Ex: Saturation air at 26 °C and parometric pressure 1.
Find partial air pressure?

$P_B = P_a + P_v$ (From Dalton Law)

From steamtable at 26 °C, when $T_d = T_w$ For staration

$T_w = 26\,°C \xrightarrow{Table} P_{sw} = 3.36$ kpa

$P_v = P_{sw} - P_B * A * (T_d - T_w)$ → 0

$P_v = P_{sw} = 3.36$ kpa

* $P_B = 1$ bar $= 101.325$ kpa

$P_a = P_B - P_v$

$= 101.325 - 3.36 = 97.695$ kpa

H.W

moist air at wet bulb Temperature 15 °C and dry bulb Temp 19 °C & Parometric Pressure 1 bar
Find partial airpressure?

H.W

prove that relative humidity For saturation air equal one (100%)?

H.W

prove that moisture Content For moist air equal ratio of vapour pressure to air pressure?

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EX: 15 mg of vapour in $1 m^3$ of air at 24°C and parometric pressure 1 bar Find the partial air pressure

Sol

$$P_v V_v = m_v R_v T_v$$

$$P_v = \frac{m_v R_v T_v}{V_v} = \frac{(\frac{15}{1000}) * (461) * (24+273)}{(1)} = \boxed{2053.76 \ Pa}$$

$$P_a = P_B - P_v$$

$$= 101.325 - 2053.76 = \boxed{99271.2 \ Pa}$$

From steam table

at $T = 24$ °C $\rightarrow$ $\boxed{P_{sat} = 2982 \ Pa}$

So, $P_{sat} > P_v$ $\longrightarrow$ The air is not saturation

---

H.w Find partial air pressure at ~~Td = 20 °C &~~ Tw = 15 °C and atmospheric pressure 95 m bar

Ans $P_a =$, $P_v = 1.391$ kpa

H.w moist air at $T_d = 20$ °C, $T_w = 15$ °C & $P_B = 95$ kpa Find relative humidty ?

Ans $\phi = 73.8\%$

H.W Find moisture content for moist air whe $T_d = 20°C$ & $T_w = 15°C$ at atmospheric pressure 950 m bar?

Ans $W = 9.24 \frac{g_v}{kg_a}$

H.W Find moisture air for saturation air at 20°C and Parometric pressure 950 mbar?

Ans $w = 0.0157 \frac{kg_v}{kg_a}$

H.W Find Dew Point for saturation air at 15°C & 760 mm Hg parometric pressure?

H.W Find Dew Point for moist air at $T_d = 20°C$ & $T_w = 15°C$ and atmospheric pressure 780 mm Hg?

H.W Find enthalpy for saturation air at 20°C & parometric pressure 790 mm Hg?

H.W Find enthalpy for moist air air at 20°C dry bulb Temp. & 15°C Wet bulb Temp & $P_B = 1$ bar

Ans $h = 41.764$ KJ/kg_a

mustafa

Ex: The density of moist air founded 0.018 kg/m³ with 26°C DBT & P_B = 90 kPa, calculate relative humidity?

Sol

$$\phi = \frac{\rho_v}{\rho_{v_{sd}}}$$

Sol ①

From (Ex) → $\rho_v = 0.018$ kg/m3

& From steamtable at $T_d = 26°C$ → $\rho_{v_{sd}} = \frac{1}{v_{v_{sd}}} = \frac{1}{\quad} = 0.02437$ kg/m3

$$\phi = \frac{0.018}{0.02437} =$$

OR **Sol ②**

$$\phi = \frac{P_v}{P_{sd}}$$

$$P_v V_v = m_v R_v T_v$$

$$P_{sd} V_{sd} = m_{sd} R_{sd} T_d$$

$$P_v = \frac{m_v R_v T_v}{V_v}$$

$$P_{sd} = \frac{m_{sd} R_{sd} T_d}{V_{sd}}$$

$$\phi = \frac{\frac{m_v R_v T_v}{V_v}}{\frac{m_{sd} R_{sd} T_d}{V_{sd}}}$$

$T_v = T_{sd} = T_d$
$V_v = V_{sd}$
$R_v = R_{sd}$

$$\phi = \frac{m_v}{m_{sd}} \quad , \quad m = \rho * V$$

$$\boxed{\phi = \frac{\rho_v * V_v}{\rho_{sd} * V_{sd}} = \frac{\rho_v}{\rho_{sd}}}$$

