water will be more which will increase the heat load. The maximum value of heat load is 2.3 KW.

Moreover it is founded that efficiency of cooling tower somehow depends on inlet temperature as the inlet temperature of cooling tower increases its efficiency increases because the difference between the inlet and outlet temperature is high and difference between the inlet temperature and wet bulb temperature will be low but when inlet temperature becomes high above 60°C the efficiency of cooling tower starts decreasing because difference between the inlet and outlet temperature will be same but the difference between the inlet temperature and wet bulb temperature will be high. Fig 3-b indicates the relationship between inlet temperature and efficiency of cooling tower.

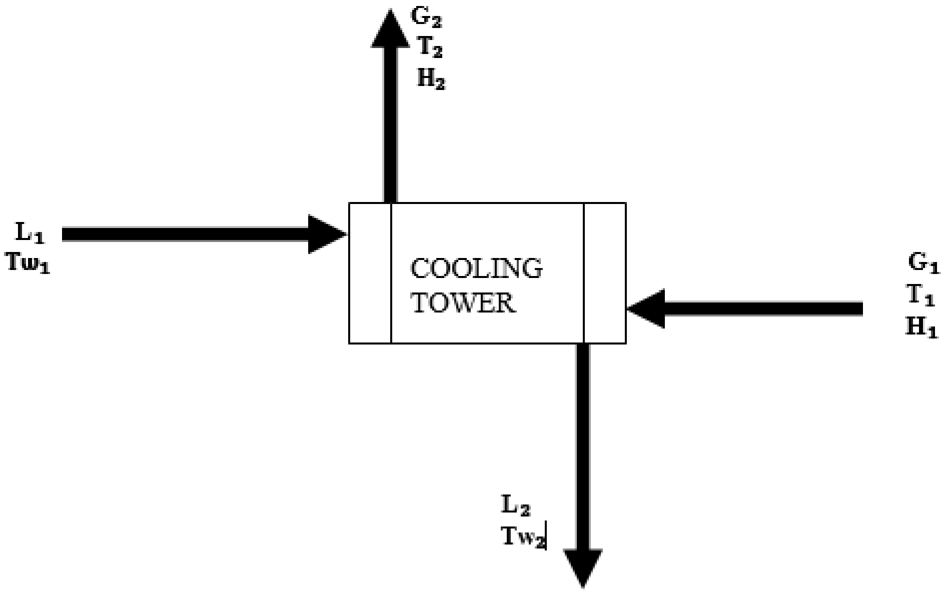

Fig. 2 Scheme of the Energy Balance Calculation

Table-2 Experimental Readings

Inlet Temperature T_1	Outlet Temperature T_2	Wet bulb Temperature Tw	Range $(T_1 - T_2)$	Heat Load $Q = mCp(T_1 - T_2)$ KW	Efficiency $\frac{T_1 - T_2}{T_1 - Tw} \times 100$
35 °C	30 °C	22.14 °C	5 °C	1.170 KW	39%
36 °C	30 °C	22.14 °C	6 °C	1.404 KW	42.15%
54 °C	44 °C	22.9 °C	10 °C	2.230 KW	32.25%
58 °C	46 °C	22.9 °C	10 °C	2.230 KW	28.75%
64 °C	56 °C	22.9 °C	8 °C	1.872 KW	19.50%
83 °C	75 °C	22.9 °C	8 °C	1.872 KW	13.33%

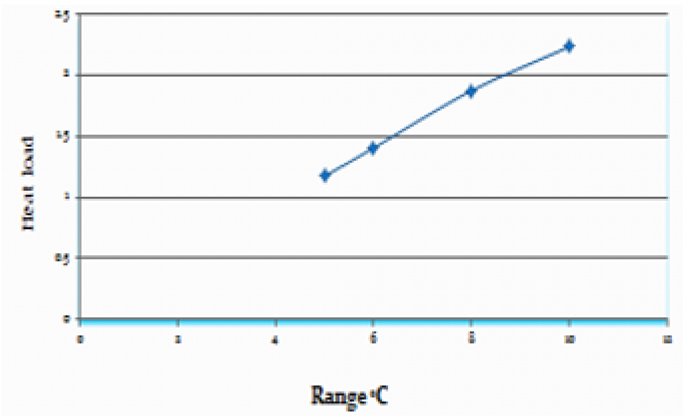

Fig. 3 (a)

