Experimental investigation to improve the performance of cooling tower for various configurations

[1]M.G. SURYA, [2]NIKHIL RAJU R, [3]KIRAN GANESH, [4]VARUN KUMAR REDDY N
1-3,Student, School of Mechanical Engineering REVA University, Bengaluru
4-Assistant Professor, School of Mechanical Engineering REVA University, Bengaluru

ABSTRACT: A notable work has been carried out by many researches which is to enhance the performance of conventional cooling towers. The heat transfer in fluids will occur by convection, evaporation and radiation. The heat transfer occurs majorly by evaporative cooling, which inturn depends mainly on enthalpy of fluid rather than the temperature difference. The present work deals with the methods to improvement in the performance of the wet cooling tower with fluidized bed for various configurations with that of the cooling tower without fluidized bed. The prototype model of forced draft fluidized bed cooling tower and forced and induced draft fluidized bed cooling tower is designed. The best results in terms of performance are obtained for forced induced draft cooling tower, the range of cooling tower is 8◦ C for 6 lpm and has a maximum effectiveness of 50 percentage.

***IndexTerms* -** Range, Fluidized bed cooling tower, Effectiveness

I. INTRODUCTION

In majority of thermal power plants the power is generated by using steam turbines. The energy required for steam generation in the boiler is obtained by the combustion of fossil fuels. Generally closed loop cycle which works on Rankine cycle is used to circulate the working fluid. The exhaust steam coming out from the turbine is condensed and circulated back to the boiler. As fossil fuels availability is diminishing day by day the system that uses less input to produce higher power with better efficiency has got great scope. The exhaust from the steam turbine is condensed by using cooling towers in power plants. In conventional powerplants in order to increase the condensation rate the cooling towers are designed which are very giant in proportion, which increases capital cost of a system hence the system with less height and that results in better condenstation has got great scope.

TYPES OF COOLING TOWER

This section describes the two main types of cooling towers: the natural draft and mechanical draft cooling towers.

I. Natural draft cooling tower

The natural draft or hyperbolic cooling tower makes use of the difference in temperature between the ambient air and the hotter air inside the tower. As hot air moves upwards through the tower (because hot air rises), fresh cool air is drawn into the tower through an air inlet at the bottom. 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 200 m. These cooling towers are mostly only for large heat duties because large concrete structures are expensive. There are two main types of natural draft

towers:

Cross flow tower*:* air is drawn across the falling water and the fill is located outside the tower.

Counter flow tower*:* air is drawn up through the falling water and the fill is therefore located inside the tower, although design depends on specific site conditions.

II. Mechanical draft cooling tower

Mechanical draft towers have large fans to force or draw air through circulated water. The water falls downwards over

fill surfaces, which help increase the contact time between the water and the 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, fills for system resistance etc.

There are two types of mechanical draft cooling tower

i. Forced draft cooling tower
ii. Induced draft cooling tower

Bhupesh Kumar Yadav, S. L. Sonipaper [1], shows the working principle of cooling tower and has fabricated the model and analyzed various parameters related to cooling tower i.e. range, approach, effectiveness and evaporation loss.

Seetharamu and Swaroop et.al [2], studied that cooling tower packing's play an important role in increasing the effective contact area between air and water to promote better heat and mass transfer. Fluidized-bed cooling towers have been shown to enhance the cooling rate. The higher pressure drop due to particles in the bed is a main drawback for this system. They again studied the performance of fluidized-bed cooling towers; ignoring the higher pressure drop compared to other film and flash type towers, their performance was excellent.Sisupalan and Seetharamu[3] examined the performance variation of a fluidized-bed cooling tower for different bed heights.Dreyer et.al[4], studied the modelling of a cooling tower splash pack. By observing all the above studies, the theme for present work has been arrived.From the above papersthe tower size was evaluated, it is observed that the performance on a smaller size. Fluidized Bed Cooling Tower (FBCT) is found to be encouraging. Hence a larger size FBCT is designed and the performance is found to be equally good. The pressure drop encountered in FBCT is comparable to that of conventional cooling towers. The packing height in FBCT reduces considerably because of fluidization.The fluidized bed cooling tower system increases contact time between cooling air and hot water so that better cooling efficiency is obtained hence the system that result in optimum performance will be designed.

III OBJECTIVES

1. Design and Fabrication of cooling tower.
2. Experimentation for different L/G ratios for cooling tower with and without fluidized bed.
3. Experiments will conduct for the different hot water inlet temperature.

The Performance comparison will be done for cooling tower without and with fluidized bed and forced and induced draft. The main objective of the project is to show the improvement in the performance of the Wet-cooling tower with fluidized bed with that of the cooling tower without fluidized bed. A prototype model of forced draft fluidized bed cooling tower is designed, fabricated, assembled and finally carry out the tests for the performance.

