INTERNAL ENERGY

Conduction, convection and radiation are the three possible modes of heat transfer between systems and between system and its surroundings.

Conduction occurs without bulk movement of molecules. Energy transfer in conduction is due to lattice vibration and free electron movement. It is the predominant mode of heat transfer in solids.

Convection occurs with bulk movement of molecules and therefore, occurs in gases and liquids. If the bulk movement or flow is due to an external device, it is known as forced convection. In the absence of an external device the flow is due to the difference in density caused by the temperature difference. This mode is known as natural convection.

Bodies separated by a distance may exchange heat in the form of electromagnetic waves without the participation of the intervening medium. It is known as radiation. It is generally a surface phenomenon. Sometimes as in the case of gas mixtures containing carbon dioxide and water vapour it is a volume phenomenon.

2.14 Sensible and Latent Heat

It is known that a substance can exists in three phases namely solid, liquid and gas. When a substance is heated or cooled temperature of the substance increases or decreases respectively unless there is any phase change. Quantity of heat added or removed to change the temperature by unit degree is known as specific heat. For solids and liquids same quantity of heat is required to cause unit degree rise for both constant pressure heating as well as constant volume heating as they are incompressible. But for gases there is appreciable difference in the quantity of heat required to cause unit difference in temperature between constant volume and constant pressure processes. Accordingly, they are known as specific heat at constant volume (C_V) and specific heat at constant pressure (C_P).

Thus to increase the temperature of m kg of the given substance by ΔT degree, amount of heat required is given by

$$Q = mC_V\Delta T \text{ at Constant Volume} \quad ...(2.5)$$

$$Q_1 = mC_P\Delta T \text{ at Constant Pressure} \quad ...(2.6)$$

If a certain single component system is undergoing phase change at constant pressue, temperature of the system remains constant during heating or cooling. Quantity of heat removed or added to cause the change of phase of unit mass of the substance is known as latent heat. For example latent heat of fusion of water is the amount of heat to be removed to solidify 1 kg of water into 1 kg of ice at a given temperature.

Let us consider a process of converting 1 kg of ice at –30°C to system to steam at 250°C at atmospheric pressure. We know that ice melts at 0°C and water evaporates at 100°C at atmospheric pressure.

For a constant rate of heating, if temperature at different instants are plotted we will get a graph as shown in Figure 2.9.

The total heat required can be obtained as follows:

$$Q = Q_{ab} + Q_{bc} + Q_{cd} + Q_{de} + Q_{ef} \quad ...(2.7)$$

$$Q_{ab} = mC_{ice}\,(t_b - t_c) \quad ...(2.8)$$

Q_{bc}= Latent heat of melting of ice at 0°C

Q_{cd} =mC_{water} (t_d–t_c) ...(2.9) Q_{de}= Latent heat of evaporation of water at 100°C

Q_{ef} =mC_{PSteam} (t_f - t_e) ...(2.10) Where C_{ice} = Specific heat of ice

C_{water} = Specific heat of water

C_{PSteam}= Specific heat of steam at constant pressure