Design and Performance Enhancement of Induced Draft Counter Flow Wet Type Cooling Tower

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Abstract:

Cooling towers are one of the biggest heat and mass transfer devices used to transfer process waste heat to the atmosphere. Cooling towers make use of evaporation whereby some of the water is evaporated into a moving air stream and subsequently discharged into the atmosphere. As a result, the remainder of the water is cooled down significantly.

The process parameters such as inlet Air Wet bulb Temperature, Flow rate of Water and fills porosity have more influence on Thermal performance of cooling tower. The Temperature of outlet water is maintained nearest to inlet air wet bulb temperature to obtain the best Thermal Performance of cooling tower.

Nomenclature

T_1-Inlet temperature of hot water circulating in cooling tower

T_2-Outlet temperature of hot water circulating in cooling tower

ρ -Mass density of water

H-Height of cooling tower

T_{a1}-Inlet temperature of air

C_{pw} -Specific heat of water

H_{a1}-Enthalpy of air at inlet temperature

W_1-Specific humidity of air at inlet temperature

V_{s1}-Specific volume of air at inlet temperature

H_{w1}-Enthalpy of water at inlet temperature

CTA-Cooling Tower Approach

HL-Heat Loss by Water

M_{w1}-Mass of water circulated in cooling tower

M_a-Mass of Air

K -Mass transfer co-efficient

η- Effectiveness of Cooling Tower

WL -Windage Losses

WBT-Wet Bulb Temperature

¢ -Relative humidity

R-Constant

D-Diameter of cooling tower

T_{a2} - Outlet temperature of air

K-Thermal conductivity of steel

H_{a2} - Enthalpy of air at outlet temperature

W_2-Specific humidity of air at outlet temperature

V_{s2}-Specific volume of air at outlet temperature

H_{w2} -Enthalpy of water at outlet temperature

CTR -Cooling Tower Range

V -Volume of Air

HG-Heat Gain

M_{mak} - Mass of Makeup Water

d_i-Inside diameter of pipe

DL-Drift Losses

EL-Evaporation Losses

1. INTRODUCTION

1.1 Cooling Tower

Cooling towers are heat exchangers which are used to dissipate large heat loads to the atmosphere. It is equipment used to reduce the temperature of a water stream by extracting heat from water and emitting it to the atmosphere. They are used in a variety such as power generation and refrigeration. Cooling towers are designed for industrial plants for various purposes and sizes to provide cool water. Typically, a condenser of a power plant and or of heating ventilation, and air conditioning (HVAC) system is cooled by water.

1.2 Induced Draft

An induced draft mechanical draft tower is a draw-through arrangement, where a fan located at the discharge end pulls air through the tower. The fan induces hot moist air out the discharge. This produces low entering and high exiting air velocities, reducing the possibility of recirculation in which discharged air flows back into the air intake.

1.3 Counter Flow Cooling Tower

In a counter-flow induced draft cooling tower, air travels vertically across the fill sheet, opposite to the downward motion of the water. Air enters an open area beneath the fill media and is then drawn up vertically. The water is sprayed through pressurized nozzles and flows downward through the fill, opposite to the air flow.

1.4 Cooling Tower Performance [4]

The important parameters, from the point of determining the performance of cooling towers, are:

1. "Range" is the difference between the cooling tower water inlet and outlet temperature.
2. "Approach" is the difference between the cooling tower outlet cold water temperature and ambient wet bulb temperature. 3. Cooling tower effectiveness (in percentage) is the ratio of range, to the ideal range, i.e., difference between cooling Water inlet temperature and ambient wet bulb temperature, or in other words it is = Range / (Range + Approach).
4. Cooling capacity is the heat rejected in kCal/hr or TR, given as product of mass flow rate of water, specific heat and Temperature difference.
5. Evaporation loss is the water quantity evaporated for cooling duty. *Evaporation Loss (m3/hr) = 0.00085 x 1.8 x Circulation rate (m3/hr) x (T1-T2) T1-T2 = Temperature Difference between inlet and outlet water.

