Unit - V

psychometry

→ Atm air is a mixture of dry air and water vapour and is called as moisture air. These science dealing the properties of moist air is called psychometry and the properties of psychometry called as psychometric properties

→ The knowledge of psychometry is essential

Dalton's law :-

It is the pre. of mixture of air & water vapour is equal to the sum of the partial pre. of each constituent and each constituent occupies the entire volume

where $p = p_a + p_b$

p = total pre. (or) barometric pre. (or) atm. pre.

p_a - partial pre. of air

p_b - partial pre. of water vapour

psychometric Terms :-

→ Dry air, moiste air, humidity, relative humidity, absolute humidity

→ Relative humidity equal to mass of moisture in a given volume by mass of moisture in the same volume when saturated

$$(\phi) - \text{relative humidity} = \frac{\text{Mass of moisture in given volume}}{\text{Mass of moisture in the same volume}}$$

$$\phi = \left[\frac{M_v \text{ actual}}{\text{saturated } M_v}\right]_{T,V}$$

$$\Rightarrow \phi = \left[\frac{m_v}{\text{saturated } m_v}\right]_{T.V}$$

T.V — Total volume

Treating vapour as an Ideal gas :-

$$\phi = \frac{\left[\frac{P_v \cdot V}{RT}\right]_{act}}{\left[\frac{P_g \cdot V}{RT}\right]_{sat}} = \frac{P_v}{P_g}$$

P_v — actual partial of pressure

P_g — saturated pre. of vapour at the dry bulb temp.

Humidity ratio [specific humidity] :-

$$\omega = \frac{\text{mass of water vapour}}{\text{mass of dry air}} = \frac{\left[\frac{P_v \cdot V}{R_v T}\right]}{\left[\frac{P_a \cdot V}{R_a T}\right]}$$

$$\omega = \frac{m_v}{m_a} = \frac{\left[\frac{P_v \cdot V}{R_v \cdot T}\right]}{\left[\frac{P_a \cdot V}{R_a \cdot T}\right]}$$

$$\boxed{\omega = \frac{R_a \cdot P_v}{R_v \cdot P_a}}$$

R_a — 0.287 kJ/kg°K , R_v — 0.462 kJ/kg K

Then $P_a = P - P_v$

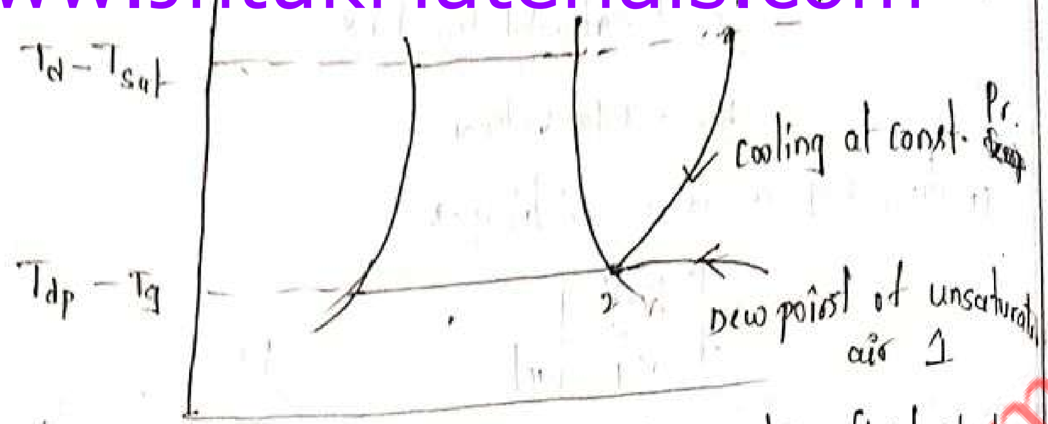
$$\omega = 0.622 \left[\frac{P_v}{P - P_v}\right]$$

when air is saturated then

$$\omega = 0.622 \left[\frac{P_g}{P - P_g}\right]$$

where P – Total pressure.

