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PERFORMANCE OF FLUIDIZED BED COOLING TOWER BY USING GLASS BALLS AND CERAMIC TILE PACKING

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ABSTRACT:

At the present scenario a lot demand of electricity for the purpose of human utilization. Through the power plant play the major role for the above mentioned need multiple process. Power plant has the various ascepts and limitations with their merits and demerits. The term heat exchange in field of thermal engineering as well as in power plant plays the major role in their efficiency of thermal conductivity. Removal of heat from the utilised flue gas contributes the different challenges for the power plant. These drawbacks and limitations are taken in the account the spark of innovation and the idea over the cooling tower. In this paper we analysis and performances over the cooling tower with the better design and modification. The technical data is taken for Mini draft cooling tower. Here the cooling is done by the application of Glass Balls and ceramic tile packing as a bed material and finally a three static bed were constructed. We are using an forced draft and the hot water temperature from 35˚C to 55˚C is used for our analysis. Instead of many material we utilize the glass and it is select for fluidised bed cooling tower for the good mechanical properties in cooling tower for this packing material.

Keywords: Fluidised bed cooling tower, Thermal conductivity, Glass ball , ceramic tiles

I. INTRODUCTION:

Cooling towers are heat removal devices used to transfer process waste heat to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly.Consider the surface of a warm water droplet or film in contact with an air stream.By radiation- This effect is likely to be very small at normal conditions and may be neglected .By conduction and convection This will depend on the temperature difference, the surface area, air velocity, etc. By evaporation This is by far the most important effect. Cooling takes place as molecules of H2O diffuse from the surface into the surrounding air. These molecules are then replaced by others from the liquid (evaporation) and the energy required for this is taken from the remaining liquid.

There are several important factors that govern the operation of cooling tower:The dry-bulb and wet-bulb temperatures of the air and warm water to consider. Further the temperature of warm water the efficiency of contact between air and water in terms of the volumetric mass transfer coefficient and the contact time between the air and the water to be noticed with a uniformity of distribution of the phases within the tower and finally the air pressure drop.

Air might enter the tower driven by a density gradient (natural draft), might be pushed into the tower (forced draft) at the base or drawn into the tower (induced draft) assisted by a fan. Several types of cooling towers have been designed on the basis of the above factors and operating strategies.

II. LITERATURE REVIEW

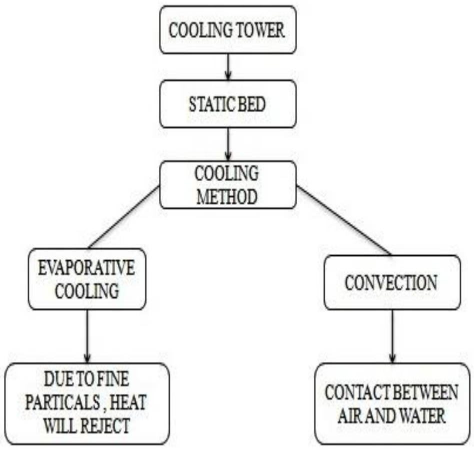
In this paper the authors described that the heat transfer and pressure drop characteristicsof splash grid type cooling tower packing.The authors correlated the tower characteristic withthe water/air mass flow ratio and mentioned that thefactors affecting the value of the tower characteristicwere found to be the water-to-air ratio, the packedheight, the deck geometry and, to a very small extent,the hot water temperature. They also mentioned thatthe tower characteristic at a given water-to-air ratiowas found to be independent of wet bulb temperatureand air loading , within the limits of air loading usedin commercial cooling towers.[1]

The author conducted the thermal and hydraulic performances of a three-phase fluidized bed coolingtower. He used spongy rubber balls 12.7 mm indiameter and with a density of 375 kg/m3 as a packing,and developed a correlation between the towercharacteristic, hot water inlet temperature, static bedheight, and the water/air mass flux ratio.[2]

In this paper we made a attempt with a experimental measurements on two pilot-scale cooling towers in order to analyse the performance of different cooling tower filling materials. They tested seven types of counter flow film type fills and correlated their pressure drop data as well as the volumetric heat transfer coefficient with the water and air flow rates.[3]

The author described anpacking in an evaporative cooling system tostudy its thermal and hydraulic performances. Therefore,this study presents an experimental investigationof the thermal performances of cooling towers filledwith the "V.G.A." type packing. This packing consistsof vertical grids disposed between walls in the form ofzig-zag. The principle of its performance is as follows:the gas (air) enters at the bottom of the tower and goesto the top of that while crossing several times the verticalgrids, whereas the liquid (water) is introduced atthe top of the tower and flows along the vertical grids.[4]

III. METHODOLOGY



The main purpose of this paper is to carry out an experimental investigation of the performance characteristics of a direct-contact counter flow wet cooling tower filled with the ceramic type and glass balls packing. Various experimental conducted based on the heat exchangers with the help of forced draft of the fluidized bed. Finally The experimental results were analysed and discussed.

