The First Law of Thermodynamics : Closed Systems

1^{st} law of thermodynamics pointed out energy can be neither created nor destroyed. It can only change forms. This law simply be stated as follows;

- During an interaction between a system and its surroundings, the amount of energy gainned by system must be exactly equal to the amount of energy lost by the surroundings.

Energy can cross the boundry of a closed system in two different forms: heat and work.

Heat

Heat is defined as the form of energy that is transferred between two systems by virtue of temperature difference.

When a system is left in a medium that is at a different temperature energy transfer takes place between the system and medium until thermal equation is established (Medium and system reach the same temperature).

Direction of energy transfer is always from the higher temperature to lower temperature. This type of energy transfer is called heat transfer. Heat transfer only takes places if the temperature difference occurs.

If in a process no heat transfer occured: we called thiis system is adiabatic. Two conditions can provide adiaatic systems;

- Well insulated processes
- Same temperature (Isothermal) processes

Adiabatic processes may not be an isothermal processes. Yes, there is no heat transfer ooccurs in adiabatic process but there isa change to ocur work transfer and as a result of this transfer temperature may change.

Heat denoted by "Q" or "Q_{12}" (means heat transfer states 1 to 2)

Q [≡] kj

means heat transfer per unit time basis or in other word rate of heat transfer

[≡] kj/s [≡] kW

Modes of Heat Transfer

Heat can be transferred in three different ways.

1. **Conduction**

In conduction, particles transfer its energy from more energetic particles to the less energetic adjacent ones as a results of interactions between the partcicles.

Conduction can takes place in solids, liquids and gases. Gases and liquids conduction occurs collisions of the molecules. In solids conduction occurs vibration of molecules in lattice structure and energy transfer of free electrons.

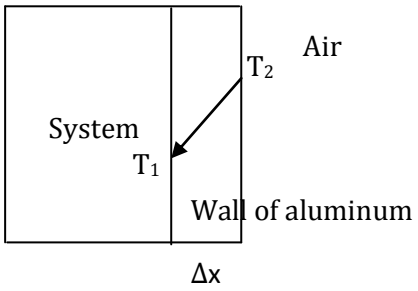

Fig. 1 Sketch of conduction mechanism

Rate of heat conduction through a layer of constant thickness proportional to the temperature differences across the layer and the area to the direction of heat transfer.

$$= k_t * A * — \quad (1)$$

Here, k_t is thermal conductivity coefficient and this number is unique with all materials.

If $\Delta x \rightarrow 0$, equation reduces to the differential form;

$$= – k_t * A * — \quad (2)$$

Equation (2) knowns Fouriers law of heat conduction. Fouriers law indicates thatt the rate of heat conduction in a dimension is proportional to the temperature gradient inn that direction. Heat is conducted in the direction of decreasing temperature and temperature gradient becomes negative.

2. **Convection**

Convection is a type of energy transfer between a solid surface and the adjacent liquid or gas. Convection includes combined effects of conduction and fluid motion. Convection examined in two phase.

1. Natural Convection: Fluid motion caused by buoyancy forces induced by density differences due to the variation of temperature in the fluid is called free (natural convection.
2. Forced Convection: Fluid is forced to flow over a surface by externally such as a aif oof fani pump etc. is called forced convection.

$$= h * A * (T_s - T_f) \quad (3)$$

Here, h is convective heat transfer coefficient. This coefficient is not a property of fluid and it must be determined by experimmentally.

3. Radiation

Radiation is the energy emitted by matter in the form of electromagnetic waves as a result of the changes in the electronic configurations of the atom sor molecules. Radiation heat transfer is a complex heat transfer method but we are not too interested in thermodynamics processes.