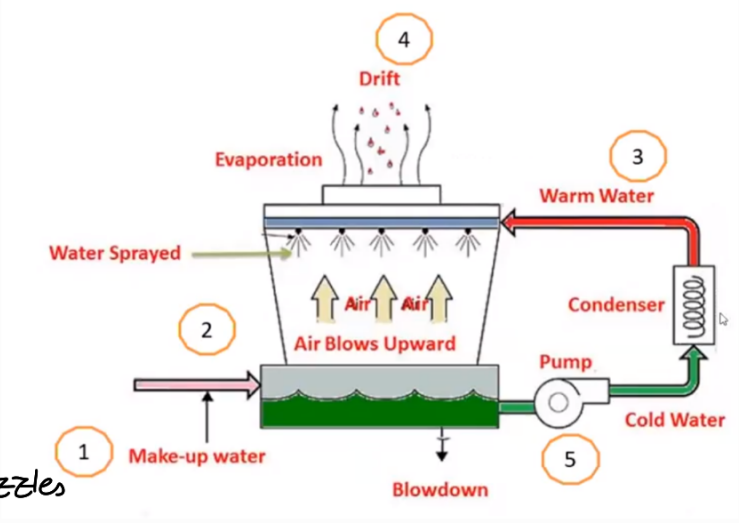
Cooling Towers

A cooling tower is a heat-exchanger between two streams: cold air and hot water or refrigerant.

How it works



- Cold water is pumped from the tank.
- It passes through a heat-exchanger, picks up heat and becomes warm.
- Warm water passes through nozzles which sprays water
- It is then subjected to air which evaporates a part of it and causes it to cool down
- This remaining water is drained back to the tank

Fill: A medium used in cooling towers to increase the surface area available for water and consequently increase heat transfer

Types of cooling towers

By draft type:

Natural draft → No fan

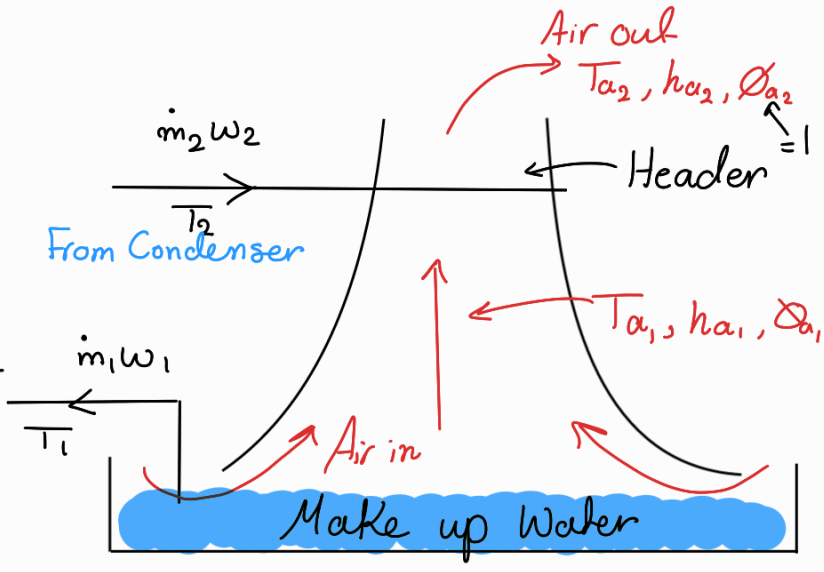
Mechanical draft → Fans are used

- Forced draft: Centrifugal fan is used
- Induced draft- cross flow: Hot water enters from top / Air enters from bottom
- Induced draft- counter flow: Hot water enters from top / Air enters from one side or opposite sides

Thermodynamic Analysis

Air is up by draft- force F_D

$$F_D = \rho g \Delta H$$ ← Cooling tower height-



$$\underbrace{\dot{m}_\omega c_{p_\omega} (T_2 - T_1)}_{\text{water in/out}} + \underbrace{\Delta \dot{m}_\omega c_{p_\omega} T_1}_{\text{Make up water enters}} = \underbrace{\dot{m}_a (h_{a_2} - h_{a_1})}_{\text{Air in/Air out}}$$

$$\dot{Q}_{C.T} = \dot{m}_\omega c_{p_\omega} (T_2 - T_1)$$

$$\Delta \dot{m}_{\omega_{\text{makeup}}} = \dot{m}_a (\omega_2 - \omega_1)$$

$$\dot{m}_a = \frac{\dot{Q}_{cond}}{(h_{a_2} - h_{a_1}) - c_{p_\omega} T_1 (\omega_2 - \omega_1)}$$