Dew point :-



It is defined as the Temp. at which condensation first starts when air is cooled at constant pre. vapour pre. 'P_v' dew point is equal to saturated pr. 'P_g' at that Temp.

psychometry chart :-

→ Graphical representation of properties of moist air called psychometry chart (or) ~~psychometric chart~~ hygrometric chart

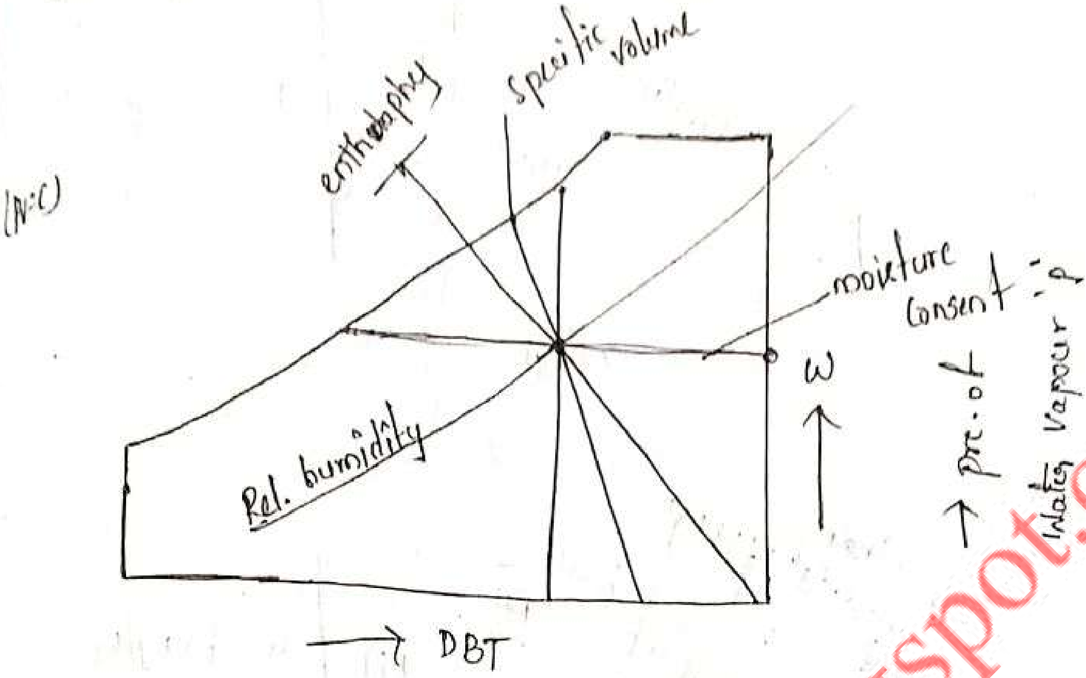
→ This chart is constructed on specific humidity, dry bulb Temperature coordinate system

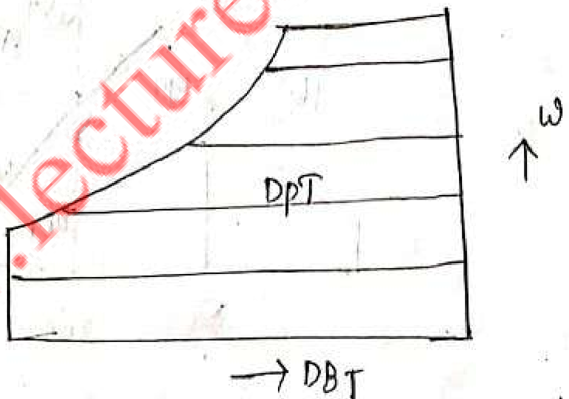
→ DBT on X-axis, Specific humidity on y-axis

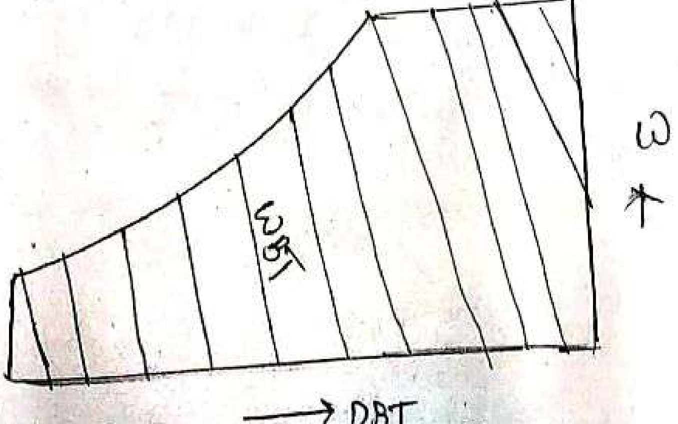
if the data 'P_g' and T from steam Table is plotted with partial pressure of water vapour as the ordinate and Temp. of T_{DB} as ~~abbscia~~ abscissa, saturation curve where $\phi = 100\%$ is established in chart by dividing saturation pressure at each dry bulb Temp into equal parts, it is possible to construct lines of constant relatively humidity

