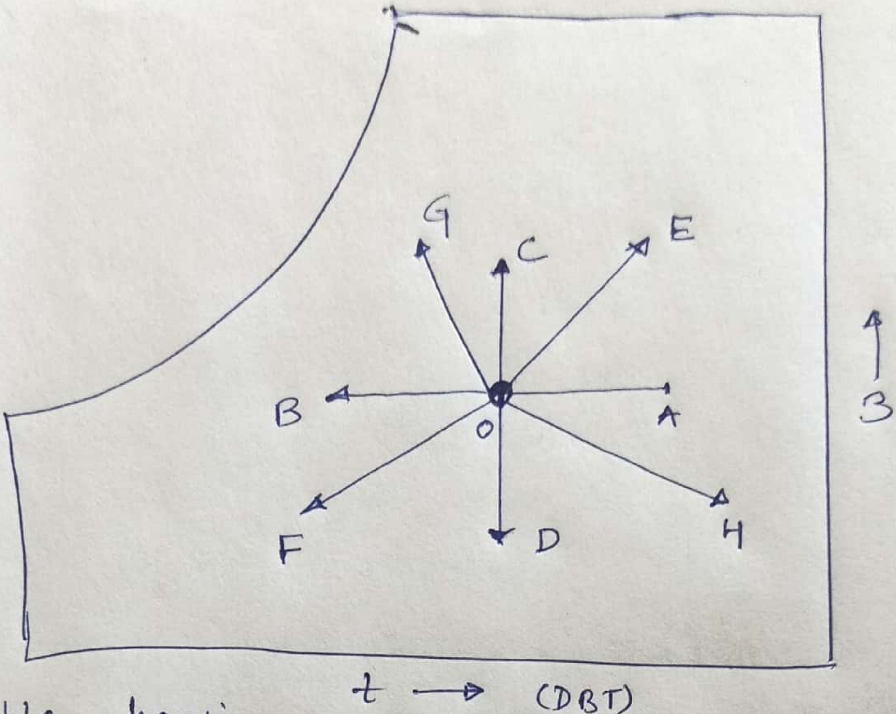
Air Conditioning Processes



i> Sensible heating ▸ OA → Temp increases only, no moisture added or removed (ω = const)

ii> Sensible Cooling ▸ OB → Temp (DBT) decreases only. no moisture added or removed Hence ω remains constant.

iii> Humidifying (OC) and Dehumifying (OD) → Only moisture content is added or decreased with no change in temp.

iv> Heating and humidifying → OE → As name suggests, both temperature and moisture content (ω) is increased

v> Cooling and dehumidifying → OF → As name suggests, both temperature and moisture content of air (ω) decreases

vi> Cooling and humidifying → OG → Temperature of air decreases but ~~but~~ moisture content (ω) increases

vii> Heating and dehumidifying → Temperature of air increases but moisture content decreases.

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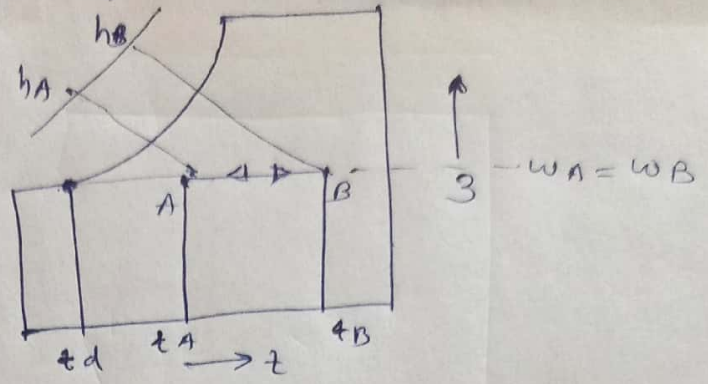
1) Sensible heating and cooling



Q_s = Sensible heat transfer = $m_a (h_B - h_A)$

if m_a ~~mass~~ circulation rate of dry air (kg/s) is known, ~~from~~ Q_s can be calculated from psychrometric chart.

