**CHAPTER-1**

From thermodynamics you have gained the knowledge that there could be energy exchange between the system and the surroundings.

These energy exchanges are work and heat.

Work

* Shaft work – for closed and open systems, the energy is transferred across the boundary by a rotating shaft.
* PV work -closed and open systems -due to volume exchange
* Flow work – open systems- required to push the liquid /gas (fluid) into or out of the boundaries of the system
* Electrical work

There are 3 questions to answer:

What is heat transfer?

How is heat transferred?

Why is it important?

Heat transfer is the thermal energy transit due to a spatial temperature difference, temperature gradient.

When there is a temperature difference between the system and the surroundings or at any points within the system, heat transfer will occur.

Some common symbols used in heat transfer

q : Heat transfer rate (J/s or W)

q’’ : Heat flux, Heat transfer rate per unit area (W/m2) , area is the one that is perpendicular (normal) to the direction of heat transfer

q’ : Heat transfer rate per unit length (W/m)

**Heat flux by conduction in direction x:**

$q^{''}\_{cond,x}=-k\frac{dT}{dx}$ Fourier’s Law

dT/dx is the temperature gradient

k is the thermal conductivity /conductivity of a material, it is a physical property. A material that readily transfers heat by conduction is a good thermal conductor and has high k.

For most solids and liquids, k=f(T) , ksolid>kliquid>kgas . This is due to the difference in intermolecular spacing for the states of matter. Unit for k is W/m.K.

$q\_{cond,x}=-kA\frac{dT}{dx}$ , A is the area perpendicular to the direction of heat transfer

The reason that we have a minus sign is that heat transfer occurs in the direction of decreasing temperature.

Under steady-state conditions ( Accumulation=0), the temperature distribution is linear with x-direction.

 T=ax+b …………. dT/dx =(T1-T2)/L

 $q^{''}\_{cond,x}=-k\frac{T-T2}{L}=k\frac{T2-T1}{L}=k\frac{∆T}{L}$

**Heat Transfer relation to Thermodynamics**

The basic thing that you perform for thermodynamic problems is to establish energy balance; application of 1st law of themodynamics for the systems.

Closed system : ∆U = Q + Wc

Open system : $∆\dot{H}$= $\dot{Q+}$ $\dot{Ws}$ (under steady state)

$\dot{Estored}$ = $\dot{Ein}- \dot{Eout}\dot{+ Eg}en$ (for an open system)

------------------------Advice: Always make reviews form the text book ----------------------------------------------

Convection occurs between the fluid in motion and a boundary surface when two are at different temperatures. The convection heat transfer mode can occur in two mechanisms: energy transfer due to random molecular motion (diffusion), energy transfer by the bulk, or macroscopic, the motion of the fluid.

$q''\_{conv}=h \left[Ts-T\_{\infty }\right]$ Newton’s Law of Cooling

h : convective heat transfer coefficient . It is a physical feature of matter.

Unlike k, h is dependent on a few more factors. Since fluid dynamics plays a vital role in the analysis of convection. You may expect h being influenced by the geometry, nature of the fluid, fluid thermodynamics and transport properties.

Radiation (Thermal radiation) is the energy emitted by matter at non-zero temperature.

The most effective medium for radiation is vacuum.

$$q''\_{rad}= εσ (T\_{s}^{4}- T\_{surr}^{4}) $$

$ε$ : emissivity : radiative property of the surface

0$\leq ε\leq 1$, $σ$ is the Stefan-Boltzman constant: $σ$=5.67 x 10-8 W/m2K4.

This property provides a measure of how efficiently a surface emits energy relative to a blackbody.

Blackbody is an ideal radiator. It is an idealized physical body that absorbs all incident electromagnetic radiation. Besides, it is an ideal emitter. It emits much more radiation as any other body at the same temperature.

The Concept of Resistances

Under steady-state condition, the heat flux by conduction is:

$q''\_{cond,x}=-k\frac{dT}{dx}$ transforms into $q''\_{cond,x}=-k\frac{∆T}{L}$

$q''\_{cond,x}=-\frac{∆T}{L/k}$ …………………$∆T$ is the driving force

RT= L/k is the resistance associated with conduction.

As L $\uparrow $ RT $\uparrow $ less heat transfer you will obtain

As k$\uparrow $RT $\downright $ more heat transfer you will obtain