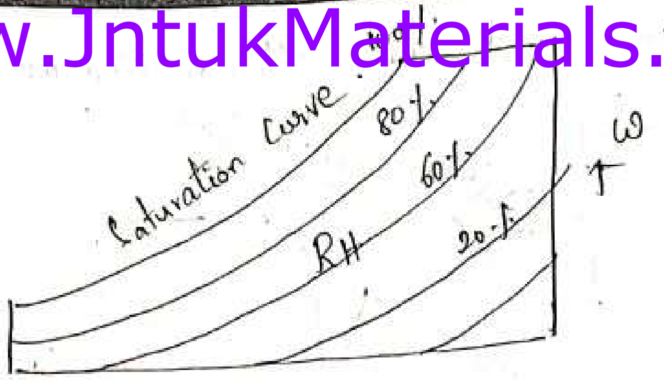
$\phi = \dfrac{P_v}{P_g}$ the chart shows the relationship b/w DBT, WBT, RH, DP (dew point, relative humidity)

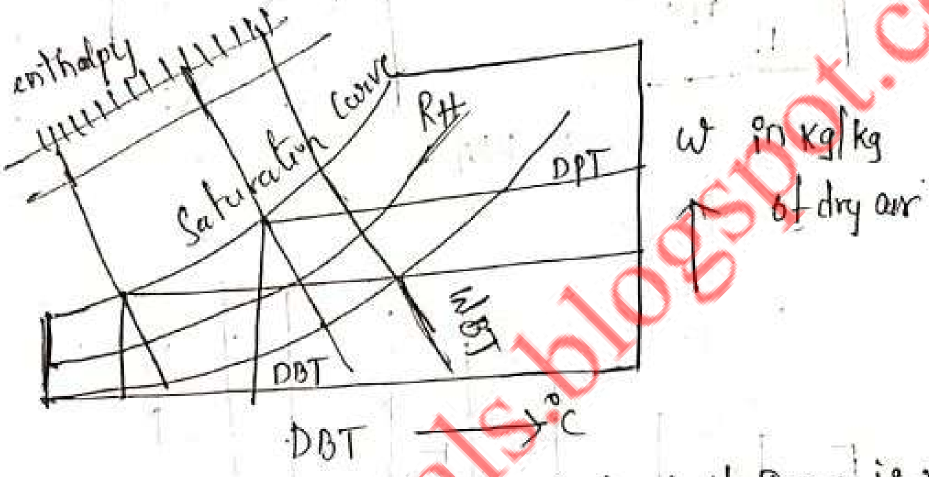
If any two point known other we find out here.





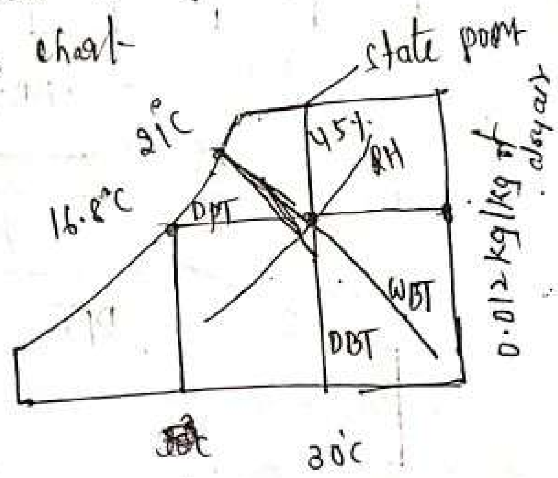






① . Find DPT, RH, moisture content if dry bulb Temp is 30°C and WBT is 21°C show above on chart

