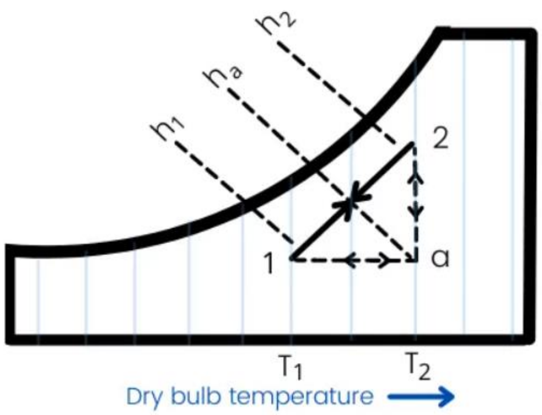
Lecture four

# Sensible heat ratio (S.H.R)

$$S.H.R = \frac{sensible\ heat}{sensible\ heat + latient\ heat}$$



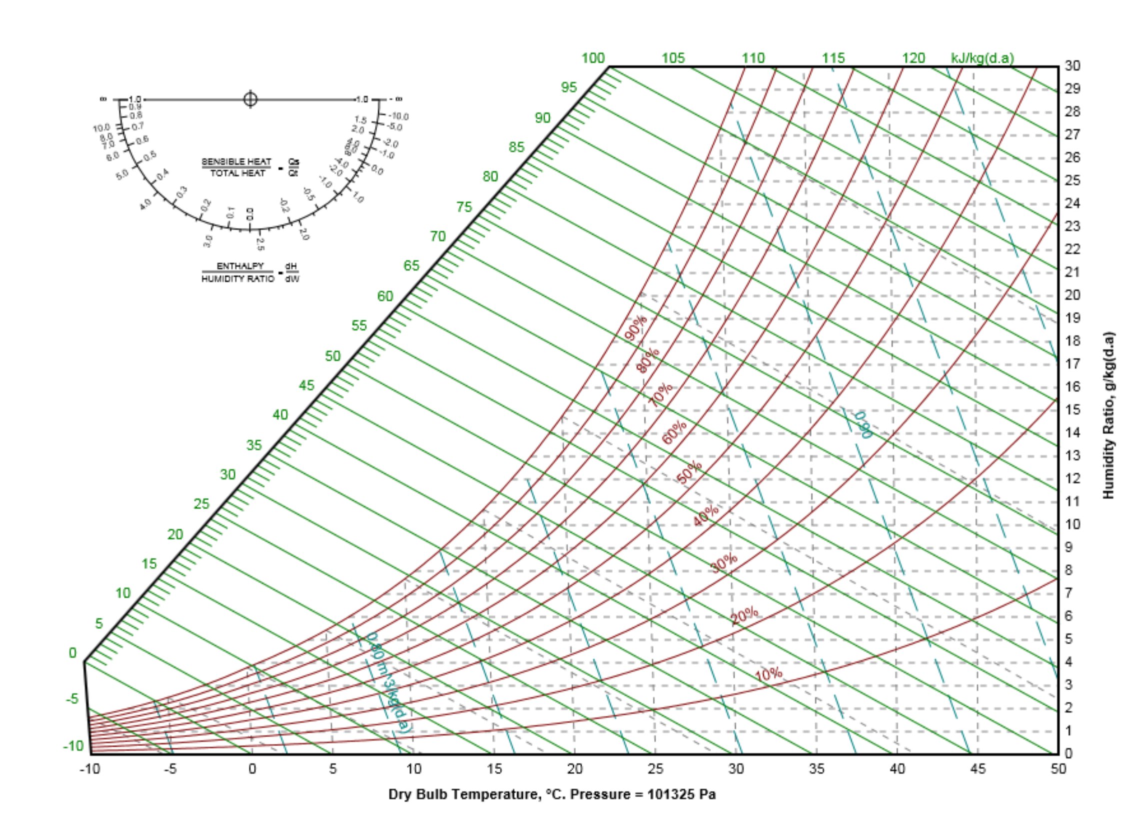

Process 1-2 indicates the total heating or cooling process.

While process 1-a indicates the part of heat used for sensible heating or cooling and process a-2 indicates the part of heat used for latent heating or cooling.

