PERFORMANCE ANALYSIS AND EFFICIENCY IMPROVEMENT OF COOLING TOWER AT MTPS-I

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Abstract - *In thermal power station one of the main part is condenser which cools the hot water. When cooling the hot water, it becomes cold water. The how water temperature is reduced by the cooling tower. When hot water enters into the cross flow induced draft cooling tower and sprayed by the nozzle, so that hot water is converted into cold water. The effective cooling water is depends upon wet bulb temperature, dry bulb temperature, size and height. This project deals with analysis of cooling tower which is one of the deciding factors used for the power plant efficiency.*

Key Words: *Wet bulb temperature, dry bulb temperature, cooling water range, cooling water approach, inlet air and water temperature, outlet air and water temperature etc.*

1.INTRODUCTION

The Mettur thermal power station is the Tamilnadu electrical board's inland thermal power facility. Industrial development is critical to the country's economic success. The facility is on Stanley reservoir's left edge, on the Ellis Surplus route. The major goal of the 840MW Mettur Thermal Electricity Station is to meet the power needs of the state of Tamilnadu's industrial centers. Work on the project began in 1981, and the first unit was commissioned in 1987. The last three units were put into service in 1987, 1989, and 1990, respectively.

1.1 SCOPE OF THE PROJECT

The scope of the project is to find the energy conservation opportunities in Mettur Thermal Power Station by following methods:

- To find the various opportunities in cooling tower casing, fan blade material and fan blade angle.
- Through replacement of motors to reduce the current and horse power.
- To optimize the blow down rate.
- To restrict flows through the large loads to design values.
- To increase the cooling tower efficiency.

2.COOLING TOWER

The cooling system conjointly includes any machinery accustomed operate the tower and any tanks, pipes or valves. A cooling is instrumentality accustomed cut back the temperature of the water by extracting heat from water and emitting to the atmosphere. cooling build use to evaporation wherever by a number of the water is gaseous into a moving air stream and afterward discharged into the atmosphere. As a results the reminder of the water is cooled down considerably. cooling square measure able to lower the water temperature over devices that use solely air to reject heat just like the radiator within the automobile and square measure thus most value effective and energy economical. cooling square measure employed in air con system for refrigeration or to cool down materials in industrial processes. cooling square measure devices that use close air to cool down water. A cooling system might contain one or a lot of cooling that use identical recirculating water.

2.1 HOW DOES A COOLING TOWER WORKS?

In a cooling tower system, the fan pushes or attracts air from the atmosphere into the tower to cool down recirculating water. Warm water, that has removed heat from associate air-con, refrigeration or process, enters the highest of the tower. because the water falls through the tower recent air is forced through it. This recent air cools the water. The cooled water then falls to a storage basin before being recirculates through system once more.

2.2 TYPES OF COOLING TOWER

The section describes about the types of cooling tower they are:

Types of draft in cooling tower

- ➢ Natural draft cooling tower
- ➢ Mechanical draft cooling tower
    1. Forced draft cooling tower
    2. Induced draft cooling tower

Types of water and air flow in cooling tower

- Cross flow
- Counter Flow

2.3 NATURAL DRAFT COOLING TOWER

This type of tower is incredibly common. It are often known by the fan at the highest of the tower. The fan pulls air up through the tower within the wrong way to that the water is falling. The air sometimes enters the tower through body of water louvers on the perimeters of the tower. This type of tower as shown in Fig. -1.