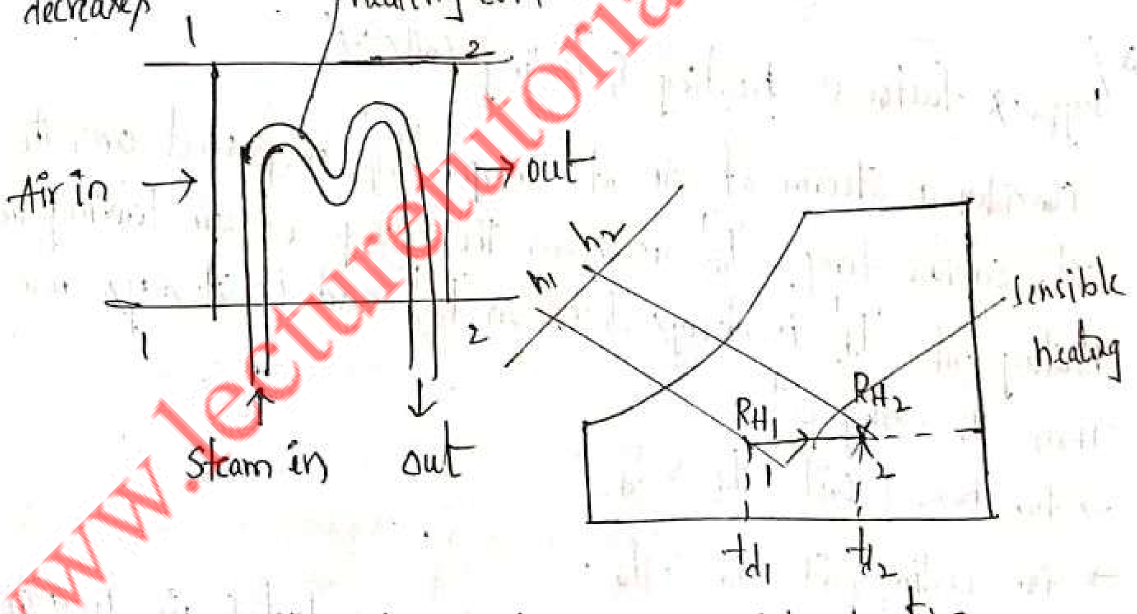
Sol →



psychometric process:-

1. sensible heating
2. sensible cooling
3. ~~pure~~ humidification & dehumidification
4. Heating and humidification
5. Heating and dehumidification
6. Cooling and humidification
7. Cooling and dehumidification.

→ Sensible Heating:- the process of heating of air without altering the specific humidity (ω) is called sensible heating. the air can be heated by passing it over a steel heating coil during sensible heating DBT increases relative humidity (ϕ) decreases



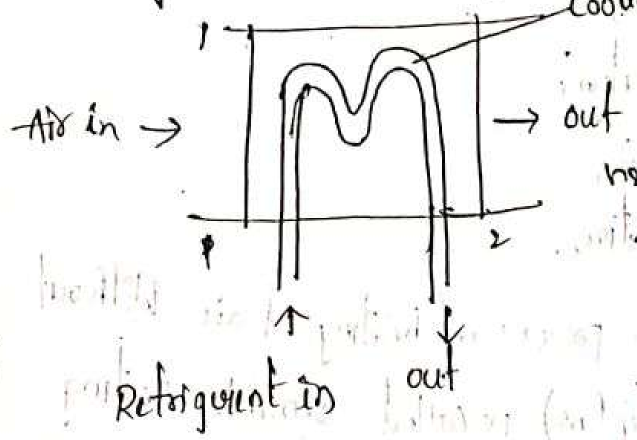
the amount of heat added during sensible heating

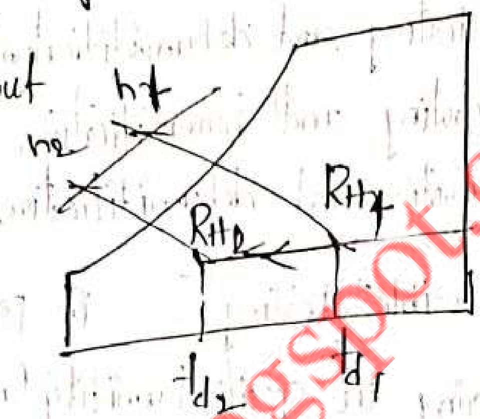
$$Q = (h_1 - h_2) = C_{pm}\,[t_{d_2} - t_{d_1}]$$

c_{pm} = ~~[illegible]~~ humid specific heat = 1.022 kJ/kgK

Then $Q = 1.022\,[t_{d_2} - t_{d_1}]$

→ **Specific Cooling :-** The process of cooling of air without altering the specific humidity is called sensible cooling. The air can be cooled by passing passing over a refergerent cooling coil. DBT decreases relative humidity increases





$$Q = (h_1 - h_2) = c_{pm} (t_{d_1} - t_{d_2})$$

$$\boxed{Q = 1.022 \, [t_{d_1} - t_{d_2}] \ kJ/kg\,K}$$

Bypass factor of heating & cooling Coils :-

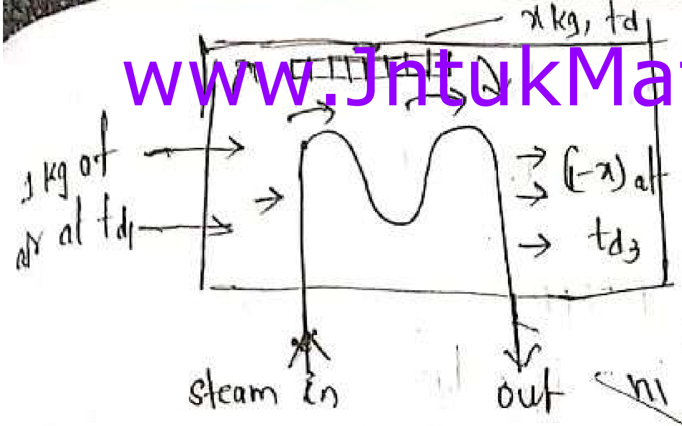
Consider a stream of air at Temp. 't_{d_1}' is passed over the coil. Surface temp 't_{d_3}' as shown the Temp of air leaving the heating coil 't_{d_2}' is always less than 't_{d_3}' and is always more the cooling coil.

