ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

PERFORMANCE OF FLUIDIZED BED COOLING TOWER

KALPANA.E, M.E (THERMAL ENGINEERING), MOHANASUNDRAM.T, M.E, Assistant Professor

Department of Mechanical Engineering

JJ College of Engineering and Technology, Trichy-9.

Abstract- The objective of this study is to investigate experimentally and theoretically heat and mass transfer characteristics of the cooling tower . These heat and mass transfer devices are based on the evaporative cooling of water in contact with ambient air. The working volume of the tower is filled with packing material to increase contact between the two phases. A column – packing unit is made of new type of packing named plastic ball. An experimental investigations have been carried out to find out the effect of the packing material on the performance of a Fluidized Bed Cooling Tower (FBCT). Form the experiments it is observed that the characteristics of the packing material does have a definite effect on the performance of FBCT. Modifications of the theoretical predictions based on the single stage equilibrium model in the light of the present experiments help in the predictions of the performance of the FBCT using packing material.

Key words: evaporative cooling, packing material

1INTRODUCTION

A cooling tower is a heat rejection device, which extracts waste heat to the atmosphere though the cooling of a water stream to lower temperature. The type of heat rejection in cooling tower is termed evaporative in that it allows a small portion of the water being cooled to evaporate into moving air stream to provide singinificant cooling to the rest of that water stream. Cooling towers are able to lower the water temperature more than devices that use only air to reject heat , like the radiator in a car and are therefore more cost-effective and energy efficient. Cooling towers may either use the evaporatioN of water to remove procees heat and cool the working fluid to near the wet bulb air temperature or in the case of closed circuit dry cooling towers, rely solely on air to cool the working fluid to near the dry bulb air temperature.

1.2TYPES OF COOLING TOWERS

Cooling towers fall into two main categories: Natural draft and Mechanical draft.

1.2.1 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. These cooling towers are mostly only for large heat duties because large concrete structures are expensive.

There are two types of natural draft cooling tower

- Cross flow natural draft cooling tower- air is drawn across the falling water and the fill is located outside the tower.
- Counter flow natural draft cooling 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.

1.2.2 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.

There are three types of mechanical draft cooling tower

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

- Forced draft cooling tower- air is blown through the tower by a fan located in the air inlet.
- Induced draft cross flow cooling tower- water enters at top and passes over fill, air enters on side (single-flow tower)or opposite sides(double-flow tower), an induced draft fan draws air across fill towards exit at top of tower.
- Induced draft counter flow cooling tower- hot water enters at the top & air enters bottom and exits at the top.

2 LITERATURE REVIEW

Several investigation and experiments are carried out on Fluidized bed cooling tower. Some of the technical aspects that are considered to carry out the present work are from the following Literature survey.

The presented Experimental investigations to find out the effect of various configurations of the packing material on the performance of a Fluidized Bed Cooling Tower (FBCT). From the experiments it is observed that the shape of the packing material does have a definite effect on the performance of FBCT and the spherical shape is not the best shape(K. N. Seetharamu and K. V. S. Varier[1]).

The performance of cooling tower usually referred to as the tower characteristic

$$\eta_d = Ka / VL = \int CpdT / (H - H')_{avg}$$

Experimental investigation leads to following conclusions. The experiments conducted in a Fluidized Bed Cooling Tower with various shapes of the packing material show that there is definitely an effect of the shape of packing material on the performance of the cooling tower. The experiments also indicate that the best shape of the packing material is not the spherical. The predictions from the single stage equilibrium model, in the light of the present experiments, are modified which can be used to predict the performance of FBCT when packing materials of different shapes are used.

This paper presents a heat exchange in a cooling tower is a complex phenomenon involving simultaneous heat and mass transfer(Kelly, N.W; Swenson, L.K [2]). The cooling tower packing plays a dual role – firstly, increasing the effective contact between air and water to promote better heat and mass transfer and secondly, it should provide least resistance to the movement of air to reduce pressure drop.

