Experimental Study to Stimulate the Transmission of Heat and Optimization of the Mass Transmission in Packaged Cooling Tower-Structures with Horizontal Fill Packs

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Abstract: Cooling tower-structures are Cooling towers are vaporization type heat removal device which cools hot water with straight interaction with atmospheric air by vaporizing a portion of the water, The cooling towers needs spewing of water over a packing surface from side to side on which a stream of air is fleeting. Mostly the most of the cooling towers produced these days are provided with vertically placed fill packs. In this investigational experimentation the cooling tower-structure are accompanied with horizontal fill packs and different constraints related to cooling tower-structure is determined. Also validation of practical model is performed by empirical relations.

Keywords: Cooling tower, heat removal device, atmospheric air

I. INTRODUCTION

The cooled water is an important source in the food processing industries, power plants, air conditioning systems, commercial buildings, and heat rejection industries. The primary source of cooled water is from the cooling tower, which varies in sizes from small industrial tower to hyperbolic tower. Several forms of cooling towers are demonstrated by several investigators to examine effectiveness.

Bedekar et al. [1] deliberated the enactment of a counter flow packed cooling tower using a film type packing, and determined that performance of tower is inversely proportional to the quotient L/G. Goshayshi and Missenden [2] also deliberated the mass transfer and the pressure drop of several kinds of corrugated packing, the investigational data illustrates a correlation between the packing mass transfer coefficient and the pressure drop. Gharagheizi et al. [3] conducted a practical and relative study on the enactment of cooling tower with two types viz- vertical corrugated and horizontal corrugated packing and indicated that the effectiveness of the tower is subjective to the mass flow ratio water and air, the prearrangement and kind of the packing. Sunil et.al [4] proposed that hyperbolic shape was beneficial owing to higher bottom area that provides aerodynamics, strength, and stability. Randhire [5] studied the performance of natural draft kind towers and indicated that it can be enriched by optimizing the heat transfer besides the packing of cooling tower.

The main motive behind this paper is to conduct an investigational study on the enactment features of direct-contact counter flow type wet cooling tower-structure with polyester horizontal packing to conclude the parameters that disturbs the thermal efficiency and heat rejected by the tower.

II. EXPERIMENTAL SETUP

The present day industrial cooling tower uses varies techniques to cool down the water to the required temperature which includes using drift eliminators, polyvinyl chloride as fill media and blower. Though these techniques aid in reaching required temperature it results in water loss.

The flat horizontal fill material contains lots of holes placed at regular intervals which enhances the heat transfer rate and reduces the mass transfer of the water in the cooling towers. The study was done with a custom made cooling tower and the variations in various parameters are described. It also consists of a madka pot.

Revised Manuscript Received on February 05, 2019.

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Fig. 1 Experimental Setup

The copper tubes of required diameter and length were bent in serpentine shape and placed below the pot. The serpentine shapes were drilled at specify points to spray the water. The water is sprayed on horizontal fill media. The fill media is fabricated by polyester material.

The fill media is manufactured by holed sheets. The sprayed water falls on the polyester fill material and get flowed on the sheet. Due to large contact surface of water with atmospheric air the water gets cooled down quickly.

III. EXPERIMENT RESULTS AND ANALYSIS

Initially pour 5000 ml of water at 50^{O} C (Initial temperature) into an earthen pot (also known as matka pot), which is cooled by a fan placed above it. Due to this, the water vaporization takes place thereby resulting in cooling of water. Then the water is allowed to flow through the copper tube above which a fan is placed. Since copper is a good conductor of heat, the heat is absorbed by copper tube. This copper tube is cooled with the help of a fan placed above it. Followed by this, the water is scattered above the perforated polyester material. The molecules at elevated energy state vaporize and flow into the perforated polyester material. The water then condenses in the perforated sheet and then it is permitted to flow-over several layers of fill media. Finally the water is collected in the tank.

A list of tests are conducted to determine the variation in temperature between the inlet and the outlet of working fluid, Heat loss in overall process, Amount of water collected at the expiration of process, Percentage of water loss, Efficiency of cooling tower.

Table. 1 various inlet temperatures used and respective outlet, Dry bulb & wet bulb temperatures

S.No	Inlet temp ◦C	outlet temp ◦C	DBT ◦C	WBT ◦C
1	50	26.8	33.7	23.8
2	55	26.7	33.7	23.8
3	45	26.2	37.1	23.8
4	37.5	26.5	37.1	23.8
5	40.5	27.7	34	25.1
6	60	27.9	34	25.1

a) Range = t_i - t_o = 50-26.8 = 23.2°C

b) Approach = t_o -t_{wbt} = 26.8-23.8 = 3°C

c) Effectiveness= ((t_i-t_o) / (t_i-t_{wbt})) = 23.2/ (50-23.8) = 23.2/26.2 = 0.88549 = 88.55%

d) Evaporation loss = 400gm/0.5hr = 800gm/hr

e) Air flow rate = 1.150*0.08495*2 = 195.433kg/s

IV. ANALYTICAL METHOD

CARRIER'S EQUATION:

