EXPERIMENTAL INVESTIGATION AND OPTIMIZATION OF COOLING TOWER EFFICIENCY BY FORCED DRAFT SYSTEM

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Abstract

Our aim is to design a cooling tower system which is used to reduce the temperature of the hot water which comes out from the thermal power plant. But in our project we certainly introduce an Electric fan which is used to reduce the temperature of the hot water by forcing air into the cooling tower to maintain the temperature of the water which comes out from the cooling tower and again been passed into the thermal power plant. The temperature of the incoming water and the out coming water from the cooling tower is measured using digital thermometer and then the velocity & speed of the air, inlet and outlet air temperature is been measured by Anemometer and "zig zag" design is included for the more efficient cooling.

Keywords *- Cooling tower, Anemometer, Velocity of air.*

I. INTRODUCTION

A Cooling tower is a type of heat exchanger used to reduce the temperature of a water stream by extracting heat from water and emitting it to the atmosphere. Cooling towers use the evaporation of water to remove process heat and cool the working fluid to near the wet-bulb air temperature. Cooling towers are able to lower the water temperatures 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.

Forced draft cooling tower is a type of mechanical draft tower which has a blower type fan at the air intake. With the fan on the air intake, the fan is more susceptible to complications due to freezing conditions. The benefit of the forced draft design is its ability to work with high static pressure. Such setups can be installed in more-confined spaces and even in some indoor situations. This fan geometry is also known as blow-through. The fan forces air into the tower, creating high entering and low exiting air velocities. The low exiting velocity is much more susceptible to recirculation.

II. RELATED WORK

Ronak Shah et al. (2012) [1]: suggested that the cooling towers are equipment devices commonly used to dissipate heat from power generation units, water-cooled refrigeration, air conditioning and industrial processes. Cooling towers offer an excellent alternative particularly in locations where sufficient cooling water cannot be easily obtained from natural sources or where concern for the environment imposes some limits on the temperature at which cooling water can be returned to the surrounding. Some techniques refer to different methods used to increase the thermal performance of cooling tower. The design of cooling tower is closely related to tower characteristic and different types of losses generated in cooling tower. Even though losses are generated in the cooling tower, the cooling is achieved due to heat transfer between air and water. In ideal condition, the heat loss by water must be equal to heat gain by air. But in actual practice it is not possible because of some type of losses. Cooling tower performance increases with increase in air flow rate and characteristic decreases with increase in water to air mass ratio.

Pushkar R. Chtale et al. (2018) [2]: suggested that Cooling Tower is a heat and mass transfer device commonly used to dissipate heat from devices like condensers in power plants, compressors, pumps in industries. Cooling tower works on the principle of evaporative cooling in which water is cooled down by the impact of high velocity flowing air. It offers an effective alternative at locations where there is cooling of water scarcity and where hot water discharge causes an environmental concern. The effective cooling of water depends on various parameters like dry bulb and wet bulb temperature of air ,fill material and its size, inlet air flow rate, air inlet angles, water flow rate and temperature etc. The basic components of cooling towers are packing, louvers, water inlet, nozzles, cooling tower basin, fans, drift eliminators, the frame and casing.

A.A. Brin et al. (2011) [3]: carried out a mathematical model of the forced draft cooling tower with full cone spray nozzle is proposed. The model represents a boundary-value problem for a system of ordinary differential equations, describing a change in the droplets velocity, its radiuses and temperature, a change in the temperature and density of the water vapour in a mist air in a cooling tower. Heat and mass transfer processes between water and air take place on upward and downward moving droplets. The new simulation data concerning influence of water flow rate, meteorological conditions, water pressure on the spray characteristics and water cooling are obtained. The maximum and minimum values of the droplet radiuses are determined, respectively, by the breaking of large droplets and the carrying away of small ones by the air flow. The dependence of the thermal efficiency of the forced draft cooling tower on the ratio between the mass flow rates of water and air is defined. No fan, irrigator is used in this forced draft cooling tower. From free to forced convection the efficiency of the forced draft cooling tower increases by 20-40 % depending on the initial water temperature and hydraulic load.