IV. COMPONENTS OF OUR COOLING TOWER

The structural components of cooling tower such as: cold water basin, framework, water distribution system, fan deck, fan cylinders, mechanical equipment supports, fill, drift eliminators, casing and louvers.

A. COLD WATER BASIN

The cold water basin has two fundamentally important functions: collecting the coldwater following its transit of the tower, and acting as the tower's primary foundation.

B. TOWER FRAMEWORK

The used materials for the framework of field-erected towers are, with steel utilized for the vertical rectangular column which is of 1.5 metres height, which can hold three beds.

C. WATER DISTRIBUTION SYSTEM

The water line we used is 22.2 mm CPVC pipelines which can hold up to 85˚C, the maximum temperature we going to use is 60˚C so it's enough for our purpose.

D. BLOWER

In our kit, we are doing an forced draft system, for that the blower above the cooling tower is very important which absorbs the heat from the hot water which is dissipated from the bed, the blower runs at high speed to absorb the hot air present inside the cooling tower.Fig 3.The photographic view of blower.

E. FILL (HEAT TRANSFER SURFACE)

Fill (heat transfer surface) is able to promote both the maximum contact surface and the maximum contact time between air and water determines the efficiency of the tower. In our cooling tower we are using glass balls and ceramic tile packing as a fill materials which are used as a bed materials in fluidised bed cooling tower. From literature reviews we preferred this balls which having heat transfer coefficients and moreover PVC materials are used as a fills in commercial cooling towers.

F. LOUVERS

Every well-designed cross flow tower is equipped with inlet louvers, whereas counter flow towers are only occasionally required to have louvers. Their purpose is to retain circulating water within the confines of the tower, as well as to equalize airflow into the fill.

G. PUMP

The pumps helps in pumping the hot water from the tank for our observation purpose. The pump having the flow capacity of 30 litres per minute.

H. VALVES

Valves are used to control and regulate flow through the water lines serving the tower.

Valves utilized for cooling tower application include:

a. Stop valves: They are used on both counter flow and cross flow towers to regulate flow in multiple-riser towers, and to stop flow in a particular riser for cell maintenance.

b. Flow-control valves: They are considered to discharge to the atmosphere, and essentially as the end-of-line valves.

c. Make-up valves: These are valves utilized to automatically replenish the normal water losses from the system.

I. HEATER

To get a hot water circulation of temperature of about 55˚C we just heating the required water for analysis purpose we using two 1000W heaters.

J. WIRING SYSTEM

The wiring system design must consider pertinent data on the available voltage (its actual value, as well as its stability), length of lines from the power supply to the motor, and the motor horsepower requirements.

K. DIGITAL TEMPERATURE INDICATOR

A temperature indicator is a device which converts the deviation of voltage during temperature changes into respective temperature voltage values. We are using a six point temperature indicator which shows the temperature values of inlet hot water temperature, outlet cold water temperature, three bed temperatures and exit air temperature.

L. THERMOCOUPLE

A thermocouple is a sensor used to measure temperature. Thermocouples consist of two wire legs made from different metals. The wire legs are welded together at one end, creating a junction. This Junction is where the temperature is measured. When the junction experience a change in temperature a voltage is created which is converted into respective temperature value by temperature indicator.

M. THERMOSTAT

A thermostat is a bimetallic switch which automatically cut of the circuit after attaining the pre- defined temperature values. We are using a needle type thermostat in which we can control the heater value from 10˚C to 60˚C. Our maximum limited temperature to the cooling tower is 55˚C.

N. MECHANICAL EQUIPMENT SUPPORTS

Customary material for the unitized supports is carbon steel, hot-dip galvanized after fabrication, with stainless steel construction available at significant additional cost.