Alternatively,

$$Q_s = m_a c_p (t_B - t_A)$$

c_p → humid ~~sep~~ specific heat

$$= Q_v \rho c_p (t_B - t_A)$$

Q_v → volume flow rate of air in m^3/s

Generally volume flow rate of air is given by cmm (cubic meter per minute)

$$\therefore Q_s = \frac{cmm}{60} \cdot \rho \cdot c_p (t_B - t_A)$$

Taking std values $\rho = (1.2)\ kg/m^3$ dry air

$c_p = 1.0216$ kJ/kg.d.a. (K)

$$Q_s = \frac{cmm \times 1.2 \times 1.0216}{60} (t_B - t_A)$$

$$Q_s = 0.0204\ cmm\ \Delta t\ \text{kW}$$

Note: Simple cooling can be done only upto DPT (t_d)

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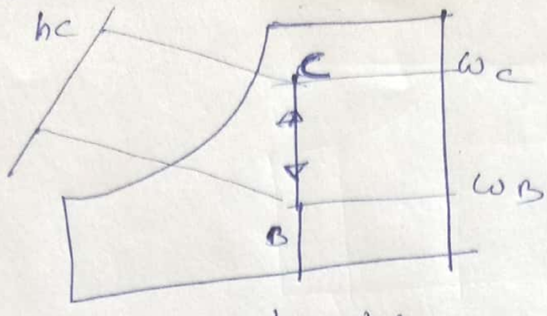
(3) Latent Heat Process (Humidifying or Dehumidifying)



Latent heat, $Q_L = m_a (h_C - h_B)$
can be calculated from psychrometric chart
if m_a (kg of d.a./s) is known.

Alternatively

$$Q_L = m_a h_{fg0} (\omega_C - \omega_B)$$

h_{fg0} → Latent heat of vaporization taken as 2500 kJ/kg

From previous section

$$m_a = \frac{(cmm) \times 1.2}{60}$$

∴

$$Q_L = \frac{(cmm) \times 1.2 \times 2500 \; \Delta\omega}{60}$$

$$= 50 \, (cmm) \, \Delta\omega \quad kW$$

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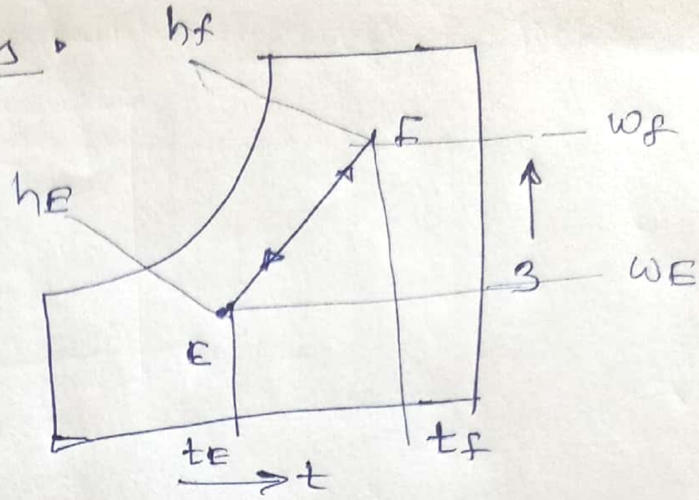
Total Heat Process :



In this process as both temperature and humidity content changes, there is both sensible heat load (Qs) and latent heat load (QL) in the process

$\therefore \quad Q = Q_S + Q_L$

Directly you can calculate it from psychrometric chart as $Q = m_a (h_F - h_E)$

Alternatively

$$Q = \underbrace{cmm \times 0.0204\,\Delta t}_{Q_S} + \underbrace{cmm \times 50 \times \Delta W}_{Q_L}$$

$$\therefore \quad Q = cmm\,(0.0204\,\Delta t + 50 \times \Delta W)$$

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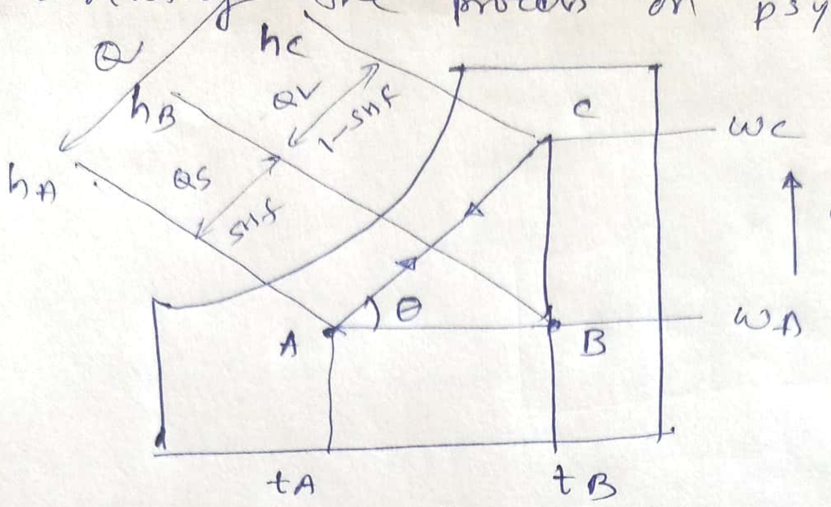
(4) Sensible Heat factor (SHF)

Definition : The ratio of sensible Heat transfer to total heat transfer is called sensible heat transfer [Refer Above]

$$SHF = \frac{Q_S}{Q_S + Q_L} = \frac{Q_S}{Q}$$

~~SHF~~

Again drawing the process on psychrometric chart.