S.P. Fisenko et al. (2004) [4]: carried out a mathematical model of a mechanical draft cooling tower was developed. The model represents a boundary-value problem for a system of ordinary differential equations, describing a change in the droplets, velocity, its radii and temperature, and also a change in the temperature and density of the water vapour in a mist air in a cooling tower. The model describes available experimental data with an accuracy of about 3%. For the first time, the mathematical model takes into account the radii distribution function of water droplets.Simulation based on their model allows one to calculate contributions of various physical parameters on the processes of heat and mass transfer between water droplets and damp air, to take into account the cooling tower design parameters
and the influence of atmospheric conditions on the thermal efficiency of the tower. The explanation of the influence of atmospheric pressure on the cooling tower performance has been obtained for the first time.It was shown that the average cube of the droplet radius practically determines thermal efficiency. The relative accuracy of well-defined monodisperse approximation is about several percent of heat efficiency of the cooling tower. A mathematical model of a control system of the mechanical draft cooling tower is suggested and numerically investigated. This control system permits one to optimize the performance of the mechanical draft cooling tower under changing atmospheric conditions. They suggested that cooling tower is a numerical control system which permits one to optimize the performance of mechanical draft cooling tower under changing atmospheric condition.

Mehdi Rahmati et al. (2018) [5]: investigated experimentally thermal performance of mechanical draft wet cooling towers by changing various parameters such as hot water temperature, water flow rate, air mass flow rate and stage numbers of packing. In fact, this research attempts to focus on packing density influences with an emphasis on the role of stage numbers of packing. The results imply that coefficient of efficiency is in direct relation with air mass flow rate. On the other hand, thermal images are provided for visualizing temperature distribution within the studied cooling tower. Afterward, these images are utilized so as to obtain pertinent temperature histograms and also temperature distribution along the vertical and horizontal directions for three packings. Finally,regression analysis is employed in order to derive design equations from the measured data.

III. OBJECTIVES

1. To cool the hot water using the forced draught system.
2. To perform the cooling action and understand the various parameters involved in cooling of hot water in thermal power plant.
3. To define the problem that occurs in thermal power plant while cooling.
4. To recognize the type of metal, equipments, and tools that are used in cooling tower.

5. To recognize types of cooling in thermal power plant.

IV. WORKING PRINCIPLE

Water is collected in a storage tank.The temperature of the water is increased by heating the water with help of a submersive heater.Then the temperature of water is sensed by using a digital thermocouple.The hot water is pumped with help of feed water pump.Using the nozzle the hot water is sprayed inside the cooling tower set-up.The hot water passes the zig-zag model, and gets simultaneously cooled by the action of high speed fan.The temperature of hot water gets reduced by action of high speed fans and exhaust fan which is located at the top.The cooled water is collected is collected in the bottom.The temperature of the cooled water is measured using the digital thermocouple.

