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Seasonal effect on the performance of counter flow induced draft cooling tower of class800 for 2x250mw

Abhisheak Kumar Verma[1], Sanjay Agrawal[1]

[1]*Department of Mechanical Engineering, B.I.E.T Jhansi, India*

ABSTRACT

To analysis the performance of counter flow induced draft type cooling tower in winter season, summer season as well as in rainy season comparatively. In this experimental work analysis, we have a counter flow induced draft type cooling tower for2x250MWof Class 800, model-85442-5.0-12(11 Working + 1 Stand by).This experimental work analysis is carried out at Parichha Thermal Power Station, Jhansi, U.P.

This paper describes the basic principles of cooling tower's operation, performance of counter flow induced draft type cooling tower. The factors that are affecting the cooling tower performances (such as hot water inlet temperature, cold water outlet temperature, wet bulb temperature, dry bulb temperature and relative humidity also).

Keywords*:*Counter flow cooling tower 2x250MW of class800, Sling Psychometer, DBT, WBT, losses, Relative humidity.

I INTRODUCTION

Hajidavalloo et al. [1] studied the mathematical model to predict the thermal performance of a cross flow cooling tower with splash type packing at different wet bulb temperatures.Spurlock and Boulder et al.[2] studied the effect of spacing slat type packing and the angle of the slats on the overall performance of a forced draft cooling tower (i.e. KAV/L). They gave the relations as a function of the water to air flow ratio (L/G) experimentally.Cooling towers(as heat exchangers) are the very important part of many of the plants like Thermal power plant, Chemical plants, Air conditioning plants, Nuclear power plants and Petroleum industry used for cooling purpose. The primary intend of a cooling tower is to reject waste heat into the atmosphere. Some research has been done on the cooling tower Gharagheizi et al. [3] studied on the act of mechanical cooling tower with two types of film packing.He reported that the (water/liquid) to (air/gas) mass flow ratio and due to the type and the thoughtful of packing affect on the performance of the cooling tower.Lucas et al.[4] studied the effect of drift eliminator andcarried out an experimental study of thermal performances of a forced draft counter flow wet cooling tower fixed with a importance type for six drift eliminators and when no drift eliminator was fixed.The comparison between their obtained results and those found in the literatures presents that the pressure water distribution systems type achieve better performances than the gravity types. Soylemez et al. [5] studied the thermal performance of counter flow wet cooling tower by using effectiveness-NTU method.In the present study, we have determined the performance(like Range, Approach, Efficiency of cooling tower, evaporative heat loss by water, Tower characteristic/Coefficient of tower/Size of counter flow induced draft type cooling tower for 2x250MW in various seasons (like winter, summer and rainy season). To achieve this objective, experimental and mathematical model of counter flow induced draft type wet cooling tower of 2x250MWunit#6 of parichha thermal power plant has been introduced.

II EXPERIMENTAL FACILITY

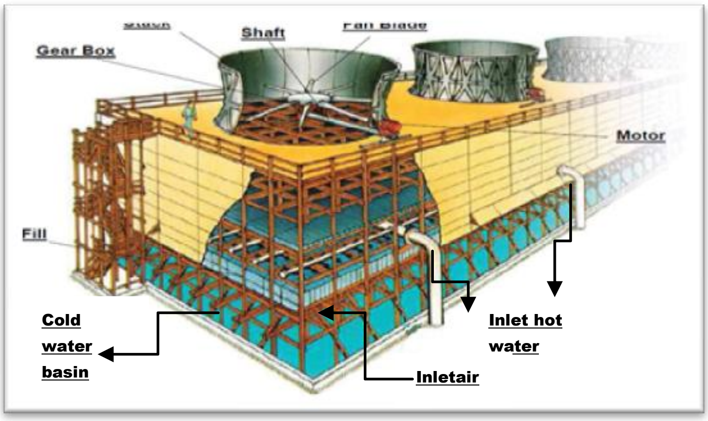
To study the performance of Counter flow induced draft type cooling tower for 2x250MWas shown in Fig.1, practical analysis has carried out in Parichha Thermal Power Plant, Jhansi, U.P.