Therefore, the sensible heat ratio (SHR) is given by,

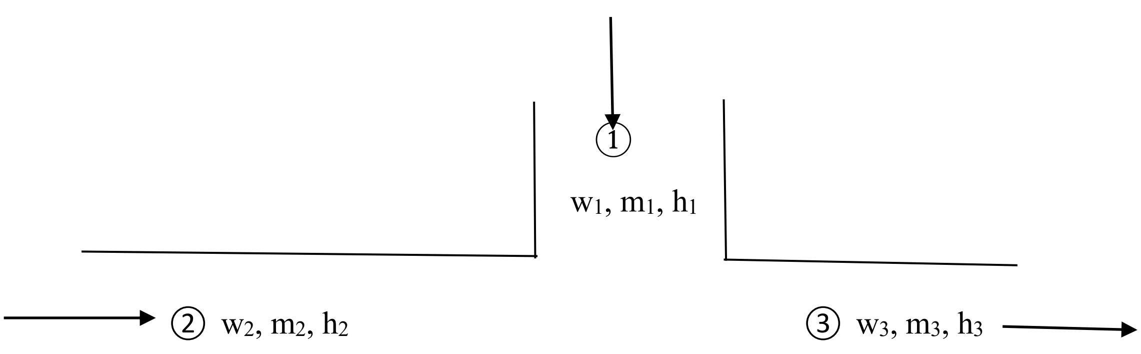
$$SHR = \frac{sensible\ heat}{sensible\ heat + latient\ heat} = \frac{h_a - h_1}{(h_a - h_1) + (h_2 - h_a)} = \frac{h_a - h_1}{(h_2 - h_1)} = \frac{sensible\ heat}{Total\ heat}$$

There are actually two SHR scales on the chart, the protractor shaped on the left side and a vertical axis on the right side.




## 2-Air mixing:

When two air streams are mixed without external heating or cooling, the process is considered adiabatic, and transfer of heat & moisture is internally conserved.



Mass conservation:

$m_1+m_2=m_3$ ………… (a)

For water vapour mass:

$m_1w_1+m_2w_2=m_3w_3$ ………… (b)

Enthalpy balance:

$m_1h_1+m_2h_2=m_3h_3$ …………... ©

subtract ($m_1w_3$) from both sides of equation (b):

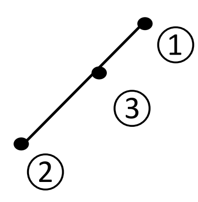
$m_1w_1- m_1w_3+m_2w_2=w_3(m_3-m_1)=w_3m_2$

$m_1(w_1-w_3)=m_2(w_3-w_2)$

$$\frac{w_1-w_3}{w_3-w_2}=\frac{m_2}{m_1}$$

Similarly for enthalpy:

$$\frac{h_1-h_3}{h_3-h_2}=\frac{m_2}{m_1}$$




From the above we conclude that the three states point must lie on a straight line in a coordinate system of mass and energy.

Note: length 2-3 is proportional to mass at state ①.

length 1-3 is proportional to mass at state ②.

e.g: Moist air at 60°C d.b. & 32°C w.b. & standard atmospheric pressure mixed adiabatically with moist air at 5°C d.b. & 1°C w.b. & standard atmospheric pressure. If the masses of dry air are 3kgs & 2kgs respectively, calculate the enthalpy, specific humidity & dry bulb temperature of the mixture.

Sol:

$W=0.622* \frac{P}{P_B-P}$

$P_1=P_{sw}-P_B.A.(t_d-t_w)$

$=4.7596 – 101.325*6.66*10^{-4} *(60-32) =2.8702$ kPa.

$W_1= 0.622 * \frac{2.8702}{101.325-2.8702} = 0.01813$ kgw/kg d.a.

$h_1 = (1.007\ t -0.026) + w\ (2501+1.84\ t)$

$=(1.007*60 – 0.026) + (2501+1.84*60) = 107.738$kJ/kg

$P_2 = P_{sw}-P_B.A.(t_d-t_w)$

$= 0.6571- 101.325*6.66*10^{-4} *(5-1) = 0.38717$kPa

$w_2=0.622* \frac{0.38717}{101.325-0.38717} = 0.002385$ kg/kg dry air.

$h_2= (1.007*5-0.026) + 0.002385(2501+1.84*5) = 10.995$ kJ/kg.

from mass balance for moisture.

$W_3=\frac{m_{1}w_1+m_{2}w_2}{m_1+m_2}$ from equation (b) as $m_3=m_1+m_2$

$=\frac{3*0.01813+2*0.002385}{3+2}=0.011832$ kgw/kg d.a.

Likewise, from equation ©.

$h_3=\frac{m_{1h_1}+m_{2h_2}}{m_1+m_2}=\frac{3*107.738+2*10.995}{3+2}=69.0408$ kJ/kg d.a.

to find the dry bulb temperature.

$h_3 = (1.007\ t_3 - 0.026) + w_3\ (2501+1.84\ t_3)$

$69.0408= (1.007\ t_3 - 0.026) + 0.011832\ (2501+1.84\ t_3)$

$69.0408 + 0.026 - (0.011832*2501) = t\ (1.007+0.011832*1.84)$

$t_3=38.37^oC.$

temperature may be obtained from a temperature balance for normal conditions thus.

$m_3t_3=m_1t_1+m_2t_2$

$t_3=\frac{m_{1t_1}+m_{2t_2}}{m_3}=\frac{3*60+2*5}{5}=38^oC$

Note: this approach is basically wrong since it assumes air is dry. However, it gives approximate results with tolerable error.

To calculate $t_{wb}$ [$P=P_{sw}-P_B.A.(t_d-t_w)$]