V. DIAGRAM

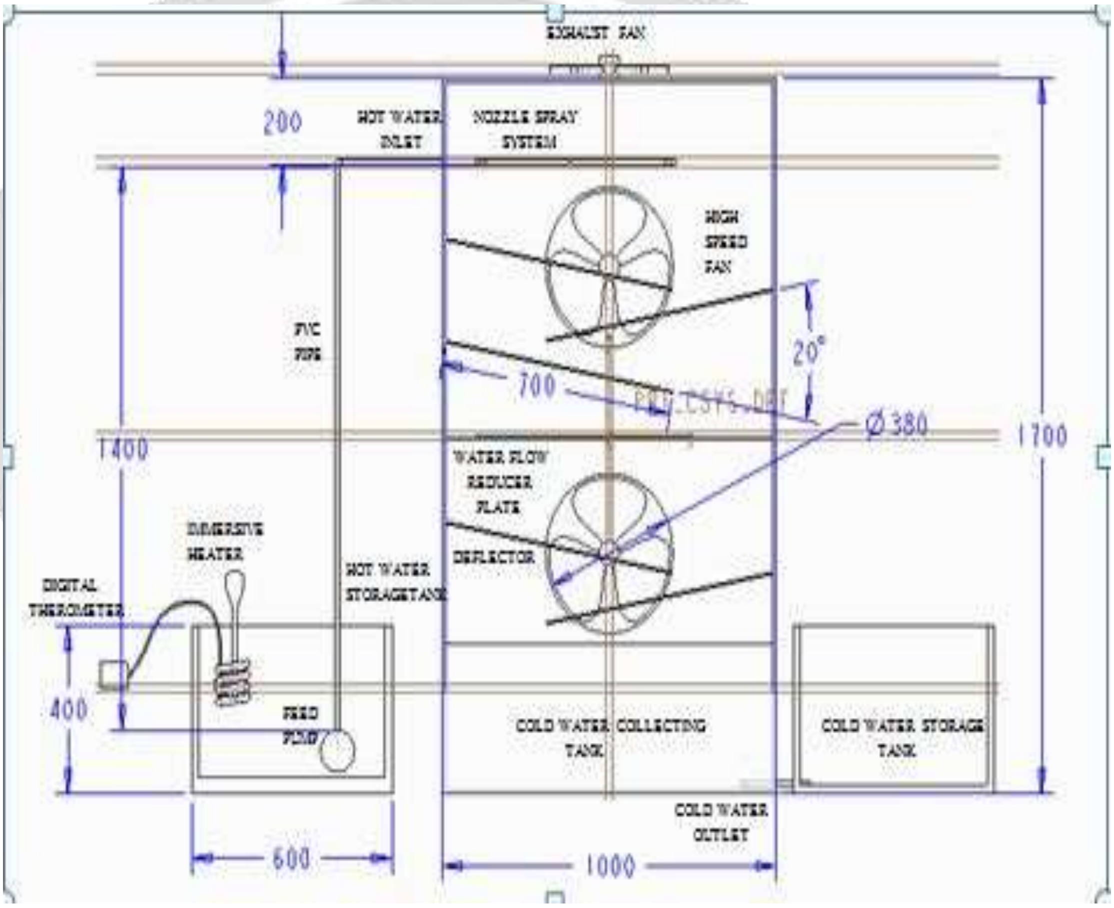


FIGURE 1. 2D LAYOUT

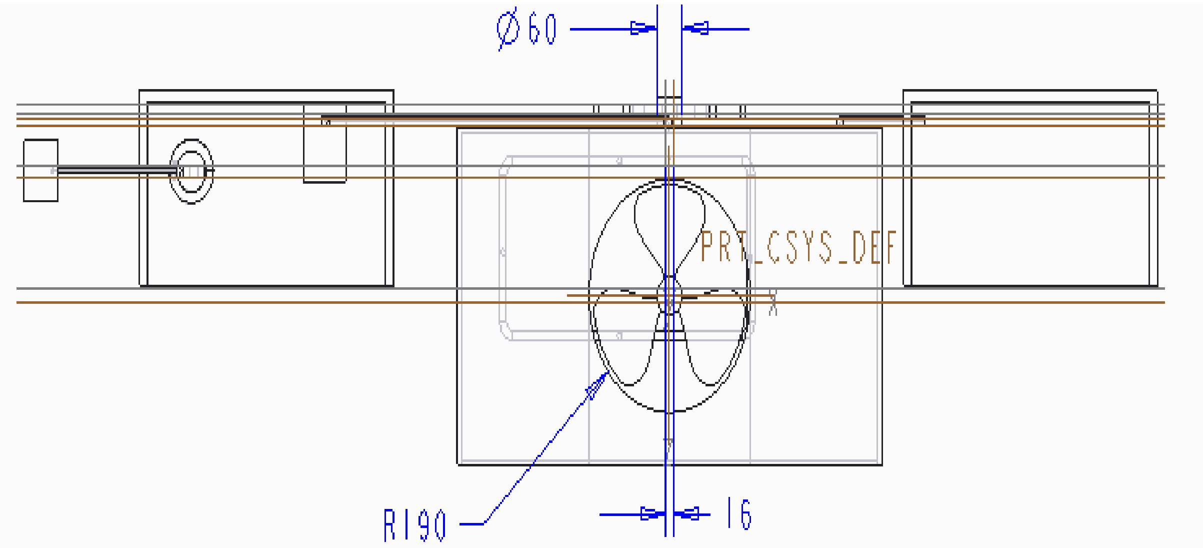


FIGURE 2. TOP VIEW

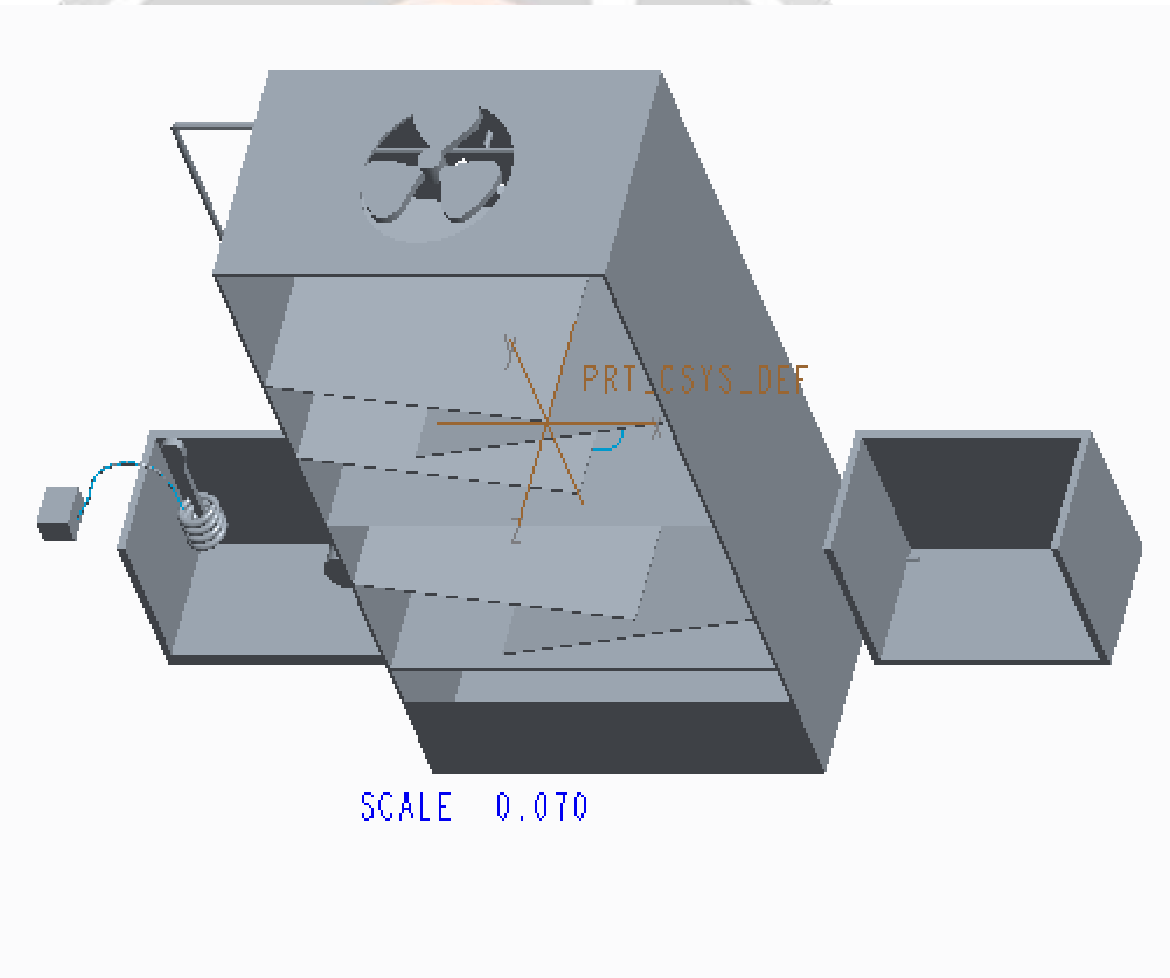


FIGURE 3. ISOMETRIC VIEW

VI. DESIGN CALCULATION

DRIFT LOSSES (DL)

DL = 0.1 x mw1/100

Where,

For drift losses multiply by 0.1 (or) 0.2 (for forced draft system)

mw1 = Volume of circulating water x Mass density of water

For ½ inch pipe – 1.1 (lit/min, kg/m) is the volume

mw1 = 1.1 x 1000

mw1=1100 Kg/hr

DL = 0.1 x 1100/100

DL=1.1 Kg/hr

EVAPORATION LOSSES (EL)

EL = 0.00085 x mw1 x (T1-T2)

Where,

T1 - Hot water temperature

T2 – Cold water temperature

EL = 0.00085 x mw1 x (T1-T2)

= 0.00085 x 1100 x (70-45)

EL=23.375 Kg/hr.