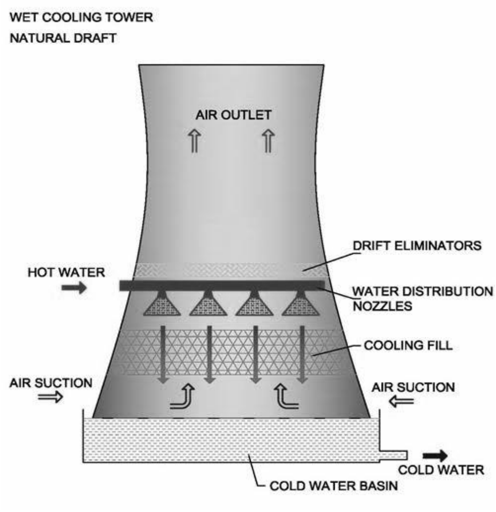

Fig -1: Natural Draft Cooling Tower

2.4 MECHANICAL DRAFT COOLING TOWERS

Mechanical draft cooling towers have giant fans to force or draw air through circulated water. The water falls downward over fill surface that facilitate increase the contact time between the water and therefore the air this helps maximize heat transfer between the 2 cooling rates of mechanical draft towers rely upon numerous parameters like fan diameter and speed of operation, fill for system resistance etc.

2.4.1 COUNTER FLOW TOWERS

Counter flow cooling tower air is drawn through the falling water and the fill therefore located inside the tower although design depends on specific site conditions.

2.4.2 CROSS FLOW TOWERS

Cross flow tower air is drawn the falling water and the fill is located outside the water.

2.5 INDUCED DRAFT COOLING TOWER

Type of mechanical draft cooling tower with a fan at the discharge (at the top) which pulls air up through the tower. The fan induces hot moist air out the discharge

2.5.1 INDUCED DRAFT COUNTER FLOW COOLING TOWER

This is a relatively popular form of tower. The fan at the top of the tower can be used to identify it. In the opposite direction from where the water is falling, the fan draws air up through the tower. Normally, air enters the tower through intake louvers on the tower's sides. This type of tower as shown in Fig. -2.

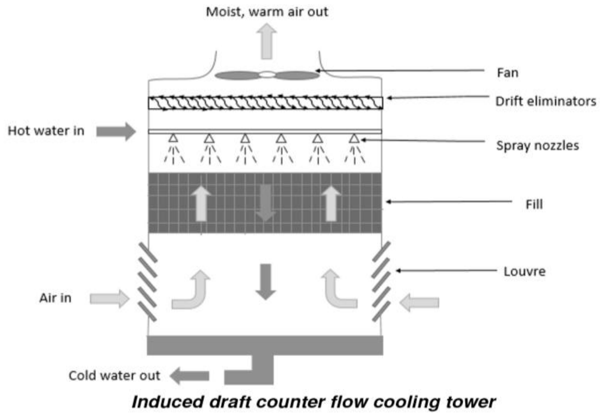

Fig -2: Induced Draft Counter Flow Cooling Tower

2.5.2 INDUCED DRAFT CROSS FLOW COOLING TOWER

The fan is also mounted on the top of a cross flow cooling tower with induced draught. In this type of tower, the fan, on the other hand, pulls or induces atmospheric air over the water falling from the top of the tower to the basin This type of tower as shown in Fig. -3.

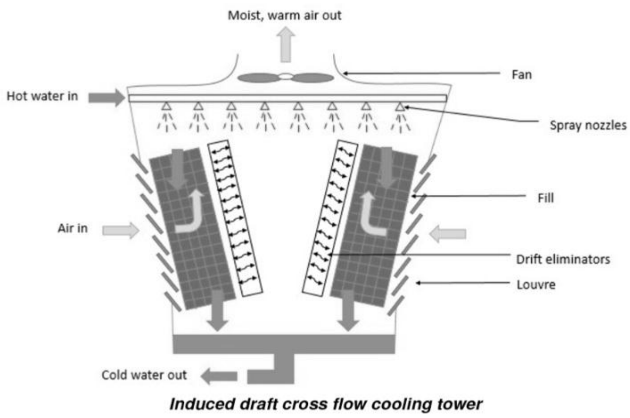

Fig -3: Induced Draft Cross Flow Cooling Tower

2.6 FORCED DRAFT COOLING TOWER

Type of mechanical draft tower in which one or more fans located at the air inlet to force air into the cooling tower.