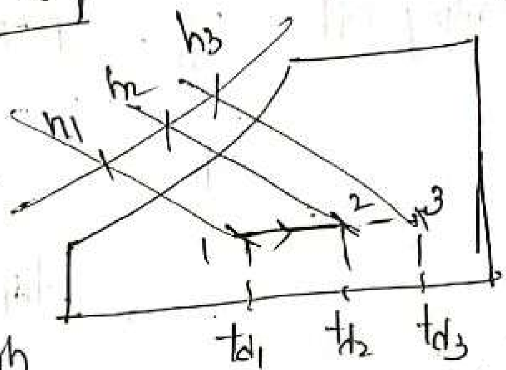
Than

→ For heating coil $t_{d_3} > t_{d_2}$

→ for cooling coil $t_{d_2} > t_{d_3}$

This is due to by pass air means of uncontacted air thus the bypass factor represents the amount of air uncontacted with the coil.





→ consider x kg of air is bypassed by allowing $(1-x)$ kg of air through the coil by balancing the enthalaphy's.

$$1 \times c_{pm}\, t_{d_2} = x \cdot c_{pm} \cdot t_{d_1} + (1-x)\, c_{pm}\, t_{d_3}$$

$$t_{d_2} = x \cdot t_{d_1} + (1-x)\, t_{d_3}$$

$$t_{d_2} = x \cdot t_{d_1} + t_{d_3} - x \cdot t_{d_3}$$

$$x\left[t_{d_3} - t_{d_1}\right] = t_{d_3} - t_{d_2}$$

$$x = \frac{t_{d_3} - t_{d_2}}{t_{d_3} - t_{d_1}}$$

∴ x is called as by pass factor, BPF for cooling coil

for cooling coil BPF ⇒ $x = \dfrac{t_{d_2} - t_{d_3}}{t_{d_1} - t_{d_3}}$

Efficiency of heating & cooling coil

The term $(1 - BPF)$ is known as efficiency of the heating coil

$$\eta_h = 1 - \frac{t_{d_3} - t_{d_2}}{t_{d_3} - t_{d_1}}$$

$$= \frac{\cancel{t_{d_3}} - t_{d_1} - \cancel{t_{d_3}} + t_{d_2}}{t_{d_3} - t_{d_1}}$$

$$\boxed{\eta_h = \frac{t_{d_2} - t_{d_1}}{t_{d_3} - t_{d_1}}}$$

Cooling coil $\eta_c = 1 - BPF$

$$\eta_c = 1 - \frac{t_{d_2} - t_{d_3}}{t_{d_1} - t_{d_3}}$$

$$\Rightarrow \frac{t_{d_1} - \cancel{t_{d_3}} - t_{d_2} + \cancel{t_{d_3}}}{t_{d_1} - t_{d_3}}$$

3.

$$\boxed{\eta_c = \frac{t_{d_1} - t_{d_2}}{t_{d_1} - t_{d_3}}}$$

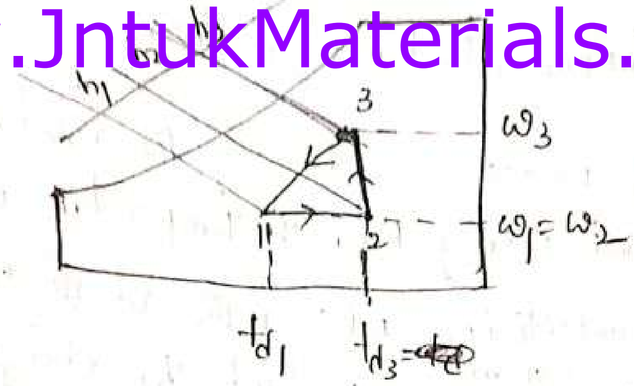
→ Sensible heat factor [SHF]

$$SHF = \frac{\text{Sensible heat}}{\text{total heat}} \Rightarrow \frac{SH}{SH + LH}$$

$$SH = h_2 - h_1$$

$$LH = h_3 - h_2$$

- Simple heating of moisture air can be done to a desired Temperature for simple cooling can be done upto dew point Temp. (dPT) because of Condensation.
- Consider a change of state from 1-3 which involves Sensible heating of latent heating the ratio of sensible heat transfer ~~is termed~~ to the total heat transfer is Termed as sensible heat factor