In this paper, a energy savings in cooling tower packings with the introduction of film type of packing, cooling tower is able to handle higher water flow rates, increasing the effectiveness of the cooling tower(Skold.J.D[3]).

The bed particles used in most of the investigations so far carried out are spherical in shape(Seetharamu, K.N; Raghavan, V.R; Murthy, P.A.K [4]). Since the bed plays a considerable role in the process of cooling, bed material of various configurations have been made use of in the three phase fluidization experiments as cooling process. The performance is compared with the predictions based on the single stage equilibrium model.

3 Experimental investigation

The tested cooling tower is a forced draft counter flow type. A line diagram and photo of the used experimental apparatus are shown Fig 1. The main part of the installation is the cooling tower, having 1m in height 0.3m × 0.3m in cross section. The front side of the column have the fiber glass arrangements up to a height 500mm from the base of the column and the remaining three sides of aluminum sheets for the visible purpose. Water is transported by pump through flow regulated valve. The water flow rate is measured by Rota meter and distributed through spray nozzles. Water is distributed in the form of falling films over the expanded wire mesh fill. The air and water flow rates are measured with an orifice meter and control value, respectively. The inlet temperatures are measured using thermometers. By using this system water is directly distributed over the plastic ball packing, and the films of falling water were uniform across the whole surface of the packing.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

Fig 1.Schematic diagram of fluidized bed cooling tower

The pressure drop at fill zone is measured by U-tube manometer. PT 100 type thermocouples were used to measure water inlet and outlet temperature and measure the water temperature in fill zone area. All thermocouples were connected to a 12 channel digital temperature indicator. A forced draught fan was used to provide air flow to the tower. The air enters into tower, passes the rain zone, fill zone, spray zone and leaves the tower. In the present experimental work many parameters affecting the performance of counter flow wet cooling towers were investigated.

In the experimental study, plastic ball packing was used as tower packing material. This type of packing is considered as unique for film packing. In this section certain calculations are made to selects the various components for fabrication purpose as well to select the bought out items such as hydraulic pump, blower, heating tank with water heater for water supply at condenser temperature into the main column and various specifications of instruments like U-tube manometers, water Rota meter, Temperature sensor with multi point digital indicator to take the temperature readings at various location.

3.1Experimental Procedure

Experiments are carried out to find out the effect of the packing material on the performance of Fluidized Bed Cooling Tower under steady state conditions. Figure shows the diagram of the process equipment used in the experiment. The apparatus used can be considered in terms of the column, water system, air system and the measuring devices. The quantities to be measured in the experiments are the liquid and gas mass fluxes and the dry and wet bulb temperatures of air at inlet and outlet in addition to the temperatures of air at inlet and outlet in addition to the temperatures of the water at inlet and outlet.

The quantity of air flow through the cooling tower was measured by the use of an inlet nozzle at the blower and an orifice at the bypass line. The pressure drop across each one of these was measured using a U-tube manometer. The nozzle was calibrated for its wall static pressure by traversing a pitot tube using an equal area method.

The orifice in the bypass line was calibrated using an airflow meter. Water flow to the bed was obtained with use of a calibrated orifice meter used in the water line to the tower. PT 100 type thermocouples were used to measure the temperatures. Two of the thermocouples which measure the wet bulb temperatures at the inlet and outlet were wetted with cloth mesh. The output of the thermocouples was measured with a sensitive D.C microvolt meter. The thermocouple used are all calibrated in an accurate thermocouple calibration bath. Switch on the blower set-up. And the start the circulating water through the cooling tower.

