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# PERFORMANCE ANALYSIS OF NATURAL DRAFT COOLING TOWER IN SUMMER SEASON & WINTER SEASON

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**Abstract**- *Cooling tower is the main part of the power plant, which is used to cool the hot water, comes from the condenser. In this paper, gives performance analysis of natural draft cooling tower in summer season & winter season. For the cooling tower humidity play a major role, it depends upon the atmospheric temperature. The humidity is more in winter season and less in the summer season. Also the air is the major factor. In the summer season air is less dense so that less air is required but in winter season air is highly dense which has more moisture with lesser dryness. Therefore, the required air for cooling purpose is more as compared to summer season. Overall one can say that the natural draft cooling tower is more efficient in monsoon or winter season as compared to the summer season. If the wet bulb temperature approach to dry wet bulb temperature than cooling will approach to unity and hence the effectiveness would tend to 100%. The effectiveness of natural draft cooling tower is 51.81% in summer season and 69.34% in winter season.*

***Keywords*** – *Cooling tower, wet bulb temperature, dry bulb temperature, humidity.*

## 1. INTRODUCTION

**1. INTRODUCTION –** Cooling tower is the essential part of the thermal power plant. It is used to cool the hot water coming from the condenser and reassess heat in the environment. The hot water is spray by the nozzle. The film type fill, splash bar are used for distribute the water. Water is the most usable part in the thermal power plant; it is used for the generation of the steam. Water resources are easily available in plenty amount, but usage of water has to be done very carefully to from the environment point of view. In the thermal power plant large amount of water is used for the steam generation and it also re-circulated. For the continuous recirculation of water, it is necessary to cool it. For this purpose, cooling tower is used in the thermal power plant. The hot water cannot be thrown back to the water reservoir, like river. It is dangerous for the aquatic creature. If done so, the hot water would heat up the river water temperature and it will be harmful to survival of fishes and other aquatic creature. Water is also taken in limited amount because one receives the recirculation of water through cooling towers.

### 1.2 Needs of cooling tower

The steam that comes out of low pressure turbine (LPT) needs to get condensed so as to recirculate it to the steam generation. All the components of condenser run at a normal temperature. For the proper performance of condenser and the equipments in the line of process, the cooling and condensation of steam need to be maintained continuously.

When the exhaust steam is allowed to pass through condenser, the water flowing through the tubes of condenser will absorb the heat of steam. This causes the condensation process of the steam and also causes for the dramatic raise in the heat of condenser water. This hot condenser water has to be cooled by some means. Here, the role of cooling tower comes in to picture. Inside the condenser pressure is kept quite low, which tends to vacuum. When hot steam exhausted from the low pressure turbine to the condenser then the temperature difference of inside condenser will decrease and hence, pressure gets affected. Now in this scenario one can claim that to maintain the condenser pressure too, cooling tower will be used.

Large amount of heat of steam will be wasted by the cooling tower which will be released to the atmosphere afterwards. Water is one of the best substances for the transaction of heat, it is economical and easily available for processing, this is one of the reasons why the water as working substance in cooling towers.

### 1.3 Types of cooling tower

1. Natural draft cooling tower
2. Mechanical draft cooling tower

This paper is concerned with the natural draft cooling tower.

Natural draft cooling tower has a long hyperbolic ceramic structure. It is widely used now these days, its efficiency is more as comparison to Mechanical draft cooling tower. In these air is taken from the atmosphere at the bottom of the cooling tower and hot water is sprayed from the certain elevation. Hot water flows through the pump and lifted at the certain height, water pipes are connected with nozzle arrangement. Nozzle sprays water on the large surface area that is called Fill area made up of PVC. In the fill area hot water and cold air gets physical contact and heat transfer process are done. The cold air takes heat of hot water and exit in the atmosphere. It works on the fundamental of pressure difference generate due to height of the tower. It has consisted less mechanical equipment, so the noisiness and operation is quite low with respect to other CT. Any types of fan is not use in the natural cooling tower so that power consumption is very less and no any rotatory part is taken consider. The heat transfer rate is very high large amount of water cooled. Length of the CT is approximately 200m and diameter 95m, so that evaporation loss is quite low.

Figure 1 - Counter flow NDCT

## 2. PERFORMANCE PARAMETER OF COOLING TOWER

a) **Range :-** It is the difference between hot water inlet temperature

   CT Range (°C) = [CW inlet temp (°C) - CW outlet temp (°C)]

b) **Approach :-** It is the difference between cold water outlet temperature and WBT

   CT Approach (°C) = [CW outlet temp (°C) - Wet bulb temp (°C)]

c) **Wet Bulb Temperature: -**The wet-bulb temperature (WBT) is the temperature read by a thermometer covered in water-soaked cloth (wet-bulb thermometer) over which air is passed. When the humidity gets 100% than WBT is approaches Dew bulb temperature.

d) **Dry Bulb Temperature:-** The dry bulb temperature (DBT) is the temperature of air measured by a thermometer freely showing to the air

e) **Effectiveness-** It is the ratio between the range and the ideal range, i.e. difference between cooling water inlet temperature and ambient wet bulb temperature, or in other word it is

= range/(range + approach).