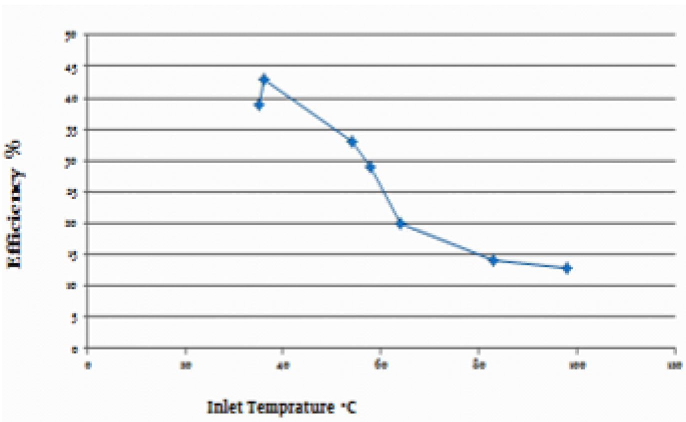

Fig. 3 (b)

Uncertainty Analyses

It is founded that the efficiency of cooling tower declines when the inlet temperature enters in the high temperature ranges above 60°C this is due to the fact that at high inlet temperature the difference between inlet temperature and wet bulb temperature (approach) becomes very large, which has inverse relation with the efficiency so the efficiency is decreases from which we can conclude that cooling tower are not suitable for high temperatures up to 80°C.

CONCLUSION

From the experiments various conclusions are postulated in which the most important was the effect of aluminium fills in performance of cooling tower aluminium being an elemental solid is corrosion free and has a reasonable good heat carrying capacity. The Specific Heat of aluminium is 900 J/kg °C which allows air to remove heat from water when they get contact over aluminium plates. The experimental was performed on small prototype design of cooling tower and it is proved to be an efficient one. In future it should be used on large scale in industry and more it is considered for more research study it will be founded to be a good method. Another fact is concluded that in winter the cooling tower performs more efficiently than summer because in winter the relative humidity of air is considerably low, the air will absorb large amount of water droplets which means air can take more heat from water, so more the relative humidity of air low will be efficient the cooling tower will perform.

Acknowledgements
The authors wish to thanks the reviewers for providing their precious time for correction and editing of this paper. We would like to thanks to the all faculty members of NFC institute of engineering and fertilizers research Faisalabad Pakistan for providing their assistance and guidance and specially helping in the fabrication of set up.

REFERENCES

[1] R Ramkrishnan and R Arumugam, Experimental Study and Performance Analysis of Ceramic Packing Cooling Tower Using Taguchi Method, *Processing and Application of Ceramics*, **2013**, 7 (1), 21–27.
[2] F Merkel, Verdunstungskühlung, *VDI-Zeitchrift*, 1925, 70, 123–128.
[3] WM Simpson and TK Sherwood, Performance of Small Mechanical Draft Cooling Towers, *American Society of Refrigerating Engineering*, **1946**, 52, 535–543 and 574–576.
[4] NW Kelly and LK Swenson, Comparative Performance of Cooling Tower Packing Arrangements, *Chemical Engineering Progress*,**1956**, 52, 263–268.
[5] SV Bedekar, P Nithiarasu and KN Seethatamu, Experimental Investigation of the Performance of a Counter Flow Packed Bed Mechanical Cooling Tower, *Energy*, **1998**, 23, 943–947.
[6] JC Kloppers and DG Kroger, Loss Coefficient Correlation for Wet Cooling Tower Fills, *Applied Thermal Engineering*, **2003**, 23, 2201–2211.
[7] JC Kloppers and DG Kroger, A Critical Investigation into the Heat and Mass Transfer Analysis of Counter Flow Wet-Cooling Towers, *International Journal of Heat and Mass Transfer*, **2005**, 48, 765–777.
[8] M Lemouari, Experimental Study of the Air/Water Heat Transfer by Direct Contact in a Column Packed with Vertical Grids- Application to the Water Cooling, MSc. Thesis, University of Bejaia, Algeria, **2001.**
[9] M Lemouari and M Boumaza, Experimental Study of the Air/Water Heat Transfer by Direct Contact in a Column Packed with Vertical Grids Application to the Water Cooling, Proceeding of 11th International Meeting on Heat Transfer, France, **2003**, 457–464.