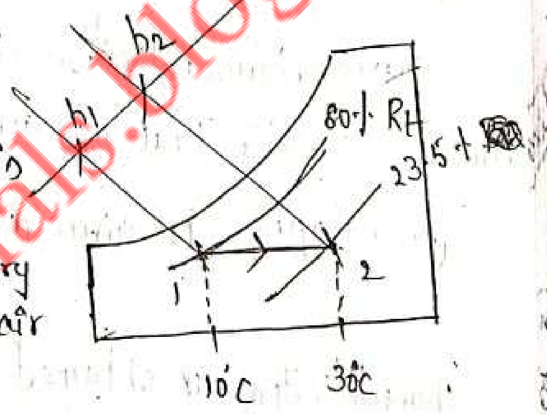


Q. Air enters a duct at $10^\circ C$ 80% RH at the rate of $150\, m^3/min$ and is heated to $30^\circ C$ without adding or removing any moisture the pressure remains constant at 1 atm find relative humidity of air at exist from the ~~depth~~ duct and the rate of heat Transfer

Sol: $t_{d_1} - 10^\circ C$, $t_{d_2} = 30^\circ C$

Relative humidity 80%

volume $V = 150\, m^3/min$



from chart $v_{g_1} = 0.81\, m^3/kg$ of dry air

$h_1 - 26\, KJ/kg$

$h_2 - 46\, KJ/kg$

mass $m = \frac{V}{v}$

$m_a = \frac{V}{v_1} = \frac{150}{0.81} = 185.15\, kg/min$

$Q = m_a [h_2 - h_1]$

$$\boxed{Q = 3703.6\, KJ/min}$$

Humidification & Dehumidification

The process of increasing the moisture content in the air with out altering dry bulb Temperature is called humidification. During Humidification DBT of air remain constant That means sensible heat of air remains constant then change of enthalaphy is given as $\boxed{h_2 - h_1 = h_{fg}[\omega_2 - \omega_1]}$

h_{fg} - latent heat of vapourization at DBT

3. The process of Decreasing the moisture content of air with out altering DBT called dehumidification.

During dehumidification DBT of air remain constant That means sensible heat of air remains constant Then change of enthalaphy is given as $\boxed{h_1 - h_2 = h_{fg}[\omega_1 - \omega_2]}$

Humidification is obtained by two methods

→ Direct method → ~~Indirect method~~

In Direct method Water is ~~sprayle~~ sprayed in atomized state into the room to be air conditioned

→ Indirect method

Water is sprayed into stream of air and This Conditioned air is supplied to the room to be air conditioned.

Eg:- Air washer is ex. for humidification & dehumidification of air

Heating & Humidification

Increase in the dry bulb Temperature and moisture content simultaneously is called heating & humidification.

This process is employed in ~~Winter~~ winter air conditioning to warm and humidify the air.

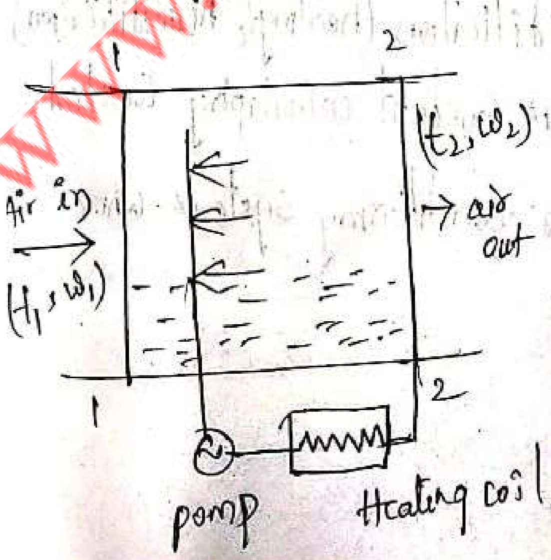
the Temp of water sprayed is higher Than DBT of Entering air. The air absorbs heat from spray water, the unsaturated air may reach Saturation and will also be heated. the process is represented by 1-2 on psychometric chart.

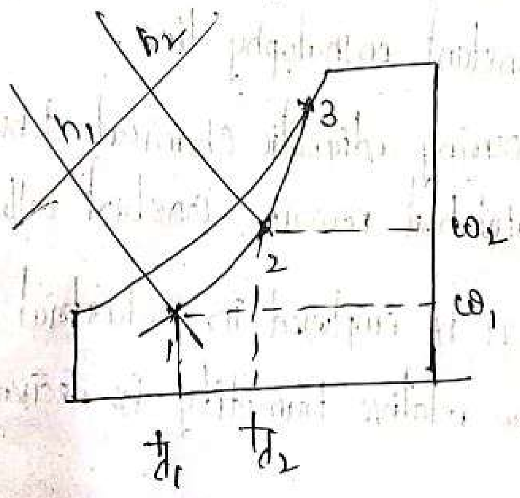
Air enters at state-1, ~~Relieves~~ leaves at state-2.

point 3 represents the mean Temp of spray water which the entering air may be assumed to approach. the spray water may be heated by an heating coil.