2. METHODOLOGY

2.1 Design Calculation [1]

2.1.1 Cooling Tower Approach (CTA)

CTA: Cooling water outlet temperature - WBT

CTA : 33 - 30

CTA : 3^0 C

2.1.2 Cooling Tower Range (CTR)

CTR: $T_1 – T_2$

CTR: 38 – 33

CTR: 5^0 C

Now, Mass of water circulated in cooling tower

M_{w1}= Volume of circulating water x Mass density of water

M_{w1} = 10 x 1000

M_{w1} = 10000 Kg / hr

2.1.3 Heat Loss by Water (HL)

HL: Mw1x C_{pw} x $(T_1 – T_2)$

HL: 10000 x 4.186 x (38 - 33)

HL: 209300 KJ / hr

2.1.4 Volume of Air Required (V)

$$V = \frac{(HL \times V_{s1})}{[(H_{a2} - H_{a1}) - (W_2 - W_1) \times C_{pw} \times T_2]}$$

$$V = \frac{(209300 \times 0.908)}{[(143.83 - 99.73) - (0.0391 - 0.0252) \times 4.186 \times 33]}$$

$$V = \frac{190044.4}{42.179}$$

$V = 4505.56\ m^3 / hr$

2.1.5 Heat Gain by Air (HG)

$$HG = \frac{V \times [(H_{a2} - H_{a1}) - (W_2 - W_1) \times C_{pw} \times T_2]}{V_{s1}}$$

$$HG = \frac{4505.56 \times [(143.83 - 99.73) - (0.0391 - 0.0252) \times 4.186 \times 33]}{0.908}$$

$$HG = \frac{190044.07}{0.908}$$

HG = 209300 KJ / hr

2.1.6 Mass of Air Required (M_a)

$$M_a = \frac{\text{Volume of air required}}{\text{Specific volume of air at inlet temperature}}$$

$$M_a = \frac{V}{V_{S1}}$$

$$Ma = \frac{4505.56}{0.908}$$

$M_a = 4962.07$ Kg / hr

2.1.7 Effectiveness of Cooling Tower

$$\eta = \frac{(T_1 - T_2)}{(T_1 - WBT)}$$

$$\eta = \frac{(38 - 33)}{(38 - 30)}$$

$\eta = 62.5\%$

2.2 Different Types of Losses Generated In Cooling Tower [3]

2.2.1 Drift Losses (DL)

Drift losses are generally taken as 0.10 % (Perrys chemical engineering hand book) of circulating water.)

$DL = 0.10 \times m_{w1} / 100$

DL = 0.10 x 10000 / 100

DL = 10.0 Kg / hr

2.2.3 Wind age Losses (WL)

Wind age losses are generally taken as 0.005(Perrys chemical engineering hand book) of circulating water.)

WL = 0.005 x m_{w1}

WL = 0.005 x 10000

WL = 50 Kg / hr

2.2.4 Evaporation Losses (EL)

Evaporation losses are generally taken as 0.00085(Perrys chemical engineering hand book) of circulating water.)

EL = 0.00085 x m_{w1} x ($T_1 – T_2$)

EL = 0.00085 x 10000 x (38 - 33)

