Study of air humidification processes

Objective:

Study of air humidification processes of steam and water spray with psychometrics chart from experimental data.

Theory:

The operating principle of this unit is as follows: a stream of air generated by a centrifugal fan is made to pass through a tunnel via a fluid thread rectifier. As it goes through the tunnel the air undergoes a series of treatments until it reaches a final chamber representing the environment to be conditioned. The air is initially humidified by means of water diffusers (spray), then humidified by means of steam diffusers and finally conveyed into the end chamber.

Humidification:

In a humidifying process, water vapor is added to moist air and increases the humidity ratio of the moist air entering the humidifier if the moist air is not saturated. Large-scale humidification of moist air is usually performed by steam injection, evaporation from a water spray, atomizing water, a wetted medium, or submerged heating elements.

Water spray:

The effect of spraying water into an airstream will be as shown in (Fig -1,a) , assuming that the air is not already saturated. Evaporation will take place and the water will draw its latent heat from the air, reducing the sensible heat and therefore the dry bulb temperature of the air (Fig -1,b).

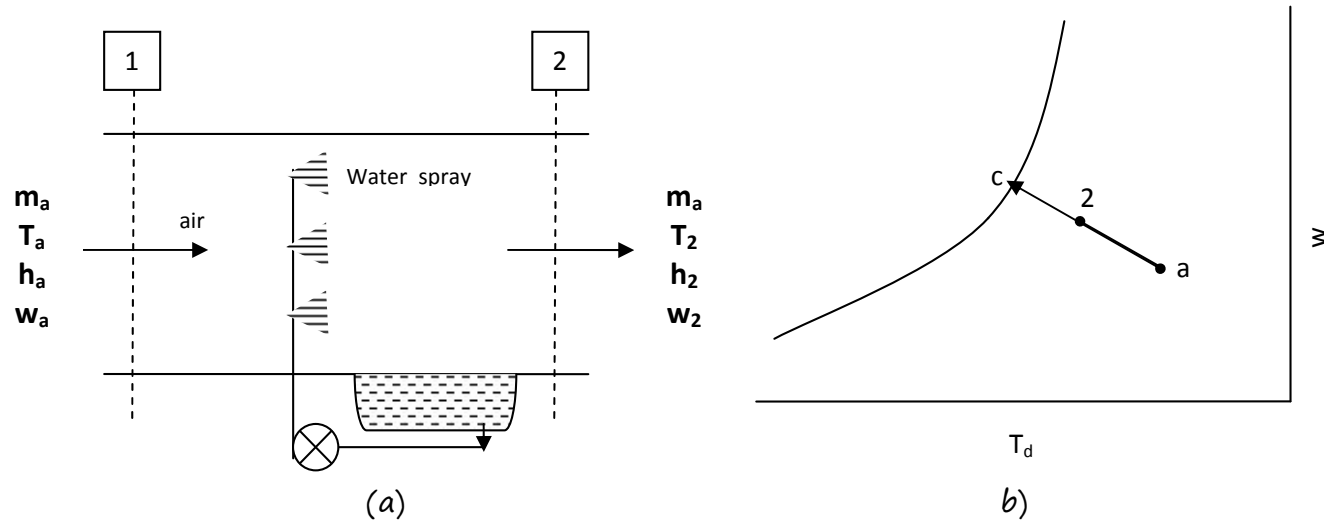


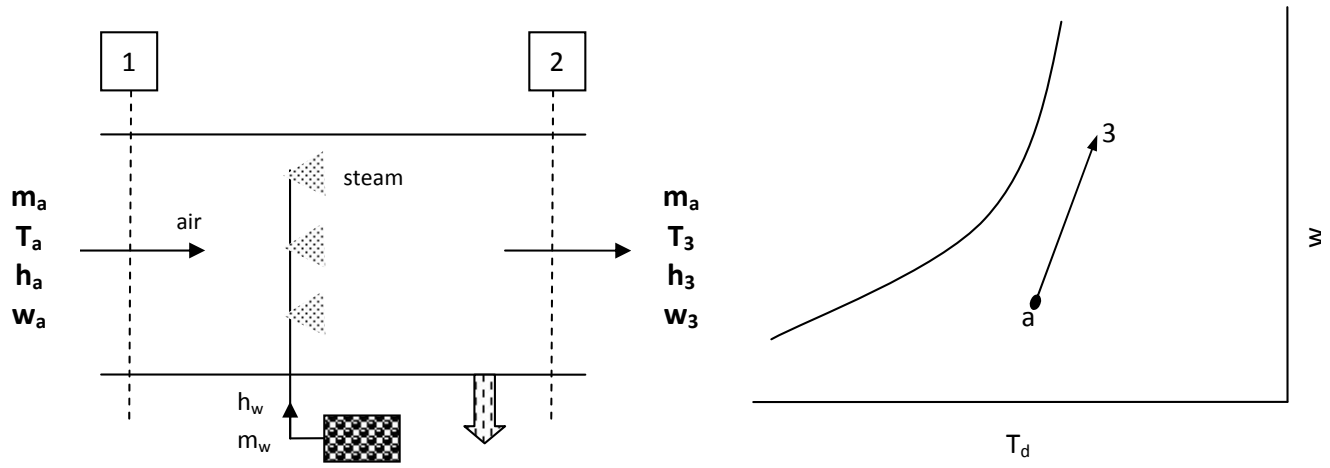
Fig.-1

The ultimate condition of the mixture; no heat is being added or removed in this process, so the enthalpy must remain constant, and the process is shown as a movement along the line of constant enthalpy. Latent heat will be taken in by the water, from the sensible heat of the air, until the mixture reaches saturation, when no more water can be evaporated.

It should be noted that this ultimate condition is difficult to reach, and the final condition in a practical process would fall somewhat short of saturation, possibly to point C in (Fig -1,b). The proportion A2/AC is termed the *saturation efficiency* of the spray system. The adiabatic (constant enthalpy) line A2 is almost parallel to the line of constant wet bulb.

Steam injection