Table 1: Technical specification of Counter Flow Induced draft type cooling tower for 2x250MW

Parameter	Specification
Cooling Tower Model	85442-5.0-12
Series	800(Reinforced Concrete Structure)
Load(MW)	250
No. Of CT fan	12(11 Working + 1 Stand By)
Diameter of the Fan(m)	10 m
Thickness of the blade(mm)	At tip=15mm and at shank=20mm
Packing height (m)	4.572
Drive Shaft series	351
Gear Reducers used	Spiral bevel/Helical gear
Gear Ratio	15:1
No. Of Pumps	4
Motor Maximum Power(KW)	50
At Running Motor Power(KW)	35
Size of the Cooling Tower(W x H),ft^2	60 x 50 ft^2

III EXPERIMENTAL PROCEDURE

To study the experimentally induced draft counter flow type cooling tower model 85442-5.0-12(11 Working + 1 Stand By) for 2x250MW. The fills are pack type and made up of PVC material [10]. Warm water exiting the condenser is pumped by a centrifugal pump and enters at the top of the cooling tower. Water is distributed uniformly across the packing material through a spray nozzles, droplets of water come in contact with ambient air flowing in a counter flow direction opposite to the flow of water. The cold water is collected at the basin of the tower and sent back to the condenser through the pump, where as the water takes up heat in condenser from steam at the exit of the low pressure turbine and again warmed water re-circulated to the top of the tower through the pump. The difference between the dry bulb and wet bulb temperatures is the driving force for the water to evaporate. And this difference in temperature is the one that decides the efficiency of the tower. Mass flow rate of air ($\dot{M}_a$) passes through the cooling towers having number of cooling towers fans are (12 CT Fans). In the present experimental work analysis, different parameters which are affect the performance of induced draft counter flow wet cooling towers for 2x250MW unit #6 are investigated. These parameters data are obtain through experimental work analysis measure daily live data with the help of measuring device in different seasons.



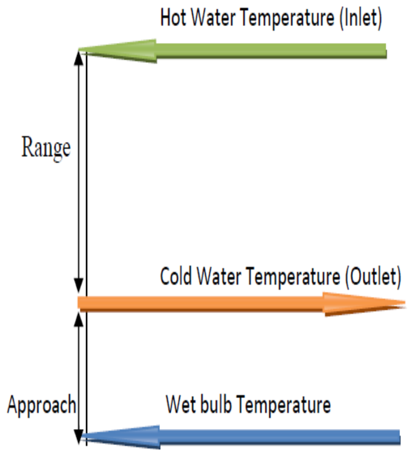


Fig.1: Isometric view of induced draft counter flow cooling tower for2x 250MW
[Parichha Thermal Power Plant]

To determine the performance of counter flow induced draft type cooling tower, the important parameters are:

3.1 Approach

The difference between the cold water temperature (cooling tower outlet) and ambient wet bulb temperature is called as cooling tower approach. Cooling tower approach is the better indicator for the performance [7].

Approach (A) = Cold Water Temperature – Wet Bulb Temperature

$= T_2 - WBT$

3.2 Range

The difference between the hot water temperature (cooling tower inlet) and cold water temperature (cooling tower outlet) is called cooling tower range [8].

Range (R) = Hot Water Temperature – Cold Water Temperature

$= T_1 - T_2$

3.3 Cooling Tower Efficiency Calculation

The calculation of cooling tower efficiency involves the range and approach of the cooling tower. Cooling tower efficiency is limited by the ambient wet bulb temperature [8].

Cooling Tower Efficiency = (Hot Water Temperature – Cold water Temperature) x 100/ (Hot Water Temperature – Wet bulb temperature)

or $\eta = (T_1 - T_2) \times 100 / (T_1 - WBT)$

Cooling Tower Efficiency = [Range / (Range + Approach)] x 100

3.4 Heat Capacity/Heat loss by water

Heat loss by water isgiven as product of mass flow rate of water, specific heat at constant and temperature difference between hot water temperature and cold water temperature at the inlet and outlet of the cooling tower. It is measured in (MJ/hr)[7].

HLW= $\dot{M}w$ x Cpw x (T_1–T_2), MJ/hr

3.5 Volume of air required (V)

Theamount of air required to carry away the waste heat to the atmosphere through the outlet of the cooling tower. It is measured in (m^3/hr)[7].

Volume of air required (V) = (HLW x Va_1) / [(Ha_2 – Ha_1) - (ωa_2 – ωa_1) x Cpw x T_2]

3.6 Heat gain by air

The amount ofheat absorbed by the air after passing through the fill film packing of cooling tower [7].

HGA = V x [(Ha_2 – Ha_1) - (ωa_2– ωa_1) x CpwxT_2] / Va_1, (MJ/hr)

3.7 Evaporation loss

Evaporation loss is the loss of water evaporated during cooling and, theoretically, for every 10^ kcal heat rejected, evaporation quantity works out to 1.8 m^3. A mathematical relation is used often [9].

Evaporation Loss = 0.00085 x circulation rate x (T_1–T_2), (m^3/hr)

3.8 Heat and mass transfer phenomena in the cooling tower

3.8.1Water evaporation rate

The mass flow rate of water that evaporates into the air stream through the film fills can be calculated from the following expression [10].