2.6.1 FORCED DRAFT COUNETER FLOW COOLING TOWER

The water in a forced draught counter flow cooling tower is cooled by air driven through the top of the water and into the falling water. This type of tower as shown in Fig. -4

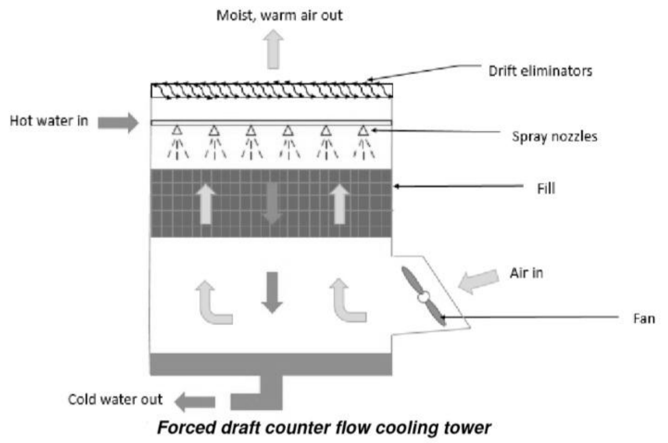

Fig -4: Forced Draft Counter Flow Cooling Tower

2.6.2 FORCED DRAFT CROSS FLOW COOLING TOWER

The fan is mounted on one or double side of the tower in a forced draught cross flow cooling tower. This fan forces atmospheric air to the fill. This fan is horizontally across the tower, passing through the water dropping from the top of the forced draft cooling tower's top to the basin through the fill. This type of tower as shown in Fig. -5.

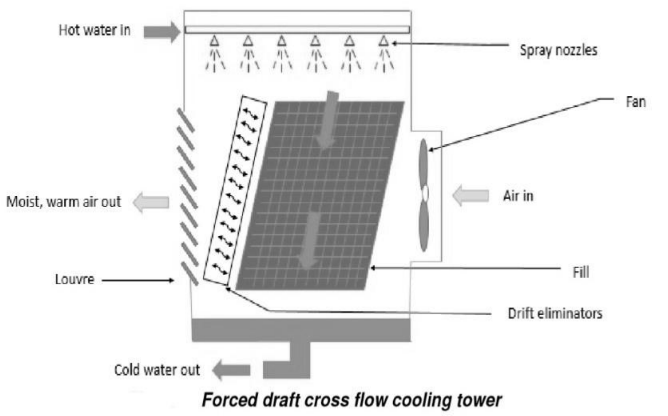

Fig -5: Forced Draft Cross Flow Cooling Tower

3. DESIGN OF INDUCED DRAFT COOLING TOWER

IDCT FAN : 11 No per unit
Totally 22 No for stage (unit I & II)
Flow control valves : 22 N per unit
Totally 44 No for stage (unit I & II)
Total height of cooling tower : 20.13m
Depth of cooling tower sump : 2.88m
Height from ground level : (11.45+5.8) =17.25m
Fan stack height : 5.80m
Height from ground level to top : 11.45m

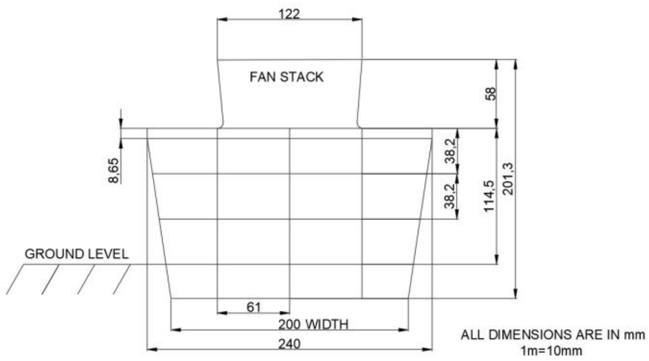

Fig -6: Design of Induced Draft Cooling Tower

3.1. COMPONENTS OF COOLING TOWER

Basic components of cooling tower is given below

- Frame and casing
- Fills
- Hot warer basin
- Cold water basin
- Drift eliminator
- Louvers
- Nozzles
- Fans