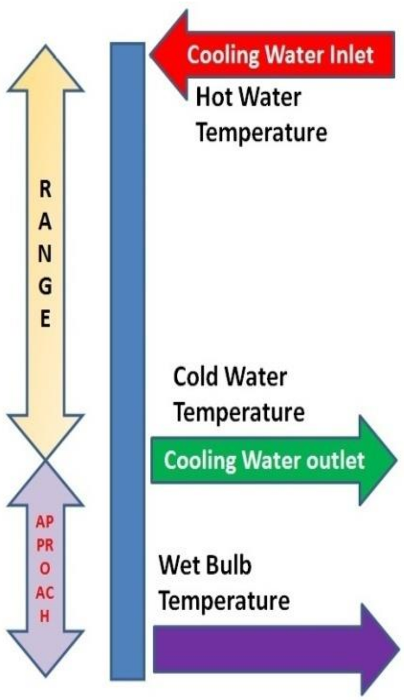


Figure 2-Range approach line diagram

## 3. SPECIFICATIONS OF NATURAL DRAFT COUNTER FLOW COOLING TOWER

| | |
|---|---|
| Tower height | 154.55 m |
| Air inlet height | 9.05 m |
| Fill depth | 1.5 m |
| Tower basin diameter | 111 m |
| Tower top diameter | 69.17 m |
| Spray zone height | 0.9m |

Figure 3 - Construction details of NDCT

| Parameters | Summer | Winter |
|---|---|---|
| Dry bulb temperature | 39$^0$C | 31.79$^0$C |
| Wet bulb temperature | 25.56$^0$C | 26 $^0$C |
| Hot water temperature(T1) | 41 $^0$C | 39.05 $^0$C |
| Cold water temperature(T2) | 33 $^0$C | 30 $^0$C |
| Relative humidity | 34.29 (%) | 63.46(%) |
| Mass flow rate of water in cooling tower | 80700 $m^3$/hr | 80200 $m^3$/hr |

Figure 3.1 - Measuring performance parameter in different season of NDCT

### 3.1 Data from psychometric chat and steam table

| | Summer | Winter |
|---|---|---|
| Enthalpy of air at inlet temperature(Ha1) | 78.07 kj/kg | 80.69 kj/kg |
| Enthalpy of air at in let temperature(Ha2) | 154.27 kj/kg | 108.39 kj/kg |
| Specific humidity of air at inlet temperature(W1) | 0.0152 kg/kg | 0.0191 kg/kg |
| Specific humidity of air at outlet temperature(W2) | 0.0434 kg/kg | 0.0286 kg/kg |

| | | |
|---|---|---|
| Specific volume of air at inlet temperature(VS1) | 0.905 m3/kg | 0.891 $m^3$/kg |
| Specific volume of air at outlet temperature(VS2) | 0.955 m3/kg | 0.9129 $m^3$/kg |
| Enthalpy of water at inlet temperature(Hw1) | 171.09 kj/kg | 162.94 kj/kg |
| Enthalpy of water at inlet temperature(Hw1) | 137.65 kj/kg | 125.12 kj/kg |

## 4. CALCULATIONS

### 4.1 Summer Season Calculations

1. **Range**

Range = T1-T2
= 41-33
= $8^0$C

2. **Approach**

Approach = Cold water temp-WBT
= 33-25.56
= 7.44

3. **Effectiveness**

Effectiveness = Range / (Range + Approach)
= 8÷ (7.44+8)
= 51.81%

### 4.2 Different types of losses

1. **Drift losses:**

Drift losses are generally taken as 0.002% to 0.005%.

Drift losses = 0.005% ×mass flow rate of water

= 0.005 x 80700 x .01 m3/hr

-= 4.035 m3/hr

2. **Evaporation losses**

Evaporation losses are generally taken as 0.00085 of circulating water
= 0.00085 x 1.8 x 80700 x 8 m3/hr.
= 987.74 $m^3$/hr.

3. **Blow down losses**

Blow down losses= evaporation losses / coc-1

= 987.76/ (6-1)

=197.55 m3/hr.

- **Heat loss by water**

HL = Mw1 ×Cpw × (T1 – T2)
= 80700 x 4.186 x 8
= 2702481.6 MJ/Hr.

- **Volume of air required (v)**

V = (HL×Vs1) / ((Ha2-Ha1)-(W2 –W1)×Cpw×T2)
= (2702481685x0.905) /[ (154.27-78.07)-{(.04834-0.0152) x4.186x33}]
=2445745.848 / 72.30
= 33827743.4 m3/hr

- **Heat gain by air (HG)**

HG = V × ((Ha2-Ha1)-(W2-W1) × Cpw×T2) / Vs1
= [33827743.4 x (154.27-78.07)- (0.04834-0.0152) x 4,186 x 33] / 0.905
= 2848258632 KJ/Hr.

- **Mass of air required (Mair)**

Mair = volume of air required/specific volume of air at inlet temperature
Mair = V / Vs1
= 33827743.4 /0.905
= 37378721.99 kg/hr.

