- Volume of air required = (HL x V_{s1}) / [(H_{a2} – H_{a1}) - (W_2 – W_1) x C_{pw} x T_2]
  = (35539.14 x 0.89) / [(105 - 83) – (0.029 – 0.021) x 4.186 x 31]
  = 1508.22228 m^3 / hr

- Heat gain by air = V x [(H_{a2} – H_{a1}) - (W_2 – W_1) x C_{pw} x T_2] / V_{s1}
  = 1508.22228x [(105 - 83) – (0.029 – 0.021) x4.186 x 31] / 0.89
  = 31615.16238 /0.890
  = 35539.14 KJ / hr

- Mass of air required = V / V_{s1}
  = 1508.22228 /0.89
  = 1694. 633236 Kg / hr

Different Types of Losses:

- Drift losses = 0.20 x m_{w1} / 100
  = 0.20 x 849/ 100
  = 1.698 Kg / hr

- Windage losses = 0.005 x m_{w1}
  = 0.005 x 849
  = 4.245 Kg / hr

- Evaporation losses = 0.00085 x m_{w1} x (T_1 – T_2)
  = 0.00085 x 849 x (41 - 31)
  = 7.2165 Kg / hr

- Cycles = XC / XM
  M = WL + EL + DL = 1.698 + 4.245 + 7.2165
  = 13.1595 Kg / hr
  XC / XM = M / (M - EL) = 13.1595 / (13.1595 – 7.2165)
  XC / XM = Cycles = 2.2143

- Blow down losses = EL / (Cycles - 1)
  = 7.2165 / (2.2143 - 1)
  = 5.9429 Kg / hr

- Efficiency of cooling tower
  = (T_1 – T_2) / (T_1 – WBT)
  = (41 – 31) / (41 - 27)
  = 71.429 %

6.3 Summer Season Calculations

Table 5: Technical Specification

Volume of circulating water (V)	0.78 m^3/ hr
Inlet temperature of water (T_1)	43^0C
Outlet temperature of water (T_2)	35^0C
Cooling range	8^0C
Wet bulb temperature (WBT)	30^0C
Height of cooling tower (H)	1.85 m
Inlet temperature of air (T_{a1})	36^0 C
Outlet temperature of air (T_{a2})	44^0 C

Table 6: Data from Psychometric Chart and Steam Table

Enthalpy of air at inlet temperature (H_{a1})	89 KJ/Kg
Enthalpy of air at outlet temperature (H_{a2})	120 KJ/Kg
Specific Humidity of air at inlet temperature (W_1)	0.0244 Kg/Kg of air
Specific Humidity of air at outlet temperature (W_2)	0.027 Kg/Kg of air
Specific Volume of air at inlet temperature (V_{s1})	0.912 m^3/Kg
Specific Volume of air at outlet temperature (V_{s2})	0.945 m^3/Kg
Enthalpy of water at inlet temperature (H_{w1})	180.0 KJ/Kg
Enthalpy of water at outlet temperature (H_{w2})	146.6 KJ/Kg

- Cooling tower approach = T_2 – WBT
  = 35 – 30
  = 5° C

- Cooling tower range = T_1 – T_2
  = 43 – 35
  = 8° C

- Mass of water circulated in cooling tower
  M_{w1} = Volume of circulating water x Mass density of water
  M_{w1} = 0.78 x 1000
  M_{w1} = 780 Kg / hr

- Heat loss by water (HL) = M_{w1} x C_{pw} x (T_1 – T_2)
  = 780 x 4.186 x (43 - 35)
  = 26120.64 KJ / hr

- Volume of air required = (HL x V_{s1}) / [(H_{a2} – H_{a1}) - (W_2 – W_1) x C_{pw} x T_2]
  = (26120.64 x 0.912) / [(120 - 89) – (0.027 – 0.0244) x 4.186 x 35]
  = 778.0125447 m^3 / hr
- Heat gain by air = V x [(H_{a2} – H_{a1}) - (W_2 – W_1) x C_{pw} x T_2] / V_{s1}
  = 1215.4338x [(120 - 89) – (0.027 – 0.0244) x4.186 x 35] / 0.912
  = 23822.02368 /0.912
  = 26120.64 KJ / hr

