Lecture two

3- Dew point temperature: The saturation temperature corresponding to the actual partial pressure of the water vapour in air.

Or: It is the temperature at which the weight of water vapour associated with a certain weight of dry air is adequate to saturate that weight of air.

e.g: Find the dew point temperature for air at 20°C d.b. & 15°C w.b. &P_B=95kP_a.

Sol: $P=P_{sw}-P_B.A.(t_d-t_w)$

$=1.7051-95*6.66*10^{-4}(20-15)=1.388kP_a$

From table at 10°C $P=1.227kP_a$, at 15°C $P=1.7051kP_a$

Explanation for interpolation:

°C	P kp_a
10	1.227
T	1.388
15	1.7051

(15-10)(1.388-1.227) = (T-10)(1.7051-1.227)

$T=\frac{(15-10)(1.388-1.227)}{(1.7051-1.227)}+10=11.68°C$

Note: If this air which is at 20°C d.b. &15°C w.b. is cooled sensibly to a dry bulb temperature of (11.68°C) it would be saturated and $t_d=t_=t_w=d_{.p}$.

6- Enthalpy of air:

The total enthalpy of an air-water vapour mixture is the sum of enthalpies of dry air and enthalpy of water vapour.

i.e. $h=h_a+W.h_{fg}$ per kg of dry air.

Now, $h_a=C_p\,(t-tr)$

Where (t_r) is the reference temperature at which (h_a) is taken.

For air-water vapour mixtures, the reference temperature is taken as 0°C for both air and steam.

For air (h) is not a linear function of temperature and for steam assume (C_p) is constant. For a barometric pressure of (101.325kPa):

h_a=1.007t-0.026 for $0 \leq t \leq 60^oC$

& h_a=1.005t for $-10 \leq t < 0^oC$

h_g= 2501+1.84 t $0 < t < 60^oC$

(t) is in degree centigrade.

h = (1.007 t -0.026) + w (2501+1.84 t)

e.g: calculate the approximate enthalpy of moist air at a state of 20°C d.b. & 15°C w.b. and standard atmospheric pressure.

Sol:

: $P=P_{sw}-P_B.A.(t_d-t_w)$

$=1.7051-101.325*6.66*10^{-4}(20-15)=1.388kP_a$

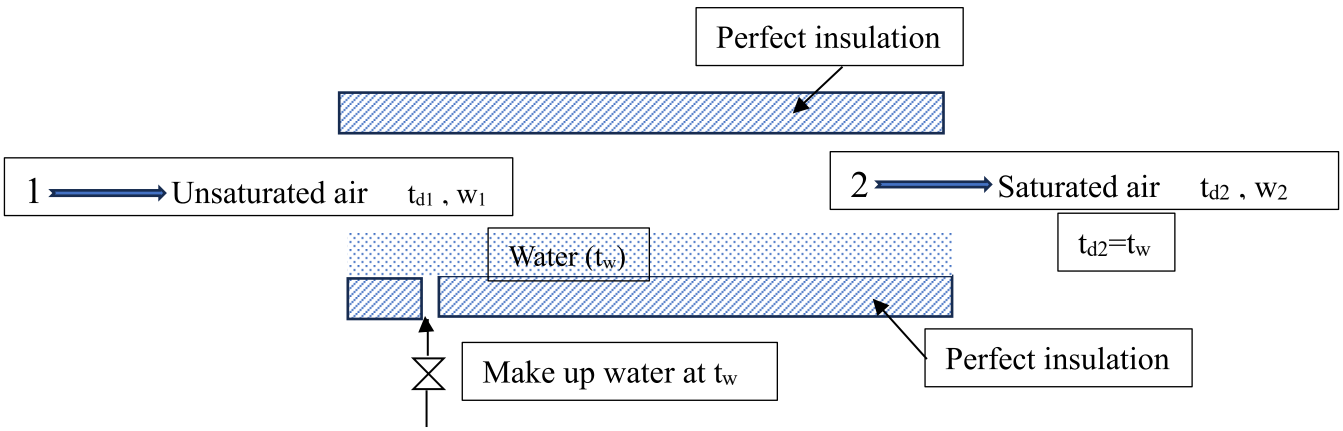
$W=0.622\frac{P}{P_B-P} = 0.622 * \frac{1.388}{101.325-1.388} = 0.008638$kg/kg dry air

h = (1.007 t -0.026) + w (2501+1.84 t)

=(1.007*20-0.026)+0.008638(2501+1.84*20)

=20.114+21.9215=42.035kJ/kg dry air.

7- Adiabatic saturation:



Adiabatic process in which no external heat flows in or out of the system, but interchange of energy can occur. Water is supplied at (t_w). If the chamber is long enough and the water surface is adequate, experiments show that air leaves in a saturated state and at dry bulb temperature equaling the initial wet bulb temperature. i.e. $t_{w1}=t_{w2}$.

$t_{d2}= t_{w1}=t_{w2}=t_w$

i.e. a constant wet bulb temperature process.

Heat balance for the process.

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

where h_{fw} = enthalpy of saturated water at (t_w).

Note: $h_2=h_{a2}+w_2h_{g2}$ &$h_1=h_{a1}+w_1h_{g1}$

Usually $(w_2-w_1)h_{fw}$ is very small and referred to as the corrective term. h_2 & h_1 are calculated from equation

$h = (1.007\, t -0.026) + w\,(2501+1.84\, t)$

For all practical purposes adiabatic saturation may be considered as a constant enthalpy process.

i.e. $h_2=h_1+D$, $D=(w_2-w_1)h_{fw}$ (corrective term)

e.g: Air at 20°C & 15°C enters an adiabatic device where it is saturated, water enters the device at 15°C, the barometric pressure is 101.325kPa. Find the initial and final enthalpies of this stream.

Sol: From the previous example:

P_1=1.388kPa , w_1=0.008638kg/kg dry air., h_1=42.035kJ/kg.

At exit for saturated air $t_{d2}=t_w$=15°C. & P_2=1.7051kPa from table.

$W_2=0.622\frac{P_2}{P_B-PP_2}=0.622*\frac{1.7051}{101.325-1.7051}=0.010646$kg/kg dry air

$h_2 = (1.007\ t - 0.026) + w\ (2501+1.84\ t)$

=(1.007*15-0.026)+0.010646(2501+1.84*15)

=15.079+26.919=41.998kJ/kg dry air.

| | (comp. the difference nearly (5) (i.e. sensible heat converted to latent)

h_1=20.114+21.9215=42.035kJ/kg.

h_2-h_1=41.998-42.035=- 0.037kJ/kg.

$D=(w_2-w_1)h_{fw}$=(0.010646-0.008638)*62.99=0.1248kJ/kg dry air.