WINDAGE LOSSES (WL)

WL = 0.005 x mw1

(Multiply by "0.005" for circulating water)

WL=0.005 x1100

WL=5.5 Kg/hr.

WATER BALANCE EQUATION FOR COOLING TOWER (M)

M = DL + EL + WL

M = 1.1 + 23.375 + 5.5

M=29.975 Kg/hr.

EFFICIENCY OF COOLING TOWER

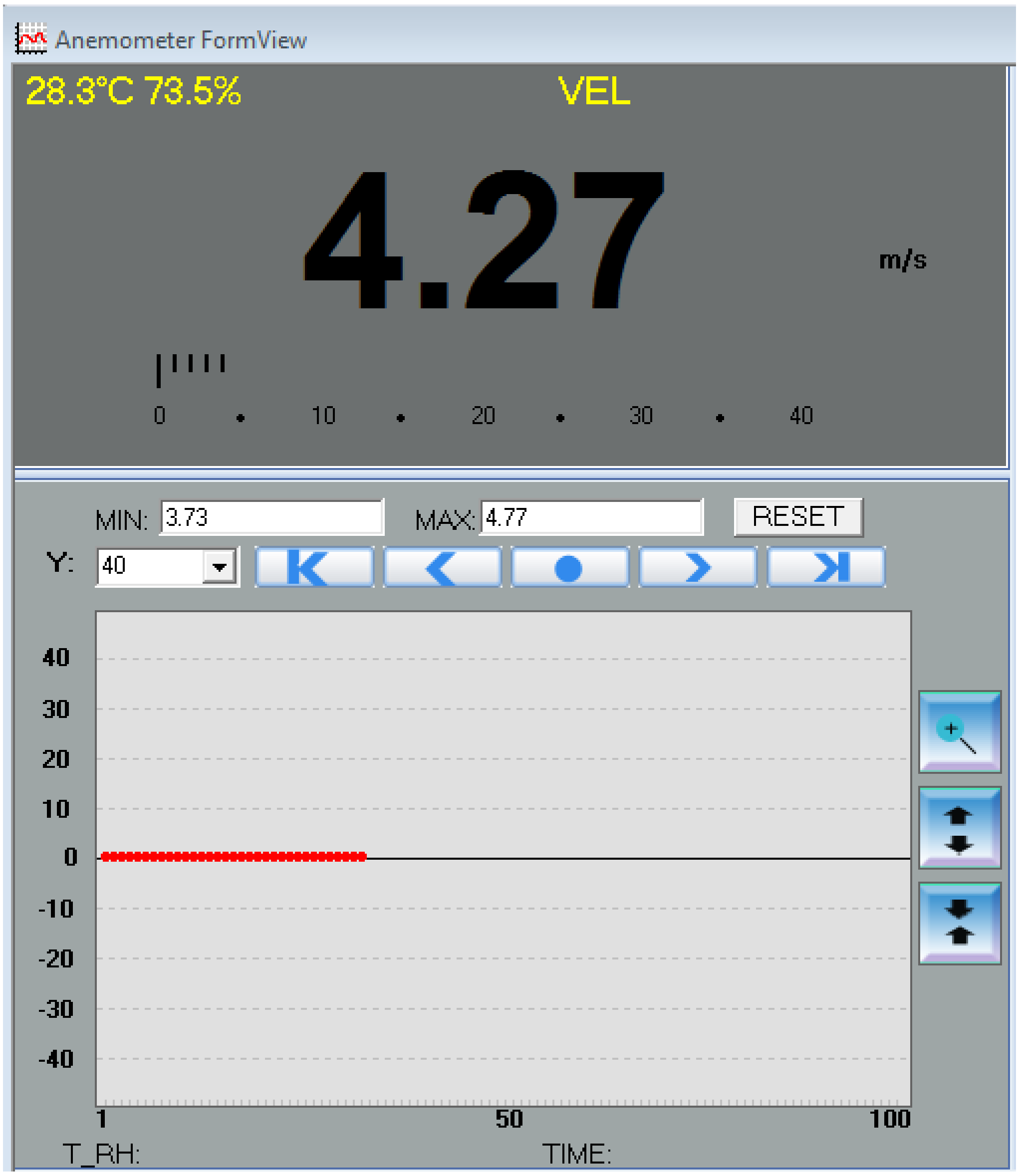
Efficiency = (T1-T2) / (T1-WBT)