These measured parameters and then used to determine the cooling tower performance in several ways. (Note: CT = cooling tower; CW = cooling water). These are

a) Range: This is the difference between the cooling tower water inlet and outlet temperature. A high CT Range means that the cooling tower has been able to reduce the water temperature effectively, is thus performing well. The formula is:

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

b) Approach: This is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. The lower the approach the better the cooling tower performance. Although, both range and approach should be monitored, the `Approach' is a better indicator of cooling tower performance.

CT Approach (°C) = [CW outlet temp (°C) – Wet bulb temp (°C)]

c) Effectiveness: This is the ratio between the range and the ideal range (in percentage), i.e. difference between cooling water inlet temperature and ambient wet bulb temperature, or in other words it is = Range / (Range + Approach). The higher this ratio, the higher the cooling tower effectiveness.

CT Effectiveness (%) = 100 x (CW temp – CW out temp) / (CW in temp – WB temp)

d) Cooling capacity: This is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and temperature difference.

IV DESIGN AND FABRICATION

The design of fluidized bed cooling tower is done based on the following parameters.

In order to maintain the L/G ratio from an approximate ratio between 0.5 to 5.5 as obtained from the literature review. 1 HP pump and a 3 H P centrifugal blower are selected as they give flow rates to maintain the required L/G ratio

The air flow rate is obtained from the control panel of the blower setup. water flow and temperature are measured by using water flow meter and control unit respectively.

Bed materials are used to increase performance of cooling tower by increasing the time of contact between air and water. The bed material used is spherical thermo coal balls of 3 to 3.5 cm diameter. The bed size of 25cm is maintained in the cooling tower duct. The line diagram of forced draft system and forced and induced draft system are shown below.

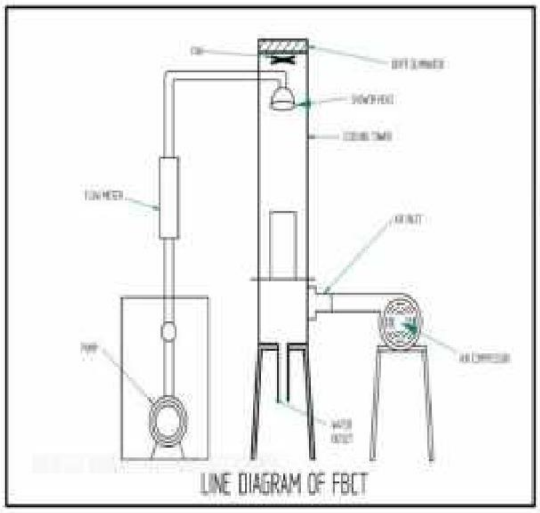


Fig 1:Line diagram of FBCT(forced draft system)

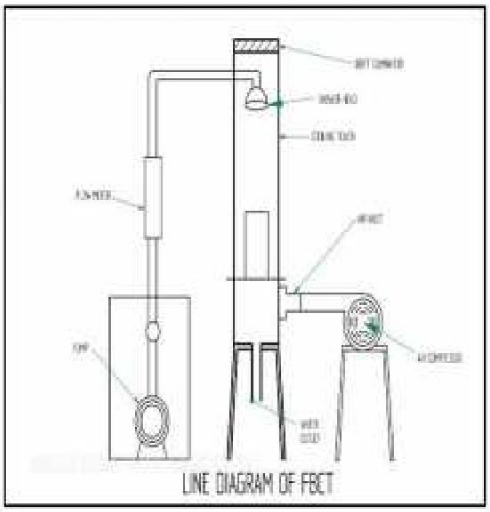


Fig2: Line diagram of FBC (forced and induced draft system)

By considering above parameters the following readings are obtained.