$P_v = P_v^{'} - 1.8\,(P- P_v^{'})\,(t-t_{wbt}) / \;2800-1.3(1.8t+32)$

Where , P_v = Vapour Pressure

$P_v^{'}$ = Saturation vapor pressure at wet bulb temperature

t_{wbt} = Wet bulb temperature

t = Dry bulb temperature

P = Barometric Pressure

AIR AT ENTRY POINT:

P=1.013bar and Pv'=0.02982bar at t_{wbt} = 24^{O}C

Pv = (0.02982-((1.8*(1.013-0.02982)*(33.7-23.8))/(2800-(1.3*((1.8*33.7)+32))))) = 0.0233bar

AIR AT EXIT POINT:

P=1.013bar and Pv'=0.02982bar at t_{wbt} = 24^{O}C

Pv=(0.02642-((1.8*(1.013-0.02642)*(33.7-23.8))/(2800-(1.3*((1.8*33.7)+32))))) = 0.0198bar

THEORITICAL EVAPORATION LOSS:

Evap loss=air flow rate (pv entry- pv exit) = 195.433(0.0232-0.01867) = 195.433(0.00453) = 885gm/hr

HEAT LOSS:

Q=m*Cp*(to-ti) = 0.166*4.187*23.2 = 461.407 joules = 16.12 kW

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Table. 2 Shows the effectiveness at different inlet temperature

S.No.	Inlet temp ^{0}C	Outlet temp ^{0}C	DBT ^{0}C	WBT ^{0}C	Range ^{0}C	Approach ^{0}C	Effectiveness %
1	50	26.8	33.7	23.8	23.2	3	88.55
2	55	26.7	33.7	23.8	28.3	2.9	90.71
3	45	26.2	37.1	23.8	18.8	2.4	88.68
4	37.5	26.5	37.1	23.8	11	2.7	80.29
5	40.5	27.7	34	25.1	12.8	2.6	83.17
6	60	27.9	34	25.1	32.1	2.8	91.98

TABLE 3 shows the heat loss at different temperatures.

Sl.No	Air flow rate kg/s	Saturate pressure of air @entry wbt (bar)	Moisture content of water at inlet	Saturatepressure of air @exit wbt bar	Moisture content of water at outlet	Evap loss Actual g/hr	Evap loss theoretic g/hr	Heat loss
	195.39	0.03	0.06	0.03	0.06	800	642.63	18.63
1	195.39	0.03	0.07	0.03	0.06	800	640.47	18.56
2	195.39	0.03	0.06	0.03	0.06	600	644.80	18.21
	195.39	0.03	0.05	0.03	0.05	500	648.05	18.42
3	195.39	0.03	0.06	0.03	0.05	800	646.75	19.25
	195.39	0.03	0.07	0.03	0.07	750	638.30	19.39

Due to large contact surface of water with the fill media the water spreads out covering the major area. This indeed makes the water to cool down quickly thus increasing the heat dissipation rate. If the contact surface area increases the heat rejection also increases is the physics behind the increase in heat flow rate.

Table. 4 Shows the variation of temperature with respect to time

Sl.No.	Time (min)	Temp ^{0}C				
1	0	50	55	45	37.5	40.5
2	5	38	38.2	34.4	32.5	36.3
3	10	34.1	33.5	31.3	29.7	33
4	15	31.4	30.8	29.2	28.3	30.2
5	20	29.5	29.1	27.7	27.2	29.1
6	25	28.4	28	26.9	27	28.8
7	30	27.4	27.3	26.5	26.8	28.1
8	35	26.8	26.7	26.2	26.7	27.7

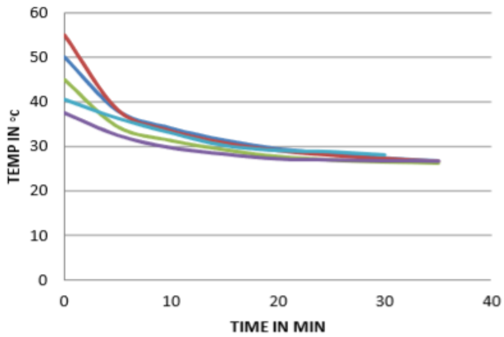

Fig. 2 Time Vs Temp

V. CONCLUSION

The effectiveness of the designed cooling tower is between 75-85% depending upon the WBT at the environment.

The cooling tower with incorporated features has less approach than conventional cooling towers, which is about only 1-2 ◦C. The effectiveness of ranges from 88.55% to 91.53%. Evaporation loss is about 160ml/hr for 1litre of water. Heat loss accounts for about 14-15 kw/hr.The unified controller based detector approach can be alternatively studied[6]. The outlet temperature of the water doesn't depend upon inlet temperature of the water, amount of inlet water. Based on the research analysis, wbt of the water-cooling tower-structure keeps on changing with respect to the humidity of the cooling tower, which occurs due to the evaporation of the water. The cost of the entire project is less when compared with small scale real time cooling towers.

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