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 BY USING ALUMINIUM/COPPER MATERIALS

MANOJ.K, M.E (THERMAL ENGINEERING), Mohanasundram.T, M.E, Assistant Professor
Department of Mechanical Engineering
JJ College of Engineering and Technology, Trichy-9, Tamil Nadu, India.

Abstract- Cooling tower is a type of direct contact heat exchanger, inside of which heat is withdrawn from the water by contact between the water and the air. The heat transfer occurs through the heat exchange between air and water and through the evaporation of a small part of the water that needs to be cooled. This will allow to cool down to a temperature lower than the ambient temperature. The phenomenon of heat and mass transfer in cooling tower is of complex one due to the direct contact between air and the water droplets from the spray nozzles which may not be uniform. 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 Aluminum and copper materials. 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.

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 a lower temperature. The type of heat rejection in a cooling tower is termed "evaporative" in that it allows a small portion of the water being cooled to evaporate into a moving airstream to provide significant cooling to the rest of that water stream. The heat from the water stream transferred to the air stream raises the air's temperature and this air is discharged to the atmosphere. Evaporative heat rejection devices such as cooling towers are commonly used to provide significantly lower water temperatures than achievable with "air cooled" or "dry" heat rejection devices, like the radiator in a car, thereby achieving more cost-effective and energy efficient operation of systems in need of cooling.. To date significant amount of work has been reported on experimental and numerical investigations of cooling towers characteristics generally denoted by KaV/L. The term KaV/L as per D Q Kern[1] usually referred as performance in terms of Number of Diffusion Units η_d. Hence

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

K. N. Seetharamu et. al. [2] carried out the experiments to find out the effect of various configurations of the packing material on the performance of a Fluidized Bed Cooling Tower (FBCT) The experiments indicates 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 and also with N. Sisupalan [3] carried out the experiments to observe Heat transfer and pressure drop in fluidized bed by varying the bed heights and reported optimum static bed height for the range of parameters investigated in the present tower is between 11 and 13 cm.

The pressure drop is in the order of 0.6 mm of water column per cm of static bed height and the maximum dynamic bed height observed is 26 cm, experimental investigations are also carried out with S. V. Bedekar, P. Nithiarasu[4] for the performance of counter flow packed bed mechanical cooling tower , the experiments are carred at lower flow rates L/G ratios less than 1 and reported that the tower characteristics decreases with increase in L/G ratio. Douglas [5] reported the performance for the cooling and humidification of a hot wet air stream in a floating bed contactor with a packing consisting of

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

hollow polypropylene spheres of diameter 38.1 mm and a static bed height, V, of 254 mm. Over the ranges tested, NTU was found to decrease with the increasing water or air mass flow rate. Experiments for water cooling in a FBCT, byBarile [6], covered static bed heights up to 457 mm and spherical packing diameters of 19 mm and 38.1 mm. The tower characteristic KaV/L was found to increase, albeit at a diminishing rate, with increased static bed height, and was slightly lower for the larger spheres. The measurements exhibited values of Ka, an order of magnitude higher than those for fixed packing towers.

1.1 Fluidized bed WORKING

Fluidization is the phenomenon by which the solid particles are made to behave like a fluid through contact gas or liquid or both. This principle is utilized in the development of three-phase fluidized bed cooling tower. At low flow rates of air the low density fluidizing solid particles lie on one another on a mesh or retaining grid at bottom of the cooling tower main body column. This state of fluidized bed is said to be in static or fixed state.

If the velocity of the air flowing upward increases, fluidization occurs, the low density bed materials forms as bubbles and intensive mixing of the bed materials and the air forms a turbulent action similar to a boiling fluid. This is the fluidized State. Further increase of the air velocity, will eventually cause entrainment of the fluidized bed particles from the column into the upward moving air. The contact and close proximity of the particles to one another ceases as the solid particles become mobile. This is the pneumatic or hydraulic transport State.

1.2Fluidized Bed Cooling Tower Theory

In order to substantiate certain assumptions made theoretically, the design and development of the cooling tower with fluidized bed requires certain experimental justification in relation to its thermal and hydraulic performance. Most investigators have resorted to empirical relationships. One of the reasons for this approach may be due to the complex nature of operation; the hydrodynamics consist of various dependent and independent parameters with the bed materials giving unpredictable fluidization behavior at many experimental conditions. Moreover, the FBCT hydrodynamics directly influences the degree of fluidization.

Since this in turn affects the rate of heat and mass transfer, it follows that the thermal and hydraulic performance are interrelated. In this chapter, new methods that attempt to generalize the different theories relating to fluidized bed hydrodynamics and heat and mass transfer are put forward taking into account the work of other investigators. Additionally, new theoretical techniques are presented so as to justify the present experimental work on heat and mass transfer and hydrodynamics.

Heat and Mass Transfer Several methods that provide an indication of a cooling tower thermal performance exist. The most common being the range of cooling. This is normally defined as the difference in temperature between the inlet hot water temperature and the and the outlet cooled water temperature. It may be represented as: CT Range (°C) = [CW inlet temp – CW outlet temp]

Another simple method of evaluating tower performance is called the approach to the wet-bulb temperature. This is the temperature attained by a small reservoir of water in contact with a large amount of air flowing past it. The approach may be defined as the difference in temperature between the outlet cooled water temperature and the inlet air ambient wet-bulb temperature

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

The performance of cooling tower usually referred to as the tower characteristic, η·- performance in number of diffusion units depends on the L/G ratio, temperature level of cooling and ambient air wet bulb temperature

2 Experimental setup

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.

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

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.

Fig 2.1. 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.

2.1Experimental 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}-

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

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.

3 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 3.1 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.

The above Graph 3 indicates the performance of the cooling tower is always higher for each value of L/G ratio with fluidized bed compared honeycomb. The blue curve with square mark indicating the performance without fluidized bed shows at L/G ratio 0.5 it is very less of 0.5328 numbers of diffusion units and suddenly increase at L/G ratio and again decrease and increase at higher L/G ratio. It is observed from the performance with clearly high FBCT at flow rate of the cooling tower.

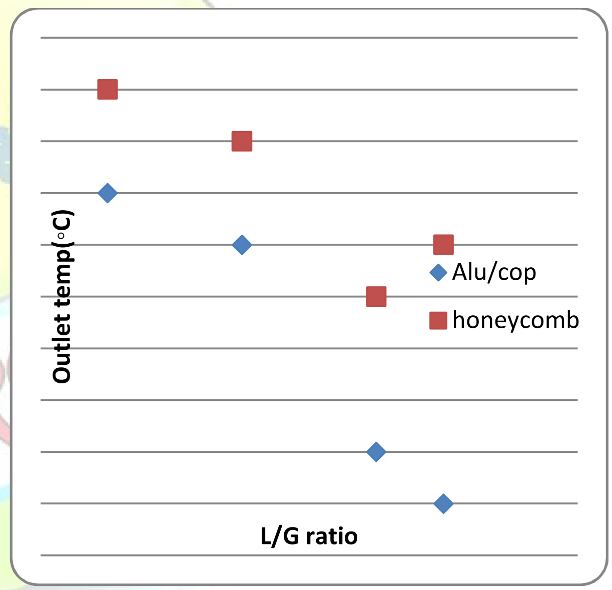

Fig 3.1 L/G Ratio Vs Outlet Temperature (˚C)

4 CONCLUSIONS

The using Aluminum/copper packing materials high efficiency and its production is 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

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

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.

5 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-Dessouky Hisham (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.