T_1-Inlet air temperature

T_2-Outlet air temperature

T_3-Inlet water temperature

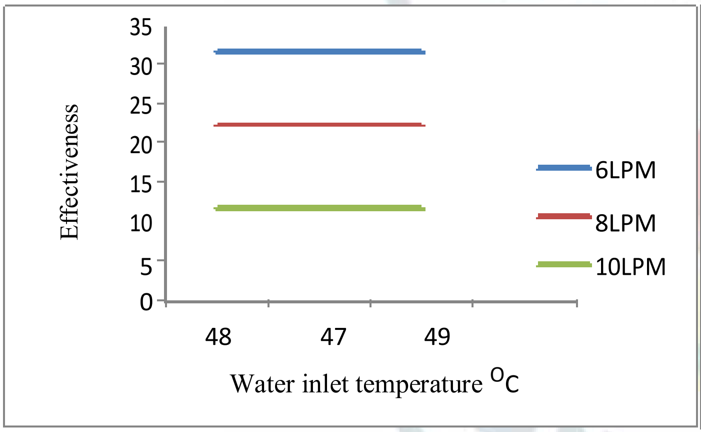
T_4-Outlet water temperature

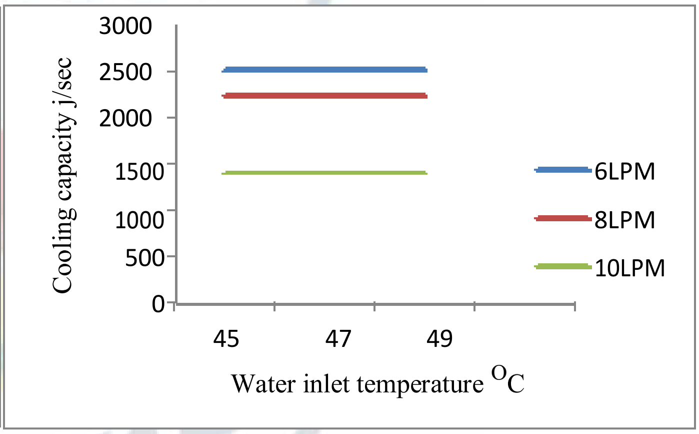
T_5-wet bulb temperature

WITHOUT BED MATERIALS (FORCED DRAFT)

FOR 6 LPM

T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	Range °C	Approach °C	Effectiveness %	Cooling capacity J/Sec
28	38	48	43	25	5	18	21.739	2093
28	39	49	44	26	5	18	21.739	2093
28	40	50	45	27	5	18	21.739	2093

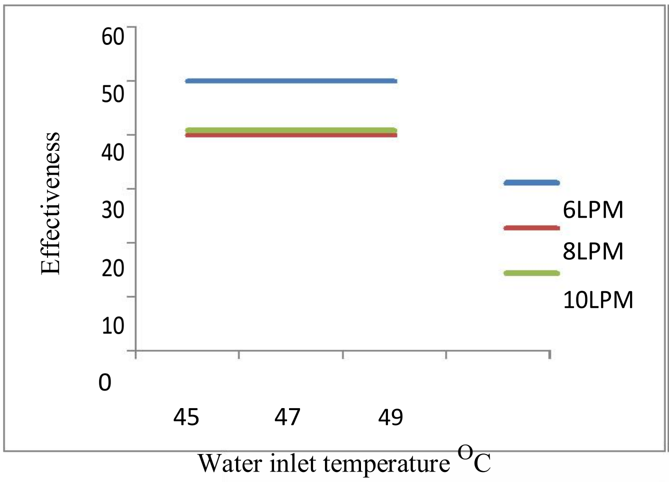




WITH BED MATERIALS (FORCED DRAFT)

FOR 6 LPM

T_1 °C	T_2 °C	T_3 °C	T_4 °C	T_5 °C	Range °C	Approach °C	Effectiveness %	Cooling capacity J/Sec	Water carried away cooling
28	38	48	42	29	6	13	31.578	2511.6	0.080
28	39	49	43	30	6	13	31.578	2511.6	0.0936
28	40	50	44	31	6	13	31.578	2511.6	0.107



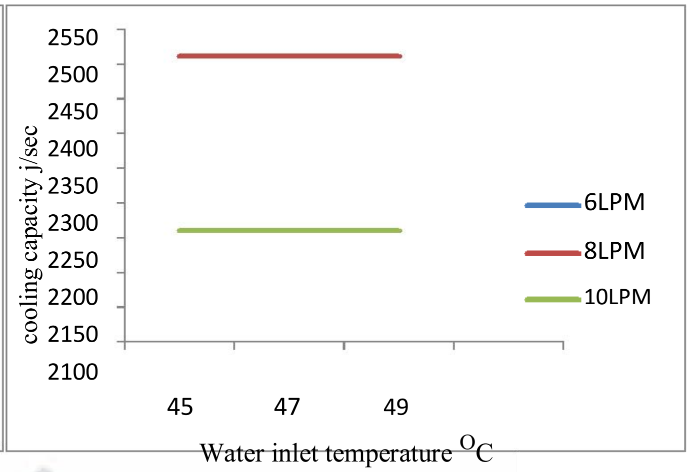


Figure 3 Experimental setup of FBCT

V CONCLUSION

The range of cooling tower can be increased by using fluidized bed. The use of fluidized bed cooling tower increases the cooling rate by 50 % compared to normal cooling tower, due to increase in inlet temperature of water decreases the effectiveness as same quantity of air is available for cooling for all operating temperatures of cooling tower, L/G ratio decreases accordingly the cooling rate increases. For optimum utilization of fluidized bed the flow rate of cooling air should be increased.

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