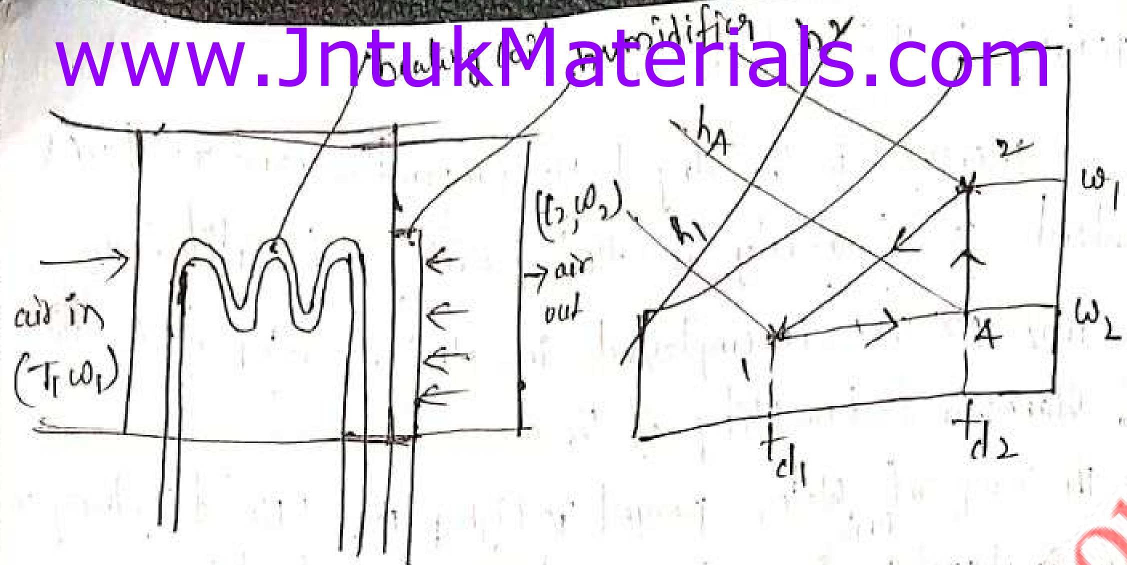
the final stage-2 of air may be achieved by Sensible heating [1-A] in a heating coil and increasing the moisture content by humidifier [A-2] as shown in graph-B

In This process DBT, WBT, T, of the living air is greater Than entering air





(a)



(b).

Heating and dehumidification :-

→ Here DBT of air increased and moisture content is decreased by using chemicals which have high affinity for moisture is called adiabatic chemical dehumidification.

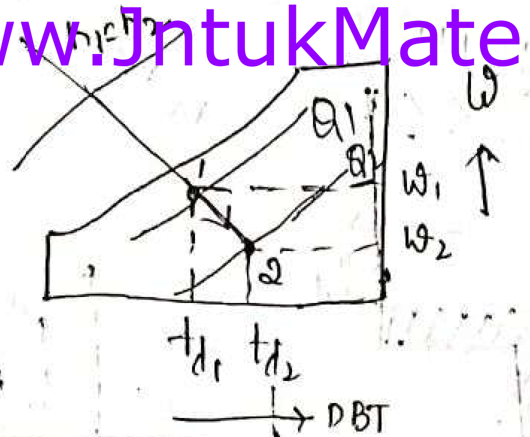
→ A ~~System~~ stream of air passed over absorbent as air comes and contact with absorbent moisture in the air gets condensed.

→ Due to condensation specific humidity decreases and heat of condensation increases the DBT of air

→ The process shown by 1-2 on psychometric chart line 1-2 follows constant enthalophy line.

→ During adiabatic chemical dehumidification (heating & humidification) total heat remains constant called as constant enthalophy constant.