$\dot{M}evap$ = $\dot{M}a$ x (ωa_2– ωa_1), Kg/sec

Where;

ωa_1 = specific humidity of moist air at the entry and

ωa_2= specific humidity of moist air at the exit of cooling tower respectively

3.8.2 Heat loss due to evaporation from water

The main constraint to estimate thermal performance is the heat rejected from water expressed by following equation optional by Kloppers[11]. According to this equation the water loss, due to evaporation, is considered in the energy equation, i.e.

Qevap= ($\dot{M}evap$ x Cpw x T_2), MW

IV RESULTS AND DISCUSSION

4.1 Performance characteristic of Induced draft type counter flow cooling tower

To comparison the seasonal effect analysis of Counter Flow Induced Type Cooling Tower’s performance for 2x250MW, Model: 85442-5.0-12(11 Working + 1 Stand By) in three seasons (winter season, summer season and rainy season).

Table 2: Live data Specification of various seasons

Parameters	Winter-season (Dec-Jan)	Summer- season (April)	Rainy- season (July)
Load(MW)	250	250	250
Number of pumps	3	4	4
Flow rate of circulating water in cooling tower per tower(CMH)	17325x3/2= 25987.5	17325x3/2= 25987.5	17325x4/2= 34650
Dry bulb temperature, (^{0}C)	26°C	38°C	33°C
Wet bulb temperature, (^{0}C)	13.9°C	26°C	28°C
Hot Water inlet temperature (T_1),^{0}C	29.5°C	42°C	45.5°C
Cold water outlet temperature (T_2), ^{0}C	17.5°C	31°C	35.5°C
Relative humidity (φ), %	23%	38.70%	68%
Number of cooling tower fan	10	11	11
Design air Flow rate in cooling tower, (CMH / fan)	36000	36000	36000
Inlet temperature of air (Ta_1), ^{0}C	26°C	38°C	33°C
Outlet temperature of air (Ta_2), ^{0}C	29.6°C	41°C	36.6°C

Table 3:Data from Psychrometric chart and steam table

Parameter	Winter-season (Dec-Jan)	Summer-season (April)	Rainy-season (July)
Enthalpy of hot water at inlet state (Hw_1) , KJ/ kg	73.4	175.8	190.45
Enthalpy of cold water at outlet state(Hw_2), KJ/kg	126.6	129.8	148.65
Enthalpy of air at inlet state (Ha_1), KJ/kg	38.38	79	89.54
Enthalpy of air at outlet state (Ha_2), KJ/kg	44.77	90.52	105.94
Specific humidity of air at inlet state ($Ꞷa_1$), Kg/kg of dry air	0.00479	0.01625	0.02196
Specific humidity of air at outlet state ($Ꞷa_2$), Kg/kg of dry air	0.00591	0.01914	0.02693
Specific volume of air at inlet state (Va_1), m^3/kg of dry air	0.8503	0.08897	0.8787
Specific volume of air at outlet state (Va_2), m^3/kg of dry air	0.8606	0.9	0.8857

Table 4: Comparison the results of Seasonal effect on the Performance of counter flow induced draft type cooling tower in different season.

S.N.	Parameter	Winter-season (Dec-Jan)	Summer- season (April)	Rainy- season (July)
1	Range, (°C)	12°C	11°C	10°C
2	Approach, (°C)	3.6°C	5°C	7.5°C
3	Efficiency of cooling tower, (%)	76.92%	68.75%	57.14%
6	Drift losses, (Kg/hr)	51,975	51975	69300
7	Blow down losses , (Kg/hr)	51,975	51975	69300
8	L/G ratio	0.533	1.05	1.64
9	Tower coefficient/size(M_e)	1.89	1.26	0.966
10	Evaporative mass transfer (kg/sec)	64.5	78.43	127.55
11	Heat transfer due to evaporation(MW)	4.72	10.178	18.96

V CONCLUSIONS

From the study of results and experiments work analysis conducted during this research we can conclude that

1. The efficiency of the counter flow induced draft type cooling tower is higher in winter season lower in rainy season. The efficiency of cooling tower in winter season, summer season and winter season are 76.92%, 68.75% and 57.14%.
2. The evaporation losses of the cooling tower are lower in winter season as compared to rainy season.
3. The value of L/G ratio is maximum for rainy season is maximum 1.64 and for winter season is lower=0.533.
4. Tower characteristic/size of the tower (Markel number) for counter flow induced draft type cooling tower is maximum for winter season =1.89, for summer season= 1.26 and lower for rainy season=0.966.
5. The value of mass transfer due to evaporation is higher=127.55kg/sec for rainy season and lower value=64.5kg/sec for winter season.
6. The value of heat transfer due to evaporation is maximum for rainy season=18.96MW and lower value=4.72MW for winter season.

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