The Psychrometry of Air-conditioning processes

What is the difference between sensible and latent heat?

Sensible heat

When an object is heated, its temperature rises as heat is added. The increase in heat is called sensible heat. Similarly, when heat is removed from an object and its temperature falls, the heat removed is also called sensible heat. Heat that causes a change in temperature in an object is called sensible heat.

Latent heat

All pure substances in nature are able to change their state. Solids can become liquids (ice to water) and liquids can become gases (water to vapor) but changes such as these require the addition or removal of heat. The heat that causes these changes is called latent heat.

Latent heat however, does not affect the temperature of a substance - for example, water remains at 100°C while boiling. The heat added to keep the water boiling is latent heat. Heat that causes a change of state with no change in temperature is called latent heat.

Appreciating this difference is fundamental to understanding why refrigerant is used in cooling systems. It also explains why the terms 'total capacity' (sensible & latent heat) and 'sensible capacity' are used to define a unit's cooling capacity. During the cooling cycling, condensation forms within the unit due to the removal of latent heat from the air. Sensible capacity is the capacity required to lower the temperature and latent capacity is the capacity to remove the moisture from the air.

1. Sensible cooling:

During this process, the moisture content of air remains constant but its temperature decreases as it flows over a cooling coil. For moisture content to remain constant the surface of the cooling coil should be dry and its surface temperature should be greater than the dew point temperature of air. If the cooling coil is 100% effective, then the exit temperature of air will be equal to the coil temperature. However, in practice, the exit air temperature will be higher than the cooling coil temperature. Figure 2 shows the sensible cooling process 1-2 on a psychrometric chart.

The heat transfer rate during this process is given by:

$$Q_T = \dot{m}_a(h_1 - h_2)$$

$$Q_T = \dot{m}_a C_{pa}(DBT_1 - DBT_2)$$

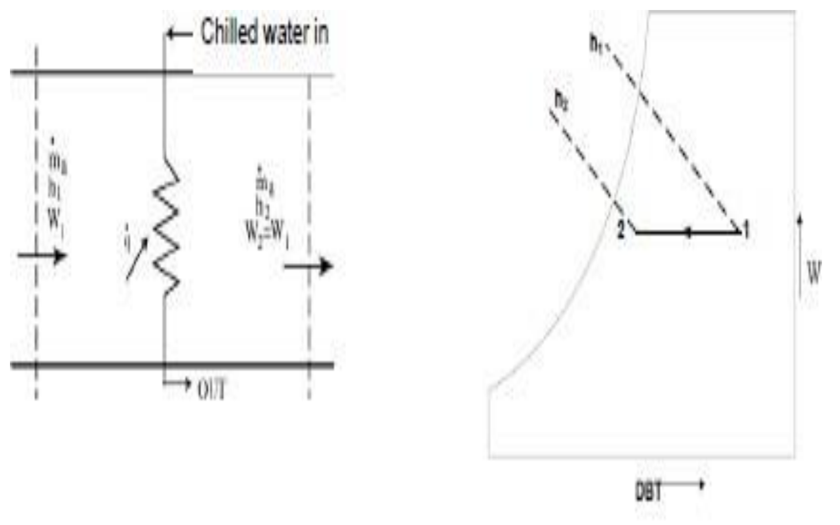


Figure 2 Sensible cooling

2- Sensible heating

During this process, the moisture content of air remains constant and its temperature increases as it flows over a heating coil, as shown in figure 3. The heat transfer rate during this process is given by:

$$Q_T = \dot{m}_a(h_2 - h_1)$$

$$Q_T = \dot{m}_a C_{pa}(DBT_2 - DBT_1)$$

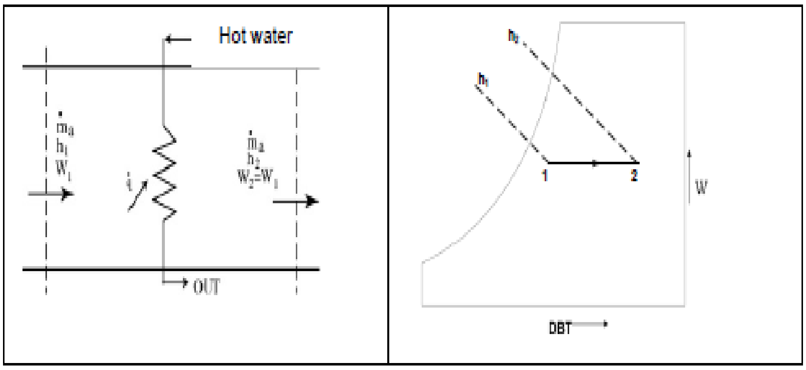


Figure 3 Sensible heating

The variation in the physical properties of the moist- air for the two cases, are summarized below:

properties	Sensible heating	Sensible cooling
P_s	constant	constant
w	constant	constant
D.P	constant	constant
DBT	increase	decrease
WBT	increase	decrease
v	increase	decrease
h	increase	decrease
RH	decrease	increase

Example1:

Calculate the load on a battery when heats 1.5 m3/s of moist-air, initially at a state of 21 ^oC DBT, 15 ^oC WBT and 101.325kPa barometric pressure, by 20 ^oC. if low pressure water at 85 ^oC flow and 75 ^oC return is used to achieve this. Calculate the mass flow rate necessary of water.

$Q_{1-2} = m_a (h_2 - h_1)$

from the chart

h_1= 41.88 kJ/kg

h_2 = 62.31 kJ/kg

υ_1 = 0.8439 m^3/s

$$\dot{m} = \frac{\dot{V}}{v_1} = \frac{1.5}{0.8439} = 1.777 \text{ kg / s}$$

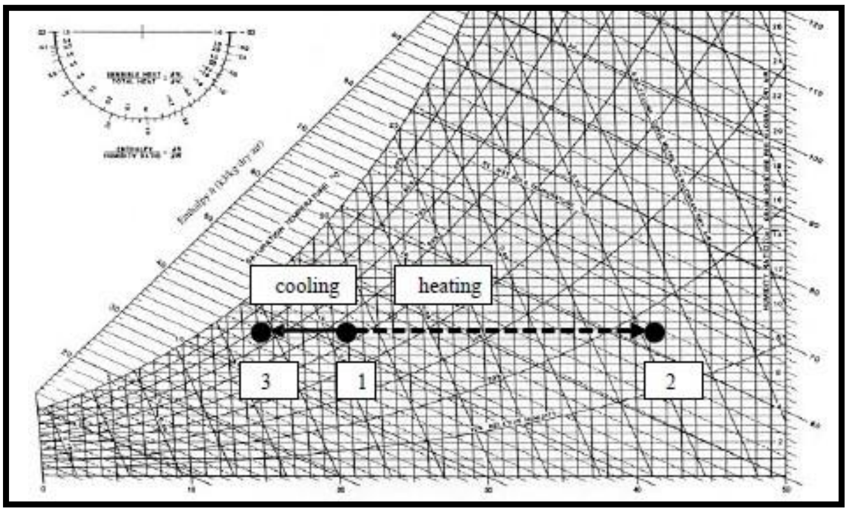
$Q_{1\text{-}2} = 1.777\ (62.31 - 41.88) = 36.3\text{kW}$

Heat gain by moist-air= heat lost from

the water $Q = m_w\ .c_w.(t_{wout} - t_{win})$

$36.3 = m_w \times 4.186 \times (85-75)$

$m_w = 0.867 kg_w/s$



Example2:

If the moist-air mentioned in example 1 is cooled sensibly by 5 oC using cooler coil, what is the flow rate of chilled water necessary to effect this cooling if the flow return temperature of 10^{o}C and 15 ^{o}C satisfactory.

$Q_{1\text{-}2} = m_a\ (h_1 - h_3)$

$h_3 = 36.77$ kJ/kg

$Q_{1\text{-}2} = 1.777\ (41.88 - 36.77) = 9.1\text{kW}$

Heat lost from air = heat gain by water

$9.1 = m_w \times 4.186 \times (15-10)$

$m_w = 0.434\ kg_w/s$