→ It is employed in industrial air conditioning systems where low relative humidity is desirable



Cooling with Adiabatic Humidification:- (constant temp ↑ humidity)

→ the process involve lowering DBT and increasing humidity ratio means moisture content air is passed to the insulating chamber in which water is sprayed

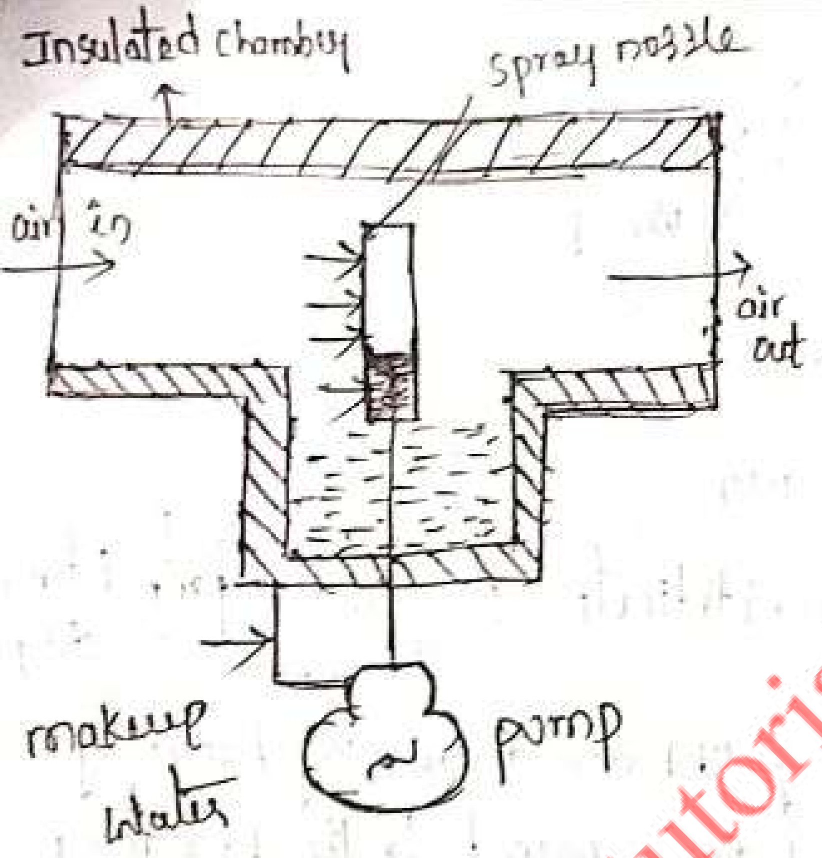
→ the Temp of water is higher than the DPT of entering air, But less than the DBT of the air under these conditions air will be cooled and humidified no heat is supplied (or) rejected form the water spray and sprayed water is circulated again & again to reach the condition of adiabatic saturation that means adding moisture without heat addition.

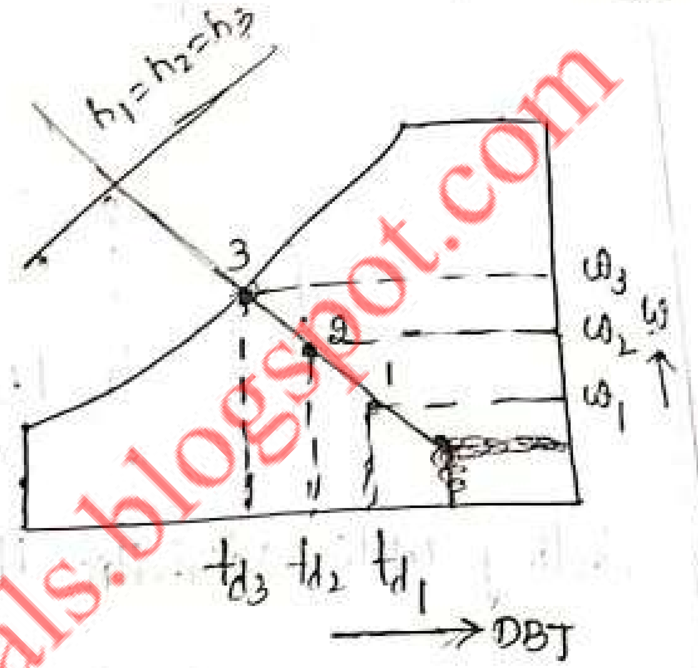
→ the total enthalaphy remains constant and heat require for evaporation of water is supplied by air, therefore its Temp. will decrease

→ In ideal conditions process is represented by line 1-3 point 3 is the final state of air. but in actual pratice final state represented by point 2 on the line 1-3

→ Effectiveness of Spray chamber $\varepsilon_{sc} = \dfrac{\text{actual drop in DBT}}{\text{Idel drop in DBT}}$

$$\boxed{\varepsilon_{s.c} = \frac{t_{d_1} - t_{d_2}}{t_{d_1} - t_{d_3}}}$$


Insulated chamber
spray nozzle
air in
air out
makeup water
pump


h1=h2=h3
3
2
1
ω3
ω2
ω1
ω
td3
td2
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