Velammal Institute of Technology, Panchetti
Department of Mechanical Engineering

ME8351- ENGINEERING THERMODYNAMICS

Focused question

UNIT – V

GAS MIXTURES AND PSYCHROMETRY

PART –A (2 marks)

1. What is the difference between air conditioning and refrigeration?

Refrigeration is the process of providing and maintaining the temperature in space below atmospheric temperature.

Air conditioning is the process of supplying sufficient volume of clean air containing a specific amount of water vapour and maintaining the predetermined atmosphere condition with in a selected enclosure.

2. Define psychrometry.

The science which deals with the study of behaviour of moist air (mixture of dry air and water vapour is known as phychrometry.

3. Name some psychrometry.

1. Sensible heating.
2. Sensible cooling.
3. Humidifying
4. Dehumidifying.
5. Heating and humidifying
6. Heating and dehumidifying.
7. Cooling humidifying
8. Cooling dehumidifying.

4. Define dry bulb temperature.

The temperature which is measured by an ordinary thermometer is known as dry bulb temperature .It is generally denoted by td

5. **Define wet bulb temperature.**

It is the temperature of air measured by a thermometer When its bulb is covered with wet cloth and exposed to a current rapidly moving air.It is denoted by tw.

6. **Define dew point temperature**.

The temperature at which the water vapour presents in air begins to condense when The air is cooled is known as dew point temperature .It is denoted by tdp.

7. **Define relative Humidity (RH) and specific humidity.**

RH is the ratio of the mass of water vapour (mv) in a certain volume of moist air at Given temperature to the mass of water vapour in the same volume of saturated air at the Same temperature.

$$RH = mv / mvs$$

Specific humidity (ω) is the ratio of mass of water vapour (mv) to the mass of dry air in the given volume of mixture.

$$\omega = mv / ma.$$

8. Differentiate between absolute and relative humidity.

Absolute humidity is defined as the ratio of the mass of water vapour (mv) in Certain volume of moist at given temperature to the mass of water vapours at Atmospheric conditions

RH is the ratio of the mass of water vapour in a certain volume of moist air at a given Temperature to the mass of water vapour in tha same volume of saturated air at the same Temperature.

$$RH = mv / mvs$$

9. **Define DTP and degree of saturation.**

DTP is the temperature to which moist air to be cooled before it starts condensing.

Degree of saturation is the ratio of specific humidity of moist air to the specific Humidity of saturated air at temperature.

$$\mu = \frac{\text{Specific humidity of moist air}}{\text{Specific humidity of saturated air}}$$

10. What is dew point temperature? How is it related to dry bulb and wet bulb? Temperature at the saturation condition?

It is the temperature at which the water vapour present in air begins to condense The air is cooled.For saturated air, the dry bulb, wet bulb and dew point temperature are All same.

11. State Dalton's law of partial pressure.

The total pressure exerted by air and water mixture is equal to the barometric

Pressure. $Pb = pa + pv$

Where

Pb = barometric pressure.

pa = Partial pressure of dry air.

pv = Partial pressure of water vapour.

12. Define Apparatus Dew point of cooling coil.

For dehumidification, the cooling coil is to be kept at a mean temperature which is below the dew point temperature of the entering .This temperature of the coil is called ADP temperature.

13. List down psychometric process.

1. Sensible heating process

2. Sensible cooling process.

3 .Humidification process.

4. Dehumidification process.

5. Heating and humidification process.

6. Cooling and Dehumidification process.

7. Adiabatic mixing airstreams process.

8. Evaporative cooling process.

14. Define bypass factor of coil.

The ratio of the amount of air which does not contact the cooling coil to the Amount of supply air is called BPF

$$BPF = \frac{\text{Amount of air bypassing the coil}}{\text{Total amount of air passed.}}$$

15.Define the humidification process.

Humidification is defined as the process of adding moisture at constant dry bulb Temperature.

16. State the effects of very high and a very low bypass factor. Very high by pass factor:

1. It requires lower ADP .Refrigeration plant should be of larger capacity.

2. It requires more air .Larger fan and motor required.

3. It requires less heat transfer area.

4. It requires more chilling water Larger piping required

Very low by pass factor.

1. Higher ADP is to be employed.

2. It requires less air. Fan and motor size reduced.

17. What factors affect by pass factor?

1. Pitch of fins.

2. Number of coil tubes.

3. Air velocity over the coil.

4. Direction of air flow.

18 .What are the assumption made while mixing two air streams?