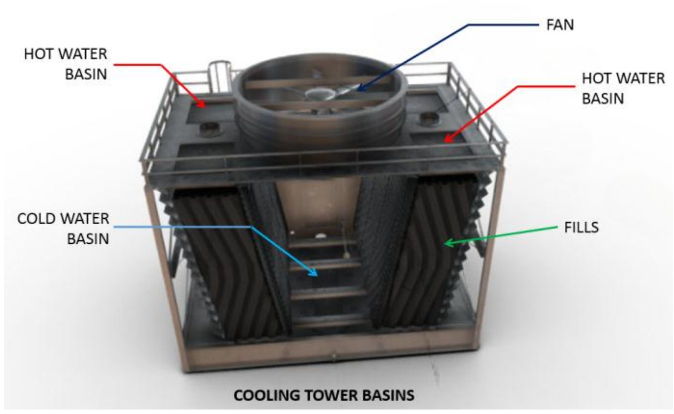

Fig -7: Cooling Tower Basins

3.2 PERFORMANCE OF COOLING TOWER

During the performance evaluation, portable monitoring instruments are used to measure the following parameters.

- Wet bulb temperature
- Dry bulb temperature
- Cooling tower inlet water temperature
- Cooling water outlet temperature
- Inlet and Exhaust air temperature
- Range and Approach
- Air and water flow rate

4. PROBLEM IDENTIFICATION IN INDUCED DRAFT COOLING TOWER

The cooling towers efficiency and performance is reduced due to these problems they are given below

- Algae grows fastly due to sunlight falling on cooling tower hot water basin. Algae blocks the cooling tower nozzle.If algae grows contionously these leads to stop the water flow to the cooling tower.
- The temperature of the hot water doesn't maintain evenly on all cells of the cooling tower. Uneven temperature cause efficiency drop
- Dust and garbages are blocks the cooling tower nozzle.

To solve these problems cover the cooting tower by using GI roof sheets.

4.1 FACTORS AFFECTING THE COOLING TOWER

- Capacity
- Range
- Head load
- Algae growth.

5. ALGAE GROWTH IN COOLING TOWER

5.1 HOW ALGAE IS FORMED IN COOLING TOWER

Moisture, sunshine, and nutrients are required for algae to flourish. Because cooling towers are exposed to the outside air, they frequently enable outside bacteria (algal nutrients) and sunlight to enter the water. As a result, if left untreated, algae may soon grow out of control.

5.2 PROBLEM OF ALGAE GROWTH IN COOLING TOWER

- If algae are growing continuously, they block the cooling tower spray nozzle and reduces the water flow
- They make more maintenance cost then regular maintenance.
- This makes more water loss.

5.3 REDUCTION OF ALGAE GROWTH IN COOLING TOWER

- To control the algae growth, prevent sunlight falling on hot water basin of the cooling tower by using GI roof sheets.
- Periodic water chemical dosing reduces the water nutrients and algae growth
- Periodic maintenance and cleaning excess algae improves the cooling tower performance.

Fig -8: Algae Growth Cooling Tower

6. PROVIDING GI ROOF SHEET ON COOLING TOWER HOT WATER BASIN

6.1 PURPOSE OF PROVIDING GI SHEET ON COOLING TOWER HOT WATER BASIN

- To reduce algae growth in cooling tower
- To maintain hot water temperature evenly on all cells of the cooling tower

- To prevent spray nozzle blockage due to dust particles forming on hot water basin.