Total heat $= h_c - h_A$ (kJ/kg of d.a)
Sensible heat $= h_B - h_A$ (kJ/kg of d.a)
Latent heat $= h_c - h_B$

$$\therefore SHF = \frac{h_B - h_A}{h_c - h_A} = \frac{h_B - h_A \leftarrow QS}{\underbrace{(h_c - h_B)}_{QL} + \underbrace{(h_B - h_A)}_{QS}}$$

$$= \frac{0.0204\,\Delta t}{0.0204\,\Delta t + 50\,\Delta\omega}$$

$$SHF = \frac{1}{1 + \frac{50\,\Delta\omega}{0.0204\,\Delta t}} = \frac{1}{1 + 2451\tan\theta}$$

$\frac{\Delta\omega}{\Delta t} = \tan\theta$
from figure

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The incoming moist air at point ① has temp t_1 and humidity content ω_1, it has dew point temp t_d. It means if the temp of air is lowered below t_d (or at least t_d), dew will be formed and moisture will get separated.

Now, the air is passed over the cooling coil which has temp t_s which is well below DPT (t_d) of entering air.

This temp (t_s) of cooling coil is called Aparatus Dew Point.

The air ~~er~~ leaves the coil at temp t_2 and at humidity ω_2. It means ($\omega_1 - \omega_2$) moisture is removed from air.

Air is not cooled to lowest temp t_s (ADP). ~~It is viewed~~ The processes is viewed as mixing of two parts of air. One part of air comes in contact with coil and cooled to temp t_s, other part does not come in contact and remain at temp t_1. The final temp t_2 is the temp which is produced by mixing of this "contacted" and "uncontacted" air.

The bypass factor (BPF) of apparatus represent the fraction of this "uncontacted) air and denoted by X.

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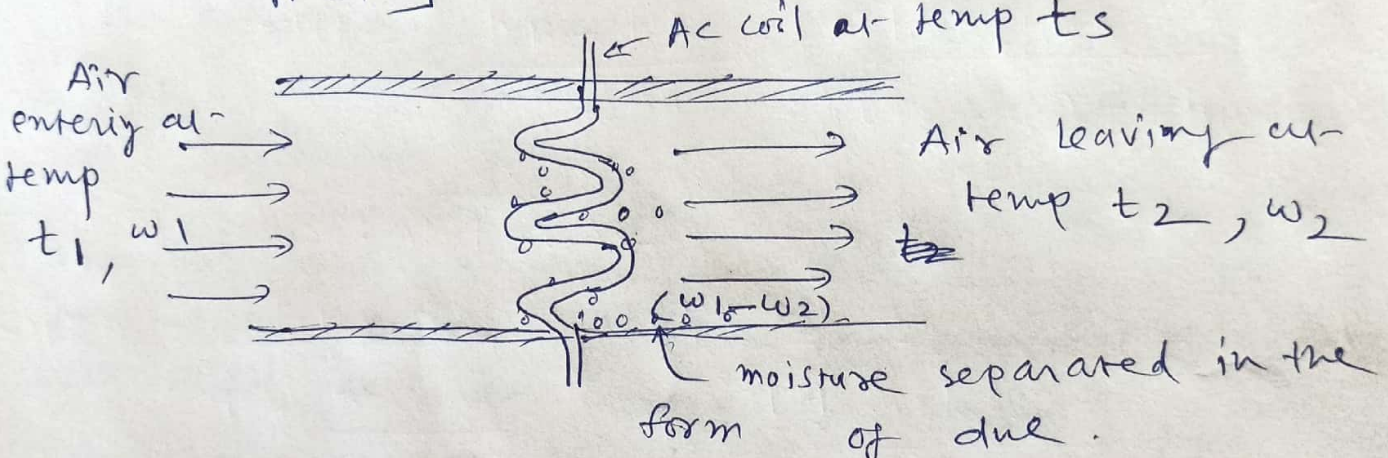
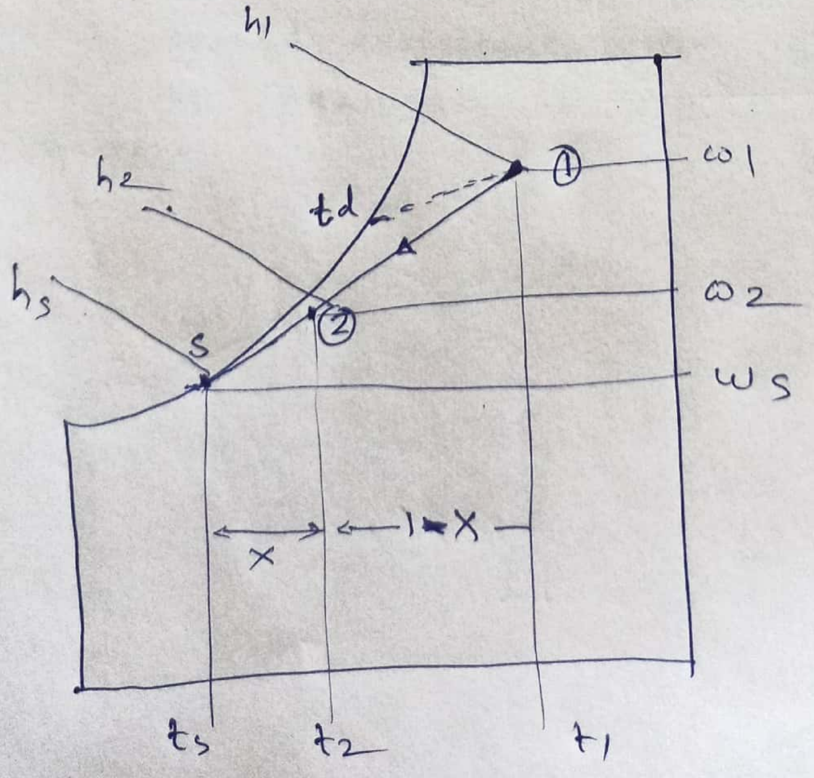
* Bypass factor and Apparatus Dew Point (ADP)

