Lecture seven

Water injection.

The simplest case to consider and one that provides the moist insight into change of state of the air stream subjected to humidification by the injection of water is where ***all the injected water is evaporated***. The following figure shows what happens when total evaporation occur, air enters a spray chamber, all injected water being evaporated, no falling to the bottom of the chamber to run to waste or to be circulated. The feed water temperature is important to release that since total evaporation has occurred. State 2, 3 and 4 must be lie nearer to the saturation curve, but just how nearer will depend on the amount of water injected. Two equations, a heat balance and mass balance, provide the answer required:

$h_1+h_w=h_2$

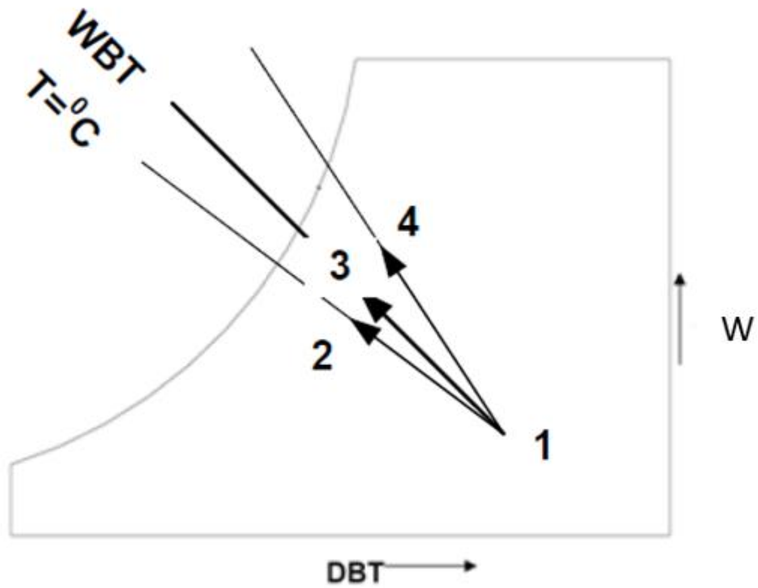
$m_{a1}+m_w=m_2$

$W_2=m_a+m_w$ the associated kg of dry air be ignored.

m_w: the amount of feed water in kgw/kga flowing through the spray chamber.

Applying the heat balance:

$$h_1+h_w=h_2=(1.007DBT_2 -0.026) + W_2(2501 +1.84DBT_2)$$



humidification by water injection

Humidification by steam injection

Steam injection may be dealt with by consideration at a mass and energy balance.

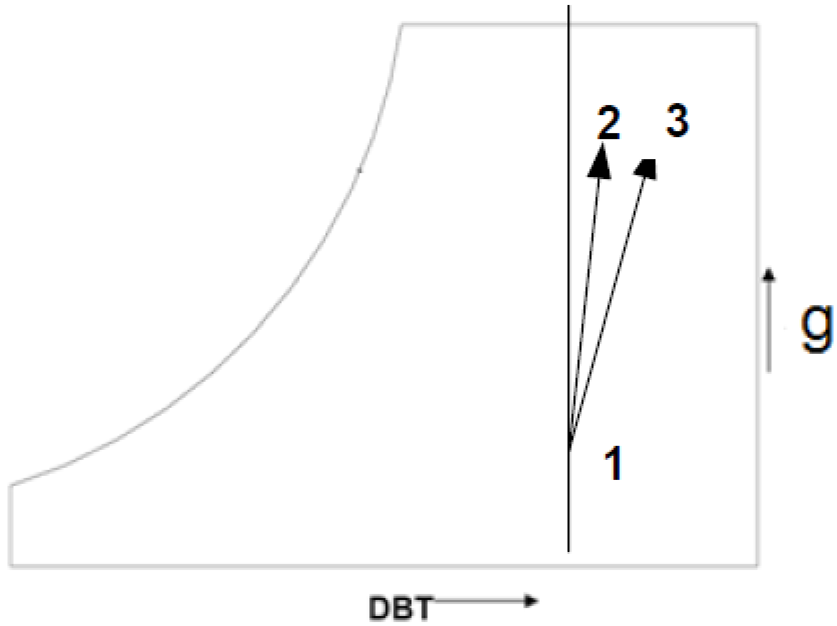
$W_2 = W_1 + m_s$

m_s: mass of steam injected in kg into one kg/s of dry air stream.

$h_2 = h_1 + m_s h_s$

The change of state takes place almost along a line of constant DBT between limits defined by smallest and largest enthalpies of injected steam, provided the steam is in dry saturated condition. The following figure shows the possibility of steam injection.

The lowest possible enthalpy is for dry saturated steam at 100° C, the other extreme is provided by the steam which has maximum enthalpy at 2804.2 kJ/kg, which is exist at 30 bar and 233.9° C.



Example 1:

Dry saturated steam at 100° C is injected at a rate of 0.01 kg/s into a moist airstream moving at a rate of 1 kg of dry air per second and initially at a state of 28° C DBT, 12° C WBT and 101.325 kPa. barometric pressure. Calculate the leaving state of moist airstream.

Solution:

from the psychrometric chart h1=33.2 kJ/kg W_1=2.1 gw/kga

hg=2676.1 kJ/kg from table at (100°C and 101.325 kPa).

W_2=2.1gw/kg d.a+(10gw/s /1kg d.a/s)=12.1gw/kga =0.0121kgw/kg d.a.

h2=33.2+0.0121x2676.1=65.58kJ/kg

65.58=(1.007 DBT2-0.026) + 0.0121(2501+1.84DBT2)

DBT2=34.34° C

Example 2:

Dry saturated steam with maximum enthalpy is injected at a rate of 0.01 kgw/s into a moist air stream moving at a rate of 1 kg of dry air per second and initially at a state of 28° C DBT, 12° C WBT and 101.325 kPa barometric pressure. Calculate the leaving state of moist airstream.

Solution:

From the psychometric chart h1=33.2 kJ/kg W_1=2.1g/kga, the maximum enthalpy of steam is 2804.2 kJ/kg at 30 bar and 233.9° C saturated.

$W_3 = W_1 + 0.01$kgw/s /1kg/s =0.0021+0.01=0.0121kgw/kg d.a

$h_3 = h_1 + W_3 * h_g$

h3=33.2+0.0121x2804.2=67.13kJ/kg

67.13=(1.007DBT3-0.026)+0.0121(2501+1.84DBT3)

DBT3=35.84° C

It can be seen from examples 1 and 2 for the range of states considered, the change in DBT is not very great, so, we can conclude that, the change of state following **steam injection is up a line of constant Dry Bulb Temperature.**