1. Surrounding is small.

2. Process is fully adiabatic.

3. There is no work interaction

4. Change in kinetic and potential energies are negligible.

PART –B

1. Explain the following terms: (a) Mole fraction, (b) Mass fraction.

1. Mass Fraction: If a gas mixture consists of gases 1, 2, 3 and so on, then the mass of the mixture is the sum of the masses of the component gases.

$$m_m = m_1 + m_2 + m_3 + ... m_s = \sum_{i=1}^{K} m_i.$$

The mean fraction or mass fraction of any component is defined as the ratio of mass of a component to the mass of the

mixture mathematically $x_1 = \frac{m_1}{m_m}$

In mass or gravimetric analysis mass of each component is specified.

2. **Molar Fraction:** It is the ratio of the mole number of the mixture. The total number of moles of a mixture is the sum of the number of its component

$$N_m = N_1 + N_2 + N_3 + \ldots + N_1 = \sum_{i=1}^{K} N_1.$$

Then, $Y_i = \frac{N_1}{N_m}$.

In molar analysis moves of each component are specified the number of moles N_1 the mass m_l and the molar mass N of a component and mixture is related by

$$m_1 = N_1 M_1 \qquad \ldots (2)$$

$$m_m = M_m M_m \qquad \ldots (3)$$

From (1) (2) and (3)

$$m_m = \Sigma m_1 = \Sigma N_i m_i$$

$$M_m = \frac{m_m}{N_m} = \frac{\Sigma N_i M_i}{N_m} = \Sigma Y_i M_i.$$

$$\therefore Y_i = x_i \frac{M_m}{M_i}.$$

2. Explain the following terms: .

1.Sensible cooling
2. Sensible heating
3. Cooling and dehumidification
4. Heating and humidification
5. Cooling and humidification
6. Heating and de-humidification

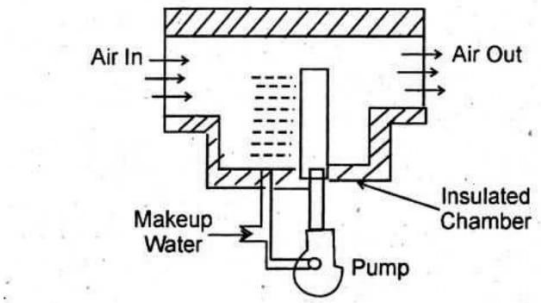
Adiabatic cooling:

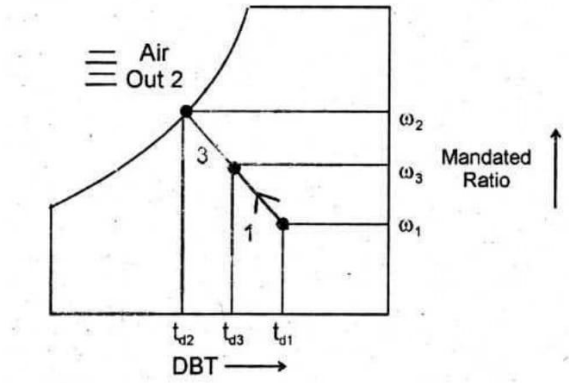
In this type of cooling, the air is passed through an insulated chamber. This insulating chamber has sprays in which water is maintained at a temperature higher than the dew point temperature of entering air but lower than its dry bulb temperature. So, both cooling and humidification are done without supplying or rejecting heat from water spray. At the time, the same water is recirculated again and again, the main disadvantage in this method is, perfect humidification of air is not possible.

The performance of the spray chamber is measured by its effectiveness.

$$\text{Effectiveness} = \frac{\text{Actual drop in dry bulb temperature}}{\text{Ideal drop in dry bulb temperature}}$$

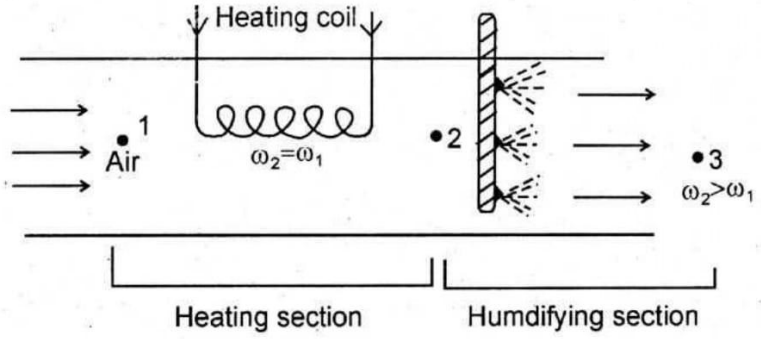
$$= \frac{t_{d1} - t_{d3}}{t_{d1} - t_{d2}}.$$