Ans

Prove

Ex: Calculate The specific Volume for moist Air with 40 °C & $\phi = 80\%$ and parametric Pressure 100 kPa

Sol

$$v_a = \frac{R_a T_d}{P_a} \quad ---(1)$$

$$v_v = \frac{R_v T_v}{P_v} \quad ---(2)$$

$$\phi = \frac{P_v}{P_{sd}}$$, $P_{sd} = 7.375$ kp at $T_d = 40°C$ from Table

$P_v = 5.9$ kPa

$P_a = P_B - P_v$
$= 100 - 5.9 = 94.1$ kPa

$$v_a = \frac{287 * (313)}{94.1 * 10^3} =$$ Ans

When $T_v = T_d$

$$v_v = \frac{461 * (313)}{5.9} =$$ Ans

Prove Enthalpy of Moist Air (h)

$h = h_a + w\, h_v$

$h_a \rightarrow kJ/kg_a$

$h_v \rightarrow kJ/kg_v$

$w \rightarrow kg_v/kg_a$

$h_a = C_{Pa} T = 1.005 T$

$h_v = C_{Pv} T_d + h_{fg} + C_{Pv} (T - T_d)$ at $T_d = 0$

$C_{Pa} = 1.005$ $\quad -10 < T < 0$

$C_{Pa} = 1.007$ $\quad 0 < T < 60°c$

$h_v = 2501 + C_{Pv} T$

$h_v = 2501 + 1.84 T$

$h_v = 1.005 T + w(2501 + 1.84 T)$

Humid specific heat $c_{ph} = C_{Pa} + w\, C_{Pv}$

E

Explain adibatic saturation

Adiabatic process in which no external heat flow in or out of the system but inter change of energy can occure.

If water is supplied at T_w and the chamber illustrated in fig (2) long enough and the water surface is adopted, the leavening air was in saturated state and the dry bulb temperature equaling the interning wet bulb temp.

$$(T_{w_1} = T_{w_2} = T_{d_2} = T_s)$$

That is a constant wet bulb temp. process

Heat balance for the process

$$h_2 = h_1 + (w_2 - w_1) h_{fw}$$

$h_{fw} \rightarrow$ enthalpy of saturated water at (T_w)

$$h_1 = h_{a_1} + w_1 h_{g_1}$$

$$h_2 = h_{a_2} + w_2 h_{g_2}$$

usually $[(w_2 - w_1) h_{fw}]$ is very small and refer to as the correction term, h_2 & h_1 are calculated from

$$h = (1.007T - 0.026) + w(2501 + 1.84T)$$

∴ For all practical purpose adiabatic saturation be consider as constant enthalpy process as.

i.e. $h_2 = h_1 + D$

$$D = (w_2 - w_1) h_{fw}$$

Example

Air at 20 °c dry bulb and 15 °c wet bulb enters an adibatic where it is saturated and water enter the device at 15 °c, the barometric pressure 101.325 kpa. Find enthalpy o steam

sol

$P_{atm} = 101.325$ Kpa

$P_{v_1} = P_{sw_1} - P_B\, A\,(T_{d_1} - T_{w_1})$

P_{sw} from table at T_w

$P_1 = 1.37$ Kpa

$w_1 = \frac{P_{v_1}}{(P_{at} - P_{v_1})} = 0.00853$ Kgw/Kga

$h_1 = (1.005\, T_{d_1} - 0.026) + w_1 (2501 + 1.48\, T_{d_1}) = 41.76$ Kg/Kga

where is saturated state $T_{w_1} = T_{w_2} = T_s$ from table

$P_2 = P_s = 1.707$

$w_2 = 0.01066$ Kgw/Kga

$h = (1.005\, T_{w_2} - 0.026) + w_2 (2501 + 1.48\, T_{w_2}$

Q/ Prove that $W = 0.622 \frac{P_v}{P_a}$

Q/ Prove that $\phi = 100\%$ For saturated air

Sensible and latent heats

Sensible heat (Q_s): Is the heat added or removed from the moist air at constant moisture content (W).