EL = 42.5 Kg / hr

Water balance equation for cooling tower is

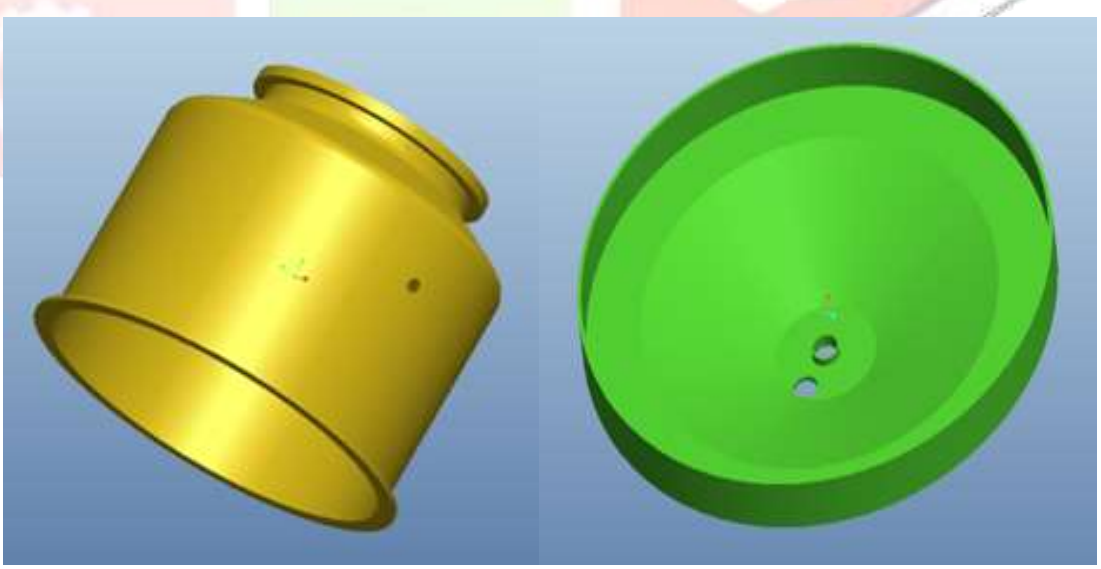
M = DL +WL + EL

M = 10+50+42.5

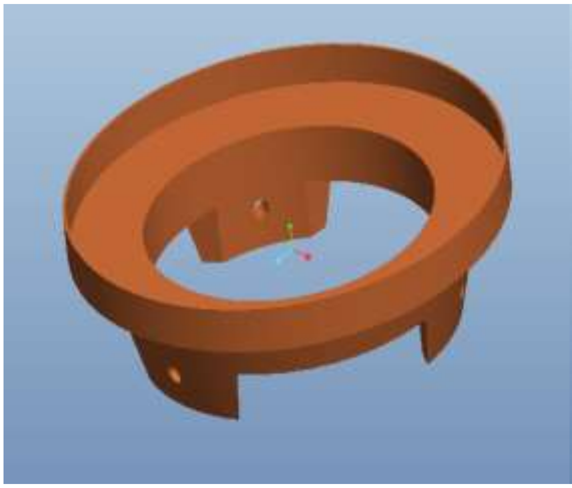
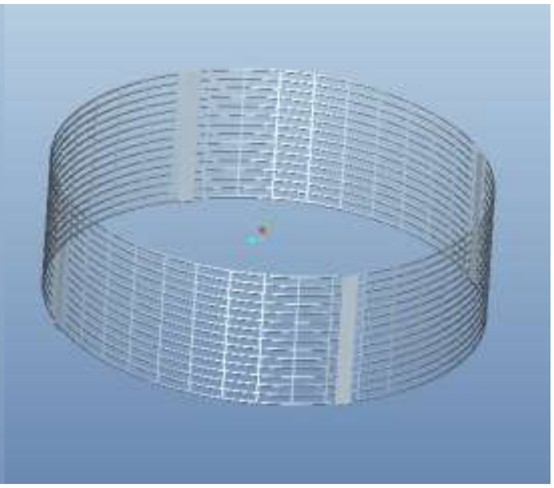
M = 102.5Kg / hr