V. WORKING PRINCIPLE

Hot water circulation plays a major role on testing the cooling tower. Further the Water is to be heated at various required ranges of 35-55 C. The heater is mounted on the tank and then it is connected to the thermostat where its automatically cut off for the set temperature. After the process of heating the water is sent to a storage tank where it is pumped to the cooling tower through pipeline. At the bottom of the tower a blower is placed for forced draft arrangement and made a provision for the pipeline to enter from the side of the tower. Before the water directly reaches the bed the water is splits into droplets with the help of the shower. The bed consists of glass balls and ceramic tile packing which are used as a bed material in fluidized bed cooling tower. The three stages of bed cooling tower packed where in a range of 200mm for each bed stage. And this process is carried out repeatedly.

VI. EXPERIMENTAL PROCEDURE

After attaining the set value of the hot water the heater is automatically switched off. Then the pump is switched on. The water started tocirculated through pipeline from tank to cooling tower for sometimes to attain the steady state. Temperature between the beds were noticed and tabulated(1.1,1.2). Temperature readings are noted down with the helpof the temperature sensorand temperature indicator(thermo couple) at Hot water inlet, beds, cooled down water.

VII. RESULTS AND CALCULATIONS

Water Flow Rate (L): 1.8 m^3/ hr.

Air Flow Rate (G): 14.5 m^3/ hr.

Ambient temperature: 34˚C.

Wet bulb temperature: 30˚C.

S.No:	water temperature (°C)		Air temperature (°C)		Wet bulb temperature (°C)	Range (°C)	Approach (°C)	$\frac{KaV}{L}$ (No unit)	Effectiveness ε (No unit)	ηd %
	Inlet	Outlet	inlet	Outlet						
1.	35	31	34	37.9	30	4	1	0.112	4	80
2.	38	32	34	37.9	30	6	6	0.197	1.5	75
3.	45	36	34	37.9	30	9	6	0.214	0.818	60
4.	50	42	34	37.9	32	8	12	0.128	0.5	40
5.	55	47	34	37.9	32	8	17	0.107	0.38	32

Table 1.1, 1.2 shows the reading values taken from the tower

TABLE 1.1: COOLING TOWER MEASUREMENTS (WITHOUT BED):

S.No:	water temperature (°C)		Air temperature (°C)		Wet bulb temperature (°C)	Range (°C)	Approach (°C)	$\frac{KaV}{L}$ (No unit)	Effectiveness ε (No unit)	ηd %
	Inlet	Outlet	Inlet	outlet						
1.	35	34	34	35	33	2	1	0.025	1	50
2.	38	36	34	39	33	2	3	0.051	0.5	40
3.	45	42	34	36	33	3	6	0.077	2.7	25
4.	50	47	34	36	33	3	14	0.077	3.1	21
5.	55	52	34	36.5	33	3	18	0.077	1.4	13

TABLE 1.2COOLING TOWER MEASUREMENTS (WITH BED):

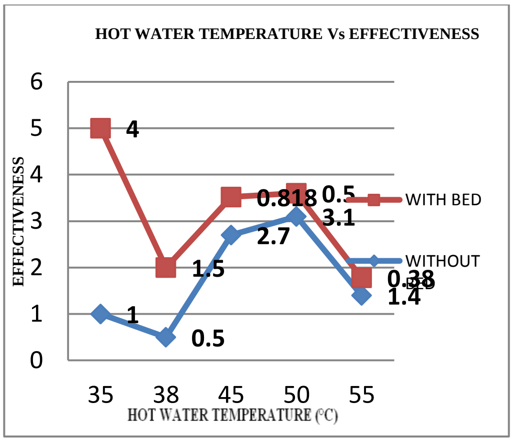
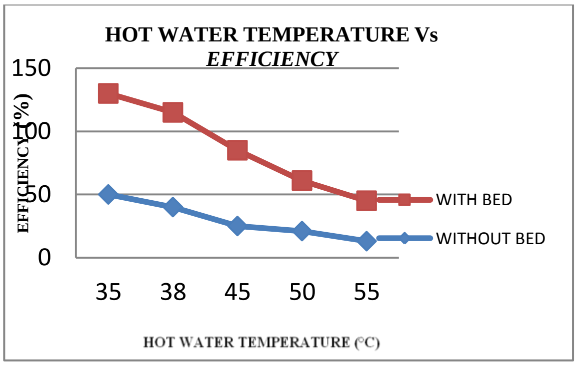
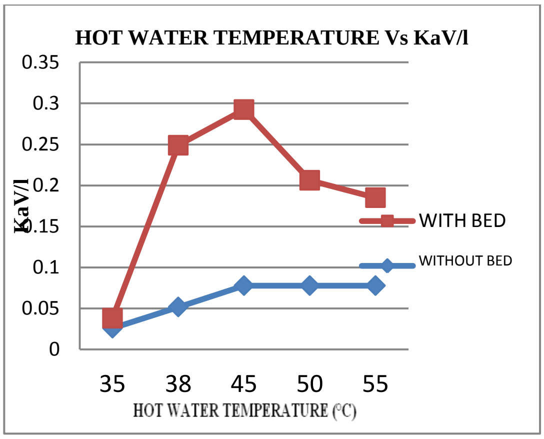