Latent heat (Q_L): Is the heat added or removed from the moisture air at constant DBT i.e. increases or decreases its moisture contents.

Example DBT = 20 °C , WBT = 15 °C , P_B = 95 kPa

at T_w = 15 °C $\xrightarrow{\text{table}}$ P_{sw} = 1.704 kPa at WBT = 15 °C

① $P_v = P_{sw} - P_B * A (T_d - T_w)$
$= 1.388$ kPa

at T_d = 20 °C $\xrightarrow{\text{table}}$ P_{sd} = 2.337 kPa

② $\phi = \dfrac{P_v}{P_{sd}} = \dfrac{1.338}{2.337} = 59.5\%$

③ $W = 0.622 \dfrac{P_v}{P_a}$, $P_a = P_B - P_v = 95 - 1.388 =$ —

$W = 0.00923$ kgv/kga

④ Dew point at $P_v = 1.388$ kPa $\xrightarrow{\text{table}}$ $T_{d.p} = 12$ °C

⑤ specific volume

$V_a = m_a R_a T_d / P_a \rightarrow V_a = \dfrac{1*287*293}{93612} = 0.898$ m³

$V_v = \dfrac{m_v R_v T_v}{P_v} = \dfrac{0.00923*461*293}{} = 0.898$ m³

$W = m_v = 0.00923$ kgv/kga

$V = V_a = V_v$

⑥ $h = 1.005 * 293 + 0.00923 * (2501 + 1.84 * 293) = 43.5$ kJ/kg

Ex: The density of Air has been founded to be 0.018 kg/m3 with 26 °C DBT and Barometric pressure of 90 kPa. calculate the relative humidity

$$RH = \frac{P_v}{P_{sd}}$$

$$P_v = P_{sw} - P_B * A (T_d - T_w)$$

$$PV = mRT$$

$$P\nu = RT \qquad \text{at adibatic saturation}$$

$$P_v = \frac{R_v T_v}{V_v} \quad \& \quad P_{a_{sd}} = \frac{R_a T_d}{V_a}$$

$$RH = \frac{\frac{R_v T_v}{V_v}}{\frac{R_a T_a}{V_a}} = \frac{\rho_v}{\rho_a} \qquad R_v = R_a \qquad \Rightarrow \quad RH = 75\%$$

$$\rho_a = \frac{1}{40.936}$$

$$v_g = 40.936 \xrightarrow{\text{table}}$$

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Air-Conditioning and Refrigeration I

(Sheet No.1)

Q1/What is equivalent pressure in meters for water for the head of the air of300m assuming that the density of the air equals to 1.2kg/m^3.
Ans:.36m

Q2/with R = 462 J/kg.K to compute the specific volume of saturated vapor at 20 C.
Ans: 57.923 m^3/kg

Q3/15gm of water vapour exist in 1m^3 of air at 24°C and standard atmospheric pressure. Calculate the partial pressure of air .

Ans:99271.2 N/m^2

Q4/Air at 40°C and 80% relative humidity enters air an air-conditioner supplies air at 16°C and 96% relative humidity .find the amount of moisture removed by the cooling coil. Hint(barometric pressure =100kpa).

Ans:0.0295 kg_v/kg_a

Q5/Calculate the volume of an air-vapor mixture in cubic meters per kilogram of dry air when the following conditions prevail: t = 30 °C, W = 0.015 kg/kg, and pt = 90 kPa.
Ans:0.99 m^3/kg

Q6/An air-vapor mixture has a dry-bulb temperature of 30 °C and a humidity ratio of 0.015. Calculate at two different barometric pressures, 85 and 101 kPa, (a) the enthalpy and (b) the dew-point temperature.
Ans : a)68.3 kJ/kg ,b)17.5°C,20.3°C

Q7/Air at 30°C dry bulb and 20°C wet bulb flow with rate of 200m^3/h through humidification device which is used to increase the relative humidity . the outlet air have 20°C at saturated state Calculate the amount of evaporated water in the device knowing that the barometric pressure 101.325kpa.Hint(use mass balance)

Ans:0.988kg/h.