3. DESIGN OF COOLING TOWER

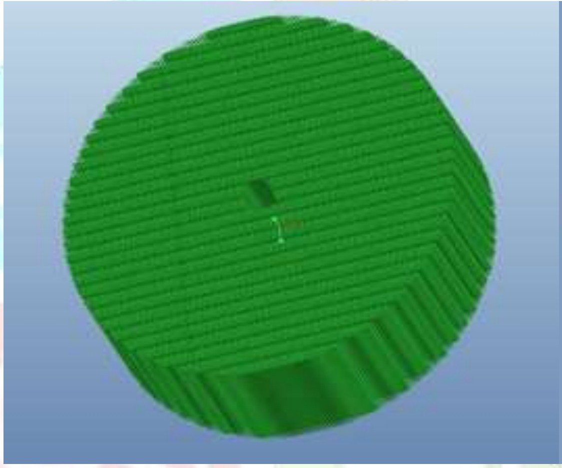
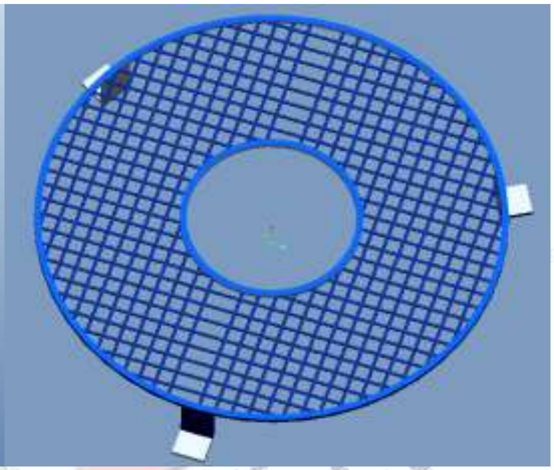
3.1 Different Design parts of cooling tower



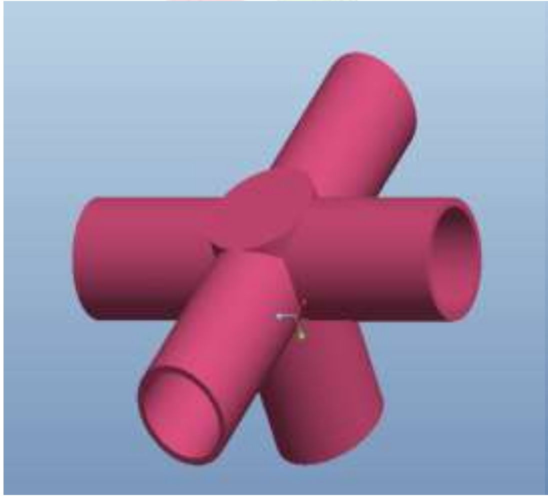
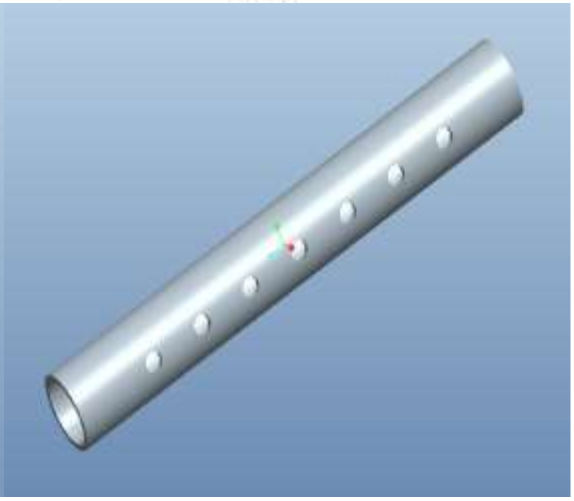
Main cover **Basin**