Humidification

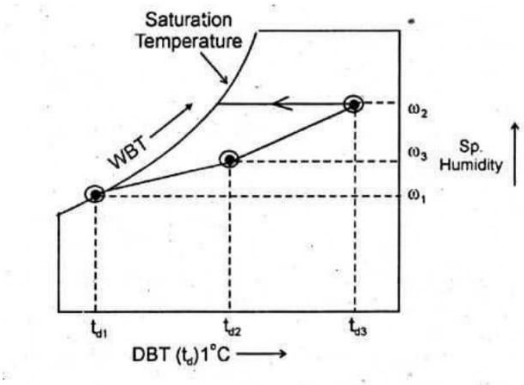
The process in which the moisture or water vapor or humidity is added to the air without changing its dry bulb (DB) temperature is called as humidification process. This process is represented by a straight vertical line on the psychrometric chart starting from the initial value of relative humidity, extending upwards and ending at the final value of the relative humidity



Dehumidification

The process in which the moisture or water vapor or the humidity is removed from the air keeping its dry bulb (DB) temperature constant is called as the dehumidification process. This process is represented by a straight vertical line on the psychrometric chart starting from the initial value of relative humidity, extending downwards and ending at the final value of the

relative humidity.



In this case, both cooling and dehumidification are carried out one by one. First, cooling is done by passing refrigeration inside the coil tube. During this time, dry bulb temperature decreases from t_{d1} to t_{d3} but specific humidity is constant. Then, dehumidification is done by removing moisture from air. Due to this, SP; humidity decreases but DBT remain constant.

$\therefore \omega_1 = \omega_2\omega_3$ **but** $t_{d1} > t_{d2} > t_{d3}$

Total heat load on the heating coil,

THL = Sensible heat load, SHL +latent heat load, LHL,

$HL = (h_1 - h_3) + (h3 - h_2)$.

The ratio of sensible heat load to the total heat load is known as sensible heat ratio or SHF,

$$SHF = \frac{SHL}{SHL + LHL} = \frac{h_3 - h_1}{(h_3 - h_1) + (h_2 - h_3)}$$

Bypass factor is calculated from formula,

$$BPF = \frac{t_{d2} - t_{d3}}{t_{d1} - t_{d3}} = \frac{t_{d2} - t_{ADP}}{t_{d1} - t_{ADP}}.$$

Where, t_{d1} and t_{d2} are DBT of air at market and outlet in the duct.

$t_{d3} = t_{ADP}$ is apparatus dew point temperature.

$$\text{Effectiveness} = \frac{\text{Actual drop in DBT}}{\text{Ideal drop in DBT}} = \frac{t_{d1} - t_{d3}}{t_{d1} - t_{d2}}$$

Mainly, this process is used in summer air-conditioning systems.

Evaporative cooling and adiabatic mixing

Evaporative cooling:

When the air is passed through an insulated chamber having sprays of water maintained at a temperature higher than the dew point temperature of entering air but lower than its dry bulb temperature, the air will be both cooled and humidified. Since no heat is supplied or rejected from the water spray and the same water is recirculated again and again.

A large quantity of water is constantly circulated through a spray chamber. The air - vapour mixture is passed through the spray and in doing so, evaporates some of the circulating water, the air may leave at a certain humidity ratio or in a saturated state. The increase in humidity is equal to the quantity of water evaporated per unit mass of dry air. After the process has been in operation for a sufficient length of time, the circulating water approaches the WBT of air.

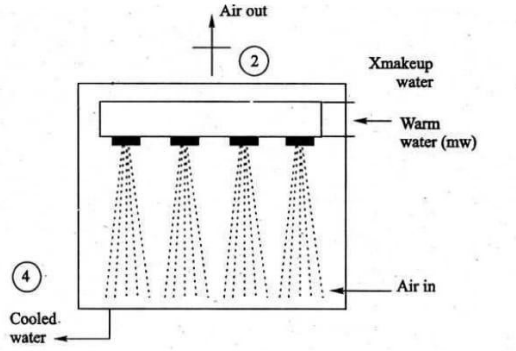
$$G_1 = G_2 = G.$$

The cooling tower utilizes the phenomenon of evaporative cooling to cool warm water below the dbt of the air.

The warm water is introduced at the top of the tower in the form of spray to expose a large surface area for evaporation to take place. The more the water evaporates the more the effect of cooling

$$G_1 = G_2 = G.$$

$$G_1 w_1 + m W_3 = G_2 W_2 + m w_4$$



$$mw_3 - m w_4 = G(w_2 - w1)$$

$$G_1 h_1 + m w_3 h w_3 = G_2 h_2 + m w_4 h w_4$$

$$G(h_1 - h_2) + m w_3 h w_3 = m w_4 h w_4$$

Adiabatic mixing

The mixing of several streams of fluid is quite common in engineering practice. The process can usually be assumed to occur adiabatically. Mixing process is highly irreversible because of eddying of fluid streams.