6.2 MATERIAL PROPERTIES OF GI ROOF SHEET

Material : Galvanized Iron (GI)
Thickness of the sheet : 0.6 – 1.2 mm
Resistance : Corrosion Resistance
Tensile strength : 300 MPa
Yield Strength : 220 Mpa

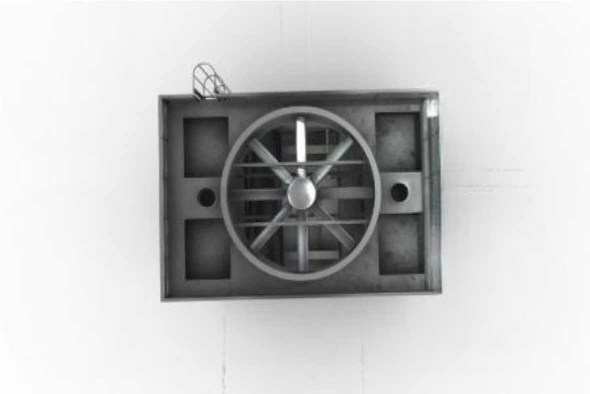

Fig -9: Cooling Tower hot water basin without GI roof sheet

Fig -10: Cooling Tower hot water basin with GI roof sheet

7. COOLING TOWER CALCULATIONS

7.1 COOLING TOWER CALCULATIONS BEFORE GI ROOF SHEET PROVIDED ON HOT WATER BASIN

Hot water temperature (t_{hw}) = 40°C
cold water temperature (t_{cw}) = 30°C
Inlet air temperature = 32.5°
Outlet air temperature = 33.9°
Cold water basin temperature = 30°C
Wet bulb temperature = 24.5°C
Dry bulb temperature = 36.5°C

1) Cooling water range = (Hot water temperature) - (Cold wate temperature)
= 40-30
= 10°C

2) Cooling water Approach =(Water outlet temperature) - (Wet bulb temperature)
= 30-24.5
= 5.5°C

3) L/G Ratio = water flow in Kg / Air flow in Kg
= 20794/7655
= 2.7164

4) Fan Air Flow Actual / Cells = (Rated fan flow × fan input) / (fan input speed rated)$^{1.3}$
=(1945950 × 56.03) / (75)$^{1.3}$
= 25.534 × 10^{6} Nm^{3}/hr

5) Air Mass Flow / Cell = flow × density of air
= (1945950 × 56.03) / (75)$^{1.3}$
= 25.534 × 10^{6} m^{3}/hr

6) Density ratio = actual air density / 0.0075
= 1.164 / 0.0075
= 15.52 Kg/m^{3}

7) Fraction of water = mass of water evaporated / mass of water
= 240.28 / 20794
= 0.0115

8) Enthalpy of inlet air (h_1)=78.5 KJ/Kg[using psychometric chart for wet bulb and dry bulb temperature]

9) Enthalpy of exit air (h_2)= h_1 + (L/G ratio × range)
= 78.5 + (2.7164 × 10)
= 105.66 KJ/Kg

10) Evaporation Loss = (Cooling water flow × cooling Tower Range) / 675
= (20794 ×10) / 67
= 308.05 m^{3}/hr

11) Make up water consumption = Evaporation loss / (coc - 1)
= 308.05 / (1.45 – 1)
= 684.55 m^{3}/hr

12) Drift loss = 0.2% of water supply
= (0.2 / 100) × (20794)
= 41.588 m^{3}/hr

13) Efficiency = [Range / (Range + approach) × 100]
= [10/ (10 - 5.5) × 100]
= 64.51%

7.1 COOLING TOWER CALCULATIONS AFTER GI ROOF SHEET PROVIDED ON HOT WATER BASIN

Hot water temperature (t_{hw}) = 42°C
cold water temperature (t_{cw}) = 30°C
Inlet air temperature = 32.5°
Outlet air temperature = 33.9°

Cold water basin temperature = 30°C
Wet bulb temperature = 24.5°C
Dry bulb temperature = 36.5°C