The switch on the heater and also switch on the pump. After reaching the study state note the following reading (i) Dry bulb temperature of heat inlet and outlet of air (T_{db1}-T_{db2}), (ii) Wet bulb temperature of heat inlet and outlet of air (T_{wb1}-T_{wb2}). Take the mass of water collected in the tank. And the temperature of water entering collected in the tank. The temperature of water entering the cooling tower T_2 & temperature of water leaving the cooling tower T_6. The manometer reading(h)=h_1˜ h_2. Note down the temperature reading $T_1$to T_6 by using digital temperature indicator. The repeat the experiment for difference flow rate.And finally calculated by efficiency of the tower. Different water temperatures are maintained by increasing or decreasing the heat input to the tank. After reaching a steady state, the air is sucked through by induced draft fan. The air and water flow rates are measured with an orifice meter and a control value, respectively. The air flow rate is maintained at different levels by adjusting the control vanes.

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

4 RESULT AND DISCUSSION

The concluded the results obtained from the experimental conduct to obtain exit water temperature in order to find the values of Range and Approach for various liquid to gas ratio (L/G ratio) and the variations of Range and Approach are obtained at different inlet temperature and for the cooling tower with fluidized bed cooling tower and the conventional cooling tower and finally the calculations are made for the performance of the cooling tower for each trials of various liquid to gas ratio at different inlet water temperatures.

The results obtained for the performance of the cooling tower from the above calculations are compared for both cases i.e for the cooling tower with fluidized bed is compared with the cooling tower without fluidized bed keeping other conditions such as L/G ratio (water and the air flow), inlet temperature, time of test duration for minutes is carried out for both the cases to get the steady values.

The performance of a cooling tower depends on the range of cooling, the approach of the cold-water to the wet-bulb temperature of air and the L/G ratio. Fig. 2 shows the outlet-water temperature variation with L/G ratio for different water flow rates. The rate of increase in water temperature is quite small at low L/G ratios. As the L/G ratio increases, a sudden increase in the slopes of the curves is observed. This change occurs at lower L/G ratios when the water flow rate is small; it is delayed with an increase in flow rate. It is apparent from Fig. 7 that locations before the steep-slope increase are zones of improved performance. As can be expected the outlet water temperature increases as (L/G) ratio increases. It can also be observed that the gave lower values than the theoretical ones.

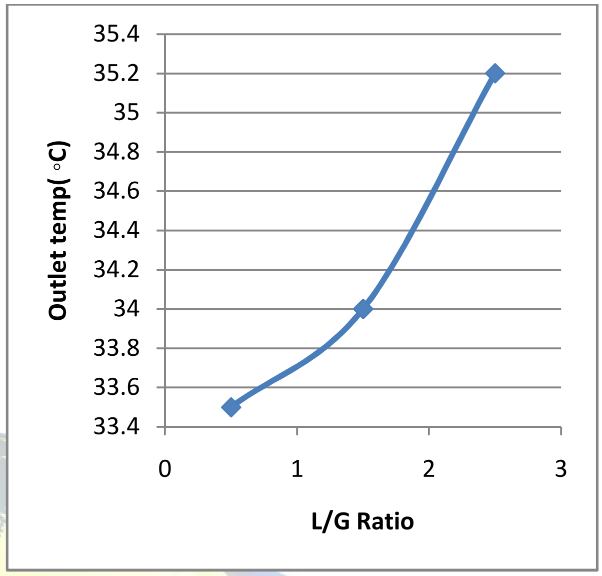

Fig 4.1 L/G Ratio Vs Outlet Temperature (˚C)

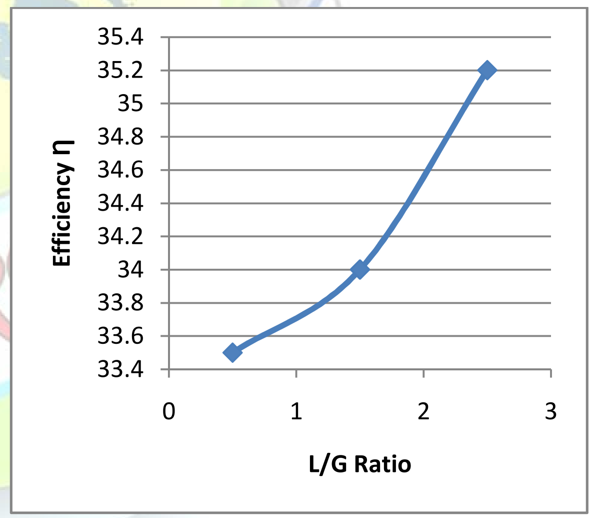

Fig 4.2 L/G ratio Vs Efficiency(Ƞ)