Fig. Graphical illustration of Hot water temperature Vs. Effectiveness



Fig;1 Graphical illustration Hot water temperature Vs. Efficiency



Hot water temperature Vs. KaV/l 9

CALCULATION:

1) Cooling tower range = $T_{wi} - T_{wo}$

= 55˚C - 47˚C.

= 8˚C.

2) Cooling tower approach = $T_{wo} - T_{wb}$

= 47˚C - 30˚C.

= 17˚C.

3) Mass of water = 1800Kg/hr.
4) Heat loss by water = $M_w \times C_{pw} \times (T_{wi} - T_{wo})$

= 60278.4 Kj/hr.

Mass of air required (Ma)
= (Volume of air required / Specific volume of air at inlet temperature)

= G / Gs1

Ma = 17.2 Kg / hr.

5) Tower Characteristics (KaV/L) :

$$= [(T_1 - T_2) / 4] \times \{(1 / \Delta h_1) + (1 / \Delta h_2) + (1 / \Delta h_3) + (1 / \Delta h_4)\}]$$

Where,

K = Mass transfer co-efficient (Kg / hr m2);

V = Active cooling volume (m^3);

T_{wi} = Water temperature entering the cooling tower, ^{0}C;

T_{wo} = Water temperature leaving the cooling tower, ^{0}C;

h_w = Enthalpy of saturated air at water temperature, kJ/(kg of dry air);

h_a = Enthalpy of air, kJ/(kg of dry air);

a = Total area of wetted surface includes the surface area of water drops as well as wetted slats or other fill material, m2;

L = water mass flow rate, kg/s;

Now,

Δh_1 = Value of $H_w - H_a$ at $T_2 + 0.1 (T_1 - T_2)$

Δh_2 = Value of $H_w - H_a$ at $T2 + 0.4 (T_1 - T_2)$

Δh_3 = Value of $H_w - H_a$ at $T1 - 0.4 (T_1 - T_2)$

Δh_4 = Value of H_w - Ha at $T1 - 0.1 (T_1 - T_2)$

KaV/L = 0.0515

6) Effectiveness $\varepsilon = (T_1 - T_2) / (T_1 - T_{a1})$

$\varepsilon = 0.38$.

7) Efficiency $\eta = (T_1 - T_2) / (T_1 - T_{wb})$

$\eta = 36.3\%$

VIII. CONCLUSION

Thus the analysis of fluidized bed cooling tower was done. Numbers of experimental runs were conducted in the forced draft cooling tower with glass balls and burnt clay as packing materials. Different variables were considered for the experimental run. In fig 1.1 represents, the variation of effectiveness of inlet hot water temperature and dry bulb temperature. The effectiveness of with bed tower value is less than 1 and without bed effectiveness valve is greater than 1. so with bed cooling tower is very effective than without bed cooling tower. Graphs represents, the variation of efficiency of inlet hot water temperature and dry bulb temperature. The efficiency of with bed cooling tower value at inlet hot water temperature of 45°C is 60% and without bed efficiency at same inlet hot water temperature is 25%. The other inlet hot water temperature results gets similarly. so with bed cooling tower is very effective than without bed cooling tower. In fig29 represents, the variation of KaV/l of inlet hot water temperature and dry bulb temperature. The KaV/l of with bed tower value is greater than without bed KaV/l valve. so with bed cooling tower is very effective than without bed cooling tower.

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