Base Stand **Air intake**

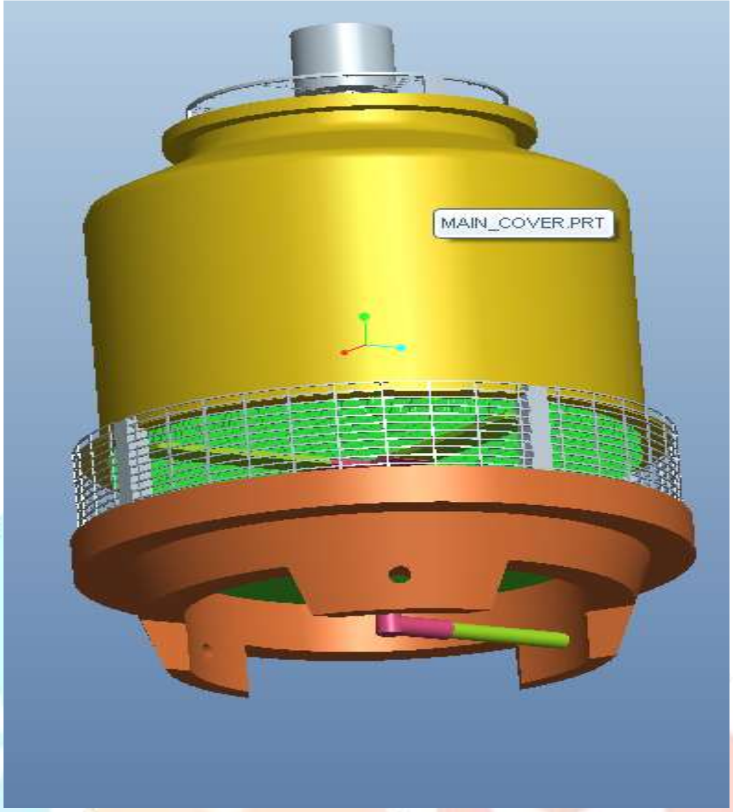



Fills **Drift Eliminator**

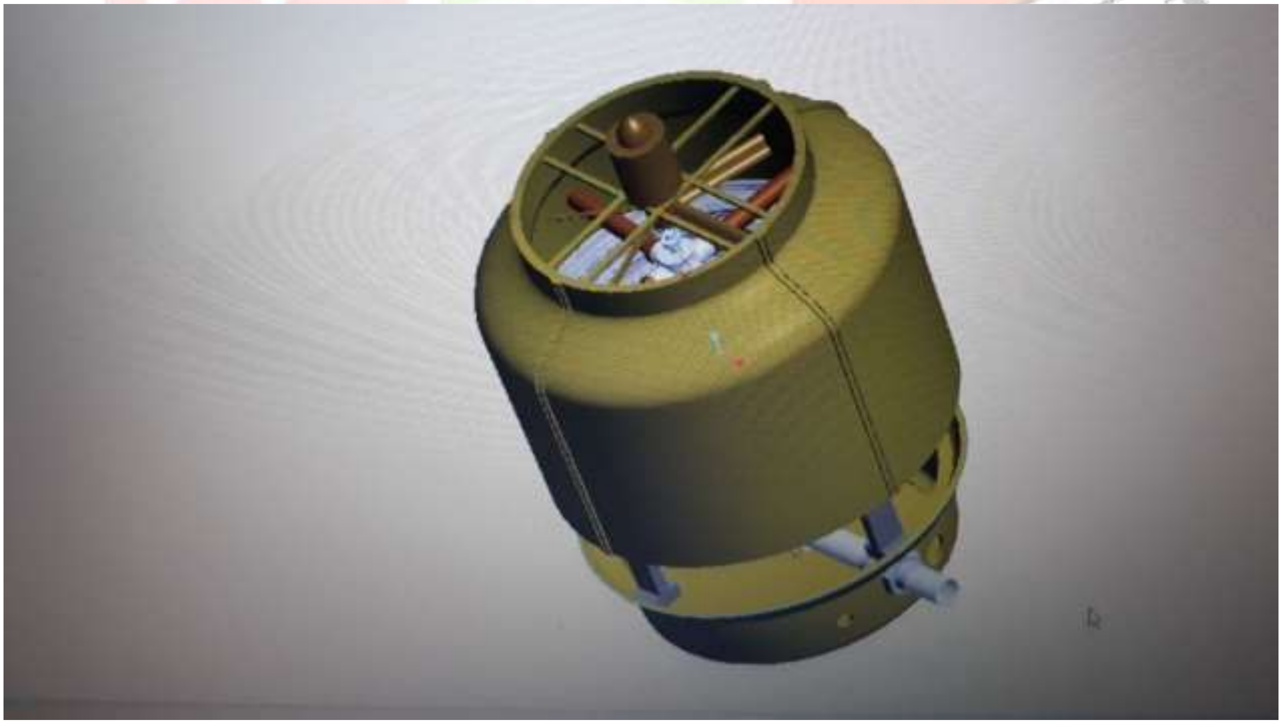



Upper pipe **Sprinkler**

3.2 Assembly parts join of the Cooling tower



3.3 3D modelling of cooling tower



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