The results obtained for the performance at inlet temperature for both cooling tower with fluidized bedand cooling tower without fluidized bed is plotted onthe graph 6 for different values of liquid to air ratioranging from 0.5 : 2.5. The above Graph 1 indicates the performance of the cooling tower is always higher for each value of L/G ratio with fluidized bed compared to without fluidized bed. The red curve with square shaped mark indicating the performance without fluidized bed shows at L/G ratio

ISSN 2394-3777 (Print)
ISSN 2394-3785 (Online)
Available online at www.ijartet.com
International Journal of Advanced Research Trends in Engineering and Technology (IJARTET)
Vol. 3, Special Issue 24, April 2016

1 it is very less of numbers of diffusion units and suddenly increases at L/G ratio again decreases and increases at higher L/G ratio.

5 CONCLUSIONS

The performance of using Plastic ball packing is very good in using because of its high efficiency and its production is very easy & simple shape.By comparison between the results obtained from the experiment and those obtained from the model. It can be seeing that the model give high accuracy relatively with real results. The tower efficiency increased with the temperature ratio because the outlet water temperature decreases as airflow rate increases.The number of transfer unit increases as the temperature ratio increases at different L/G.The pressure drop increasing with increasing airflow rate at different temperature.The use of fluidized bed cooling tower increases the cooling rate by 50% compared to normal cooling tower.As the temperature L/G ratio decreases, the cooling rate increases.

6 REFERENCES

1) Barile R.G, Dengler J.L, Hentwig T. A (1974) "Performance and design of a turbulent bed cooling tower". A. I. Ch. E. Symp. Series 8, 154-162.
2) El-DessoukyHisham (1993) "Thermal and hydraulic performance of a three-phase fluidized bed cooling tower". Experimental Fluid Thermal Science. 6(4), 31-39.
3) Grandov A, Doroshenko A, Yatskar I (1996) "Cooling towers with fluidized beds for contaminated environment".
4) Kelly N.W, Swenson L.K (1956) "Comparative performance of cooling tower packing arrangement". Chem. Ing. Progress 52, 263-268
5) Louis MbuaEgbe (2001) "Operating characteristics and design of fluidized bed cooling tower."
6) Skold J.D (1981) " Energy savings in cooling tower packings". Chem. Eng. Progr. 77, 48-53.
7) Seetharamu K.N, Raghavan V.R, Murthy, P.A.K (1981) "Analytical and experimental investigation of the performance of a fluidized bed cooling tower". Alternative Energy Sources IV,7, 41-50. Ann Arbor Science, Butterworth group,
8) Seetharamu K. N and Varier K.V.S (1988), "Performance of a fluidized bed cooling tower using bed materials of various configuration".
9) Seetharamu K.N and Swaroop S (1990) "The effect of size on the performance of a fluidized bed cooling tower". Warme- und Stoffubertragung, 26, 17-21.
10) Sisupalan N and Seetharamu K.N (1992) " Heat transfer and pressure drop in fluidized bed cooling tower". Madras, India.
11) Teoman et al (2001) "Factors effecting heat transfer between gas-fluidized beds and bubbling fluidized beds". Powder Technol, 101(2), 85-91.
12) Wozniak, M (1977) "Pressure drop and effective interfacial area in a column with a nozzle bed". Int. Chem. Eng 17, 553-559.