Consider the air passing over cooling and dehumidifying coils as shown below. [It means refrigerant is passing ~~through~~ inside coil which cooles the entering air, Also the temperature of coil is kept below DPT (dew point temp) of incoming air so that moisture in air get condensed and air leaves ∴ ~~cool~~ ~~ar~~ coil, cool and dehumidified]



Refering to psychrometric process below



$$X = \frac{t_2 - t_s}{t_1 - t_s} = \frac{\omega_2 - \omega_s}{\omega_1 - \omega_s} = \frac{h_2 - h_s}{h_2 - h_1}$$

$(1-X)$ is called contact factor

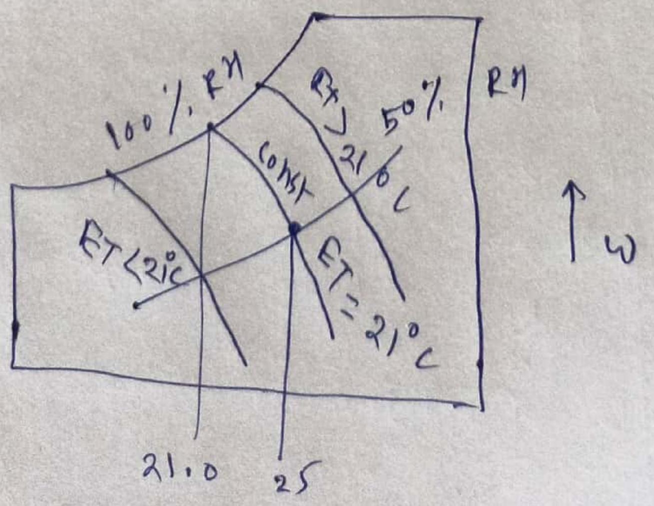
—— x ——

Comfort Air Conditioning and Effective Tempearture (ET)

Human feel comfortable depending on ① Temperature ② Humidity ③ velocity of surrounding air. It is obvious that this feeling of comfort will be different for different people.

As there are different parameters to measure human comfort, often a single parameter called Effective Temperature (ET) is considered as an index of comfort.

Effective Tempearture is defined as that temp of saturated air at which the subject (person) would experience the same feeling of comfort as measured in actual unsaturated environment.



There are variation in human comfort parameters, depending on different study.

But ~~All~~ refering to ASHRAE Chart

DBT = 20 °C to 26 °C

RH = 20% to 80%

are the ranges between which most human beings will feel comfortable

[You can refere to any good text book or material to draw comfort chart]

—x—

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