1) Cooling water range = (Hot water temperature) - (Cold wate temperature)
= 42-30
= 12°C

2) Cooling water Approach =(Water outlet temperature) - (Wet bulb temperature)
= 30-24.5
= 5.5°C

3) L/G Ratio = water flow in Kg / Air flow in Kg
= 20794/7655
= 2.7164

5) Air Mass Flow / Cell = flow × density of air
= (1945950 × 56.03) / (75)1.3
= 25.534 × 106 m3/hr

6) Density ratio = actual air density / 0.0075
= 1.164 / 0.0075
= 15.52 Kg/m3

7) Fraction of water = mass of water evaporated / mass of water
= 240.28 / 20794
= 0.0115

10) Evaporation Loss = (Cooling water flow × cooling Tower Range) / 675
= (20794 × 12) / 675
= 369.67 m^3/hr

11) Make up water consumption = Evaporation loss / (coc - 1)
= 369.67 / (1.45 – 1)
= 821.4 m^3/hr

12) Drift loss = 0.2% of water supply
= (0.2 / 100) × (20794)
= 41.588 m^3/hr

13) Efficiency = [Range / (Range + approach) × 100]
= [12/ (12 - 5.5) × 100]
= 68.57 %

8. PERFORMANCE GRAPH

8.1 RANGE vs EFFICIENCY

Graph is plotted between the range of the cooling tower and corresponding efficiency of the cooling tower

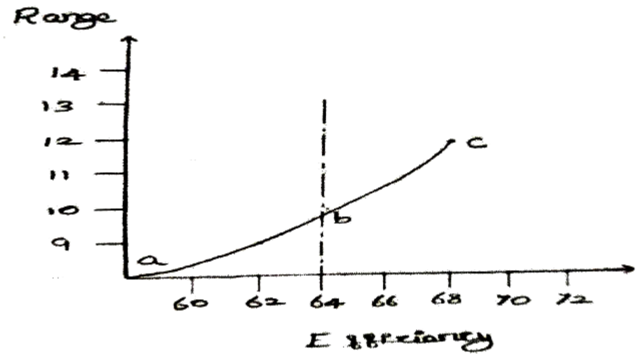

Fig -11: Range vs Efficiency Graph

8.2 INPUT vs EFFICIENCY

Graph is plotted between the input temperature of hot water and corresponding efficiency of the cooling tower.

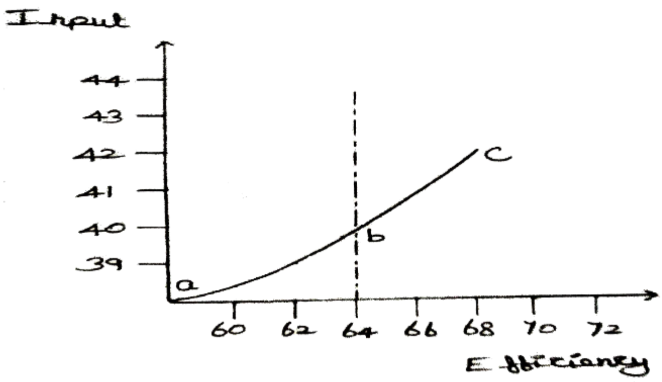

Fig -12: Input vs Efficiency Graph

9. CONCLUSION

After theoretical analysis, it works found the efficiency of cooling tower-I was **64.1%** which is lower than the designed value at **70.97%** which is due to atmospheric temperature. Because of frequent and periodic maintenance of fans. gear box, drive shaft, hot water basin, flow control valves, hot water pipe lines, and nozzles. It will attain stable efficiency. Due to scheduled maintenance. There is no algae formation in the hot water basin and so the cooling tower is still in better condition and also improvement in the cooling tower-I by providing Gl sheet on the hot water basin cell top to reduce the algae growth and cold-water temperature reduced up to **68.57%** (-4°c). It also to improve the cooling tower and generation.

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