MODULE 6
HUMIDIFICATION AND AIR CONDITIONING

LECTURE NO. 3

6.3  *Humidification and dehumidification operations and design calculations*

**Humidification operations:** In this operation, water transfers from liquid phase to gas phase. Hence, moisture content of air increases. Air with particular moisture content is useful for drying of a solid under controlled condition.

**Dehumidification operations:** It is the reverse phenomena of humidification. A portion of water vapor from moist warm air is condensed by contacting cold water in air conditioning.

6.4  *Cooling tower principle and operation*

A cooling tower is a special type of heat exchanger in which the warm water and the air are brought in direct contact for ‘evaporative cooling’. It provides a very good contact of air and water in terms of the contact area and mass transfer coefficient of water vapor while keeping air pressure drop low. Enthalpy of air is lower than enthalpy of water. Sensible heat and latent heat transfer take place from water drop to surrounding air. Schematic of heat transfer from water drop to surrounding air is presented in Figure 6.3.
Thus, cooling is accomplished by sensible heat transfer from water to air and evaporation of a small portion of water. A generalized cooling tower system is shown in Figure 6.4. The hot water which is coming from heat exchanger is sprayed at the top of the cooling tower. Air enters through the louvers at the two opposite walls of the cooling tower. During cooling process of water, around 2% water is evaporated. Make water is used to compensate the water loss due to evaporation. Blowdown is there to drain a part of water containing solid deposit. The exit cold water from the cooling tower is used in the heat exchanger or other unit operation.
Factors govern the operation of cooling tower

i. The dry-bulb and wet-bulb temperatures of air

ii. Temperature of warm water

iii. The efficiency of contact between air and water in terms of volumetric mass transfer coefficient \( k'_{\text{y/\bar{a}}} \)

iv. Contact time between air and water

v. The uniformity of the distribution of the phases within the tower

vi. Air pressure drop

vii. Desired temperature of cooled water
6.5 Types of equipment

(A) Atmospheric Towers
It is a big rectangular chamber with two opposite ‘louvered’ walls. Tower is packed with a suitable ‘tower fill’. Atmospheric air enters the tower through louvers driven by its own velocity. Direction and velocity of wind greatly influence its performance. Figure 6.5 shows the schematic of the atmospheric cooling tower.

Figure 6.5: Schematic of atmospheric cooling tower.
(B) Natural Draft Towers
A natural draft cooling tower has a large reinforced concrete shell of hyperbolic shape (also called ‘hyperbolic tower’). Natural flow of air occurs through the tower; hence it is called natural draft (refer Figure 6.6).

Factors responsible for creating natural draft
(a) A rise in temperature and humidity of air in the column reduces its density
(b) Wind velocity at the tower bottom

Fan is used to enhance the air flow rate in fan assisted natural draft tower. The typical diameter of tower is 150 m and capacity is 5,00,000 gallon/minute.

Why hyperbolic shape?
(i) More packing materials can be placed at the bottom
(ii) The entering air gets smoothly directed towards the centre
(iii) Greater structural strength and stability