- Mass of air required = V / V_{s1}
  = 778.0125447 / 0.912
  = 853.0839 Kg / hr

Different Types of Losses

- Drift losses = 0.20 x m_{w1} / 100
  = 0.20 x 780 / 100
  = 1.56 Kg / hr

- Windage losses = 0.005 x m_{w1}
  = 0.005 x 780
  = 3.9 Kg / hr

- Evaporation losses = 0.00085 x m_{w1} x (T_1 – T_2)
  = 0.00085 x 780 x (43 - 35)
  = 5.304 Kg / hr

- Cycles = XC / XM
  M = WL + EL + DL = 1.56 + 3.9 + 5.304
  = 10.764 Kg / hr
  XC / XM = M / (M - EL) = 10.764 / (10.764 – 5.304)

XC / XM = Cycles = 1.9714

- Blow down losses = EL / (Cycles - 1)

= 5.304 / (1.9714 - 1)
= 5.460 Kg / hr

- Efficiency of cooling tower

= $(T_1 – T_2) / (T_1 – WBT)$
= (43 - 35) / (43 - 30)
= 61.538 %

7. Result

Table 7: Comparison of Counter Flow Tray Type Cooling Tower and Bottle Type Cooling Tower

Parameter	*Counter Flow Tray Type*	*Bottle Type*
Range	8˚C	6˚C
Approach	5˚C	4˚C
Efficiency of cooling tower	61.538%	60 %
Heat loss by water	26120.64 KJ / hr	753480 KJ / kg
Mass of air	853.0839 kg / hr	32517.992 kg / hr
Drift losses	1.56 kg / hr	60 kg / hr
Evaporation losses	5.304 kg / hr	153 kg / hr
Blow down losses	5.460 kg / hr	210 kg / hr

Table 8: Comparison of Counter Flow Tray Type Cooling Tower Performance in Two Varies seasons

Parameter	*Counter Flow Tray Type*	
	Winter season	*Summer season*
Range	10˚C	8˚C
Approach	4˚C	5˚C
Efficiency of cooling tower	71..429%	61.538%
Heat loss by water	35539.14 KJ / kg	26120.64 KJ / hr
Mass of air	1694.633236 kg / hr	853.0839 kg / hr
Drift losses	1.698 kg / hr	1.56 kg / hr
Evaporation losses	7.2165 kg / hr	5.304 kg / hr
Blow down losses	5.9429 kg / hr	5.460 kg / hr

The fill type material bottle cooling tower efficiency is 60 % .The counter flow tray type cooling tower efficiency is 61.538%.

The efficiency of the cooling tower is high in winter season as comparison to summer season. The efficiency of cooling tower in winter season 71.429%.Efficiency of cooling tower in summer season = 61.538% the cooling tower efficiency difference between summer season and winter season is =9.891%.

The cooling tower is closely related to different types of losses generated in cooling tower. The losses of the cooling tower are high in winter season as compare to summer season.

The performance of the counter flow tray type cooling tower is dominated by wind speed, ambient air temperatures and humidity in the atmospheric conditions. When the humidity is high in atmosphere, large quantity of water is required for cooling condensate. When humidity is low in atmosphere, small quantity of water is required for cooling condensate.

The Counter flow tray type cooling tower performance such as high efficiency and low losses compared to bottle type cooling tower.

The counter flow tray type cooling is more economically, more life time, low maintenance and performs high efficiency.

8. Conclusion

The calculation of cooling tower is closely related to tower Characteristic and different types of losses generated in cooling tower such as drift losses, evaporation losses and blow down losses can be calculated.

The fill type material bottle cooling tower efficiency is 60 % .The counter flow tray type cooling tower efficiency is 61.538%.
The performance of the cooling tower is dominated by wind speed, ambient air temperatures and humidity in the atmospheric conditions. The maintenance of cooling tower in the form of removal of scale or corrosion plays important role in the performance of the tower.

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, increase in air-water contact and characteristic decreases with increase in water to air mass ratio.

The efficiency of the cooling tower is high in winter season as comparison to summer season. The efficiency of cooling tower in winter season 71.429%.Efficiency of cooling tower in summer season = 61.538% the cooling tower efficiency difference between summer season and winter season is =9.891%.. The losses of the cooling tower are high in winter season as compare to summer season.

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