Effectiveness

$$\varepsilon = \frac{R}{R + A} \times 100\%$$

Range

$$R = (T_{c\omega})_{in} - (T_{c\omega})_{out}$$

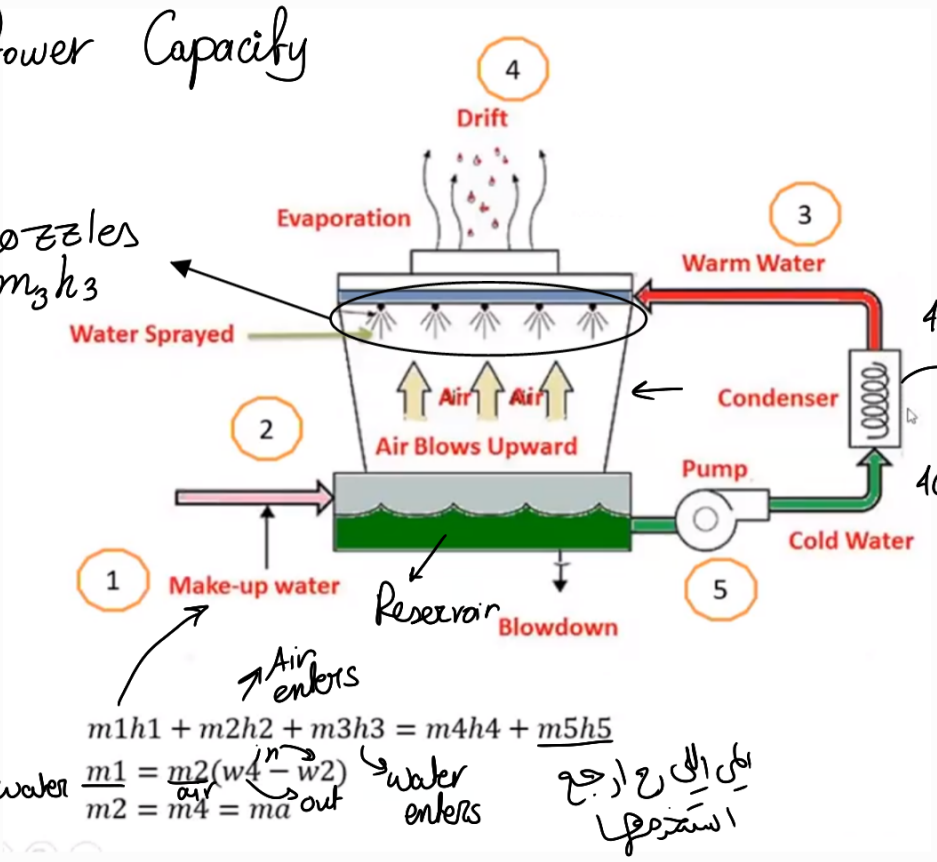
Approach

$$A = (T_{c\omega})_{out} - (T_{ambient})_{wet\ bulb}$$

Note: Air reaches thermodynamic equilibrium with incoming water : $(T_2)_{air} = (T_2)_{water}$

AC 1 Notes

Cooling tower Capacity



$m_5 \neq m_3$

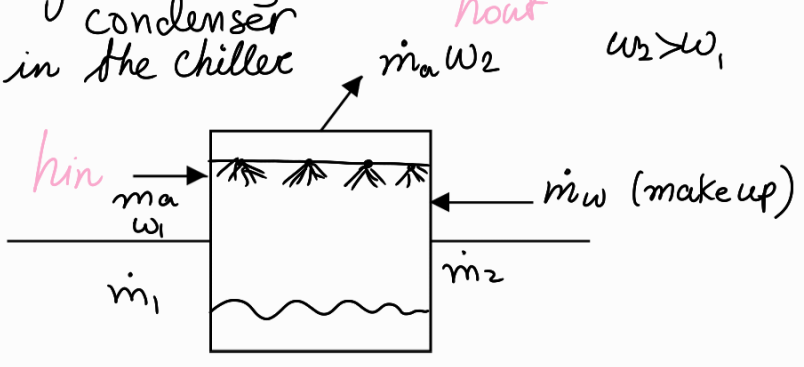
But: $m_3 + m_1 = m_5$

- Steps for finding $\dot{m}_a$, $\dot{m}_w$ for cooling tower

Q_L, COP → Q_H → Rejected by condenser in the chiller

from Selection

$\dot{m}_1$ should equal $\dot{m}_2$



Known → $Q_H = \dot{m}_w C_{pw} \Delta T_w$ ← Known

$\dot{m}_w$: found

ΔT_w: 5.6°