- **Liquid gas ratio (L/G)**

L (T1 - T2) = G (h2 - h1)
L/G = (h2 - h1) / (T1 - T2)
= (154.27-78.07) / (41-33)
= 76.02/8
= 9.52/1

### 4.3 Winter Season Calculations

1. **Range**

Range = T1-T2
= 39.05-30
= $9.05^0$C

2. **Approach**

Approach = Cold water temp-WBT
= 30-26

= $4^0$C

3. **Effectiveness**

Effectiveness = Range / (Range + Approach)
= 9.05/ (9.05+4)
= 0.6934 or 69.34%

## 4.4 Different types of losses

1. **Drift losses**

Drift losses are generally taken as 0.002% to 0.005%.

Drift losses = 0.005% ×mass flow rate of water

= 0.005 x 80200 x .01 m3/hr

= 4.01 m3/hr

2. **Evaporation losses**

Evaporation losses are generally taken as 0.00085 of circulating water
= 0.00085 x 1.8 x 80700 x 9 m3/hr
= 1110.49m3/hr

3. **Blow down losses**

Blow down losses = evaporation losses / coc-1

= 1110.49/(6-1)

= 222.098$m^3$/hr

- **Heat loss by water**

HL = Mw1 ×Cpw × (T1 – T2)
= 80200 x 4.186 x 9.05
= 3038240.66 MJ/Hr

- **Volume of air required (v)**

V = (HL×Vs1) / ((Ha2-Ha1)-(W2 –W1)×Cpw×T2)
= (3038240.66 x0.89 1x1000) / [(108.39-80.69)-{(0.0286-.0191) x4.186x30}]
=270707.24x1000 / 26.49
= 102562253.6 m3/hr

- **Heat gain by air (HG)**

HG = V × ((Ha2-Ha1)-(W2-W1) × Cpw×T2) / Vs1
= [102562253.6 x(108.39-80.69)-{(0.0286-.0191) x4.186x30}]] / .891
= 3211545.315 MJ/Hr

- **Mass of air required (Mair)**

Mair = volume of air required/specific volume of air at inlet temperature
Mair = V / Vs1
= 102562253.6/.891
= 115109151.1 kg/hr

- **Liquid gas ratio (L/G)**

L (T1 - T2) = G (h2 - h1)
L/G = (h2 - h1) / (T1 - T2)
= (108.88-80.69). / (39.05-30)
= 3.06/1

## 5. RESULT

Two observations are as shown below

| Season | Summer | winter |
|---|---|---|
| Range ($^0$C) | 8 | 9.05 |
| Approach ($^0$C) | 7.44 | 4 |
| Effectiveness (%) | 51.81% | 69.34 % |
| LOSSES | | |
| Drift losses | 4.035 $m^3$/hr | 4.01 $m^3$/hr |
| Evaporation loss | 987.75 $m^3$/hr | 1110.4 $m^3$/hr |
| Blow down loss | 197.75 $m^3$/hr | 222.87 $m^3$/hr |
| Heat loss by water | 2702481.253 MJ/hr | 3038240.8 MJ/hr |
| Volume of air required | 33827743.4 $m^3$/hr | 102562253.6 $m^3$/hr |
| Mass of air required | 37378721.9 KG/hr | 115109151.1KG/hr |
| L/G ratio | 9.52/1 | 3.06/1 |

## 6. CONCLUSIONS

In the winter season cooling tower is more efficient as compared to summer season. The effectiveness of natural draft cooling tower in summer season is 51.81 % and the same in winter season is 69.34%. The humidity of air is more in winter season because of cold, and in this season WBT (Wet Bulb Temperature) will approach to DBT (Dry Bulb Temperature). In these conditions humidity goes high, near about 70 to 80%. Humidity is the major factor for the cooling tower also; it depends upon atmospheric pressure and temperature. Range is maximum in the winter as compared to the summer season. In the winter season range will appear to nearby 9˚c to 9.05⁰c and the same in summer season will appear as 8˚c. Wet bulb temperature approaches to dry bulb temperature in winter season, so that the approach is minimum and in summer season approach is more as compared to the monsoon. Evaporation losses and blow down losses are more in the winter season with respect to summer season. Mass of air required or used will be more for cooling in winter season because of high humidity. Humidified air does not carry more heat of hot water so the mass of air required is more. In the summer season auxiliary part of condenser generates more heat due to friction. To cool these auxiliary part, more water is needed therefore more rate of mass flow is required in summer season. Liquid to gas ratio in summer season is 9.52/1, which means less air is required to cool the water. Where as in winter season liquid to gas ratio is 3.06/1which is minimum, it means more air is required for cooling purpose. Because of dryness of air in summer is more the amount of heat of water carried by the air will be more. In the summer season air is less dense so that less air is required but in winter season air is highly dense which has more moisture with lesser dryness. Therefore, the required air for cooling purpose is more as compared to summer season. Overall one can say that the natural draft cooling tower is more efficient in winter season as compared to the summer season. If the wet bulb temperature is approach to dry bulb temperature than cooling will approach to unity and hence the effectiveness would tend to 100%.

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