= (70-45) / (70-35)

=0.7143x100

Efficiency =71.43%

VII. EXPERIMENTAL VALUES AND GRAPH



SERIES	DESCRIPTION	TEMPERATURE(°C)
1	INLET WATERTEMPERATURE	70
2	OUTLET WATER TEMPERATURE	47

NO.	T&RH	DATA	UNIT	TIME
24	28.3°C 73.!	4.49	m/s	\8:22:50 PM
23	28.3°C 73.!	4.58	m/s	\8:22:50 PM
22	28.3°C 73.!	4.74	m/s	\8:22:49 PM
21	28.3°C 73.!	4.68	m/s	\8:22:48 PM
20	28.3°C 73.!	4.62	m/s	\8:22:47 PM
19	28.3°C 73.!	4.46	m/s	\8:22:46 PM
18	28.3°C 73%	4.62	m/s	\8:22:45 PM
17	28.3°C 73%	4.58	m/s	\8:22:44 PM
16	28.3°C 73%	4.55	m/s	\8:22:43 PM
15	28.3°C 73%	4.46	m/s	\8:22:43 PM
14	28.3°C 73%	4.58	m/s	\8:22:42 PM
13	28.3°C 73%	4.68	m/s	\8:22:41 PM
12	28.3°C 73%	4.71	m/s	\8:22:40 PM
11	28.3°C 73%	4.65	m/s	\8:22:39 PM
10	28.3°C 73%	4.65	m/s	\8:22:38 PM
9	28.3°C 73%	4.68	m/s	\8:22:37 PM
8	28.3°C 73%	4.62	m/s	\8:22:36 PM
7	28.3°C 73%	4.55	m/s	\8:22:36 PM
6	28.3°C 73%	4.62	m/s	\8:22:35 PM
5	28.3°C 73%	4.68	m/s	\8:22:34 PM
4	28.3°C 73%	4.74	m/s	\8:22:33 PM
3	28.3°C 73%	4.65	m/s	\8:22:32 PM
2	28.3°C 73%	4.71	m/s	\8:22:31 PM
1	28.3°C 72.!	4.68	m/s	\8:22:30 PM

INLET AIR SPECIFICATIONS

Description: As plotted inthe bar graph given above shows the readings of the inlet water temperature at the initial and which is cooled by outlet air which comes out from the cooling tower. And the temperature of the air increases as the temperature of water increases and it reduces as the air temperature also reduces gradually, this occurs as the hot water is gets cooled as their is the direct contact with the air. All parameters measured are noted in the tabular column which is given below.

List of parameters measured

MASS FLOW RATE OF WATER	130kg/hr
INLET TEMPERATURE OF WATER	70°C
OUTLET TEMPERATURE OF WATER	45°C
WET BULB TEMPERATURE	35°C
HEIGHT OF COOLING TOWER	1.7m
MATERIAL OF PIPE USED FOR WATER FLOW	Pvc
DESIGN RELATIVE HUMIDITY	0.80%
EVAPORATING LOSSES	2.7625kg/hr

VIII. CONCLUSION

The cooling tower was fabricated according to the design. The cooling process and its rate of cooling value were observed and it readings were noted. Using the Digital Anemometer the various readings were noted and a graph was generated. By comparing the graph from the readings taken from the anemometer was done between the existing design and our specific design and the results are been concluded.

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