Moisture can be added to air by injecting steam, i.e. water which is already in vapour form and does not require the addition of latent heat (Fig -2,b). Under these conditions, the air will not be cooled and will stay at about the same dry bulb temperature. The steam will be at 100°C when released to the atmosphere (or may be slightly superheated), and so raises the final temperature of the mixture. Where steam is used to raise the humidity slightly, the increase in dry bulb temperature is small.



(a) (b)

Fig.-2

Procedure:

1. Turn on the study unit.
2. Calculate air velocity inside testing tunnel after turning on the centrifugal fan .
3. Measure the dry and wet bulb temperatures of ambient (T_{da},T_{wa}) .
4. Turn on water spray humidifier.
5. Measure the dry and wet bulb temperatures after spray humidifier (T_{d2},T_{w2}).
6. After turning off spray humidifier turn on the steam humidification.
7. Measure the dry and wet bulb temperatures after steam humidifier (T_{d3},T_{w3}).
8. Turn off the study unit .

Results and calculations:

$Q = V * A$ (m^3/s) V : air velocity (m /s)

A : tunnel area = $\pi D^2/4$ (m^2)

Mass flow rate through the tunnel

$m_a = Q/\upsilon$ (Kg/s) υ :specific volume of air

1- saturation efficiency (η_s) = $\frac{T_a - T_2}{T_a - T_c} = \frac{w_2 - w_a}{w_c - w_a}$

T_a : dry temperatures of the ambient. (^oC)

T_2 : dry temperature after spray humidifier. (^oC)

T_c : dry temperature after spray humidifier at 100 % saturation line . (^oC)

W_2 : humidity ratio of air after spray humidifier. (Kg_{ma} /Kg_{da})

W_c : humidity ratio of air after spray humidifier at 100 % saturation line. (Kg_{ma} /Kg_{da})

2- steam flow rate $\mathbf{m_w = m_a (w_3 - w_a)}$ (g steam/s)

enthalpy of steam :

$h_w = \frac{h_3 - h_a}{w_3 - w_a} = \frac{\Delta h}{\Delta w}$ (KJ/Kg)

h_a :enthalpy of air entering tunnel (KJ/Kg)

h_3: enthalpy of air after steam humidification (KJ/Kg)

h_w: enthalpy of steam (KJ/Kg)

w_a: humidity ratio of air entering tunnel (Kg_{ma} /Kg_{da})

w_3: humidity ratio of air after steam humidification (Kg_{ma} /Kg_{da})

Discussion:

1. Discuss the enthalpy of steam humidification with ($\frac{\Delta h}{\Delta w}$) from chart and the humidity ratio through the process.

2. Discuss the enthalpy and humidity ratio of water spray humidification with respect to steam humidification.