CEN 3311 HEAT TRANSFER

3. Heat transfer by conduction (One Dimensional unsteady-state)

Three types of problems to be discussed only;

a) Simplified case for the systems with negligible internal resistance (Lumped System Analysis)

b) Infinite body subjected to sudden convective

c) Transient heat flow in semi infinite solid:

Graphical solutions of unsteady state heat conduction problem, use of various charts for b and c

Example:

Properties of metal sphere:
ρ=3000 kg/m^3, k=20 W/mK, Cp=1000 j/kgK, α=6.66x10^{-6} m^2/s

r = 0.05 m

Ti=400°C

T∞ =20°C

To=335°C

Using Figure 6 →

$$\frac{T_0 - T_\infty}{T_i - T_\infty} = \frac{335 - 20}{400 - 20} = 0.83$$

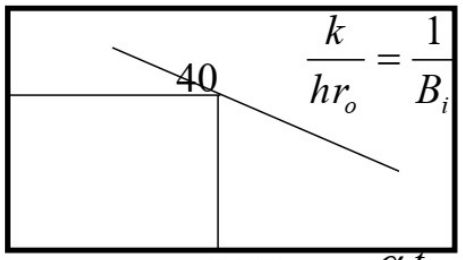
$$\frac{k}{hr_0} = \frac{20}{10 * 0.5} = 40$$

Read from Figure 6 as 0.25

Fig.6. Center temperature for a sphere of radius r_o

$$\frac{T_o - T_\infty}{T_i - T_\infty}$$

0.83



$$\frac{k}{hr_o} = \frac{1}{B_i}$$

$$\frac{\alpha.t}{r_o^{\,2}} = F_o$$

$$\frac{\alpha t}{r_0^{\,2}} = 0.25 = \frac{(6.66x10^{-6})t}{(0.05)^2} \rightarrow t = 93.85s$$

Convection: The convection heat transfer is comprised of two mechanisms. In addition to energy transfer due to random molecular motion (conduction), energy is also transferred by the bulk, or motion of the fluid. Bulk motion, in the presence of a temperature gradient, contributes to heat transfer.

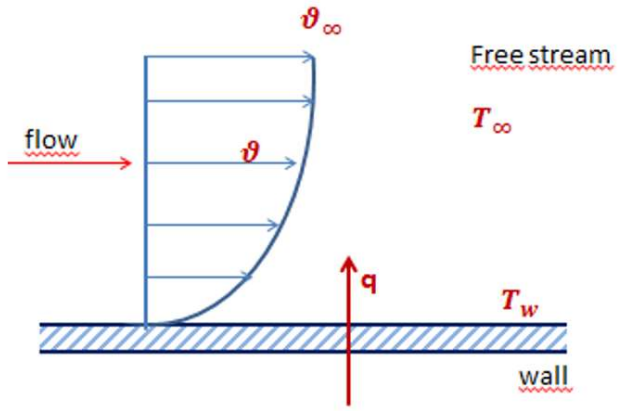
The flow of heat is associeated with the movement of a fluid. Convective heat transfer include heat transfer from metals walls, solid particles and liquid surfaces to the flowing fluid.

The convective flux is proportional to the difference between the surface temperature and the temperature of the fluid. To express the overall effect of convective Newton's law of cooling is used:

$$q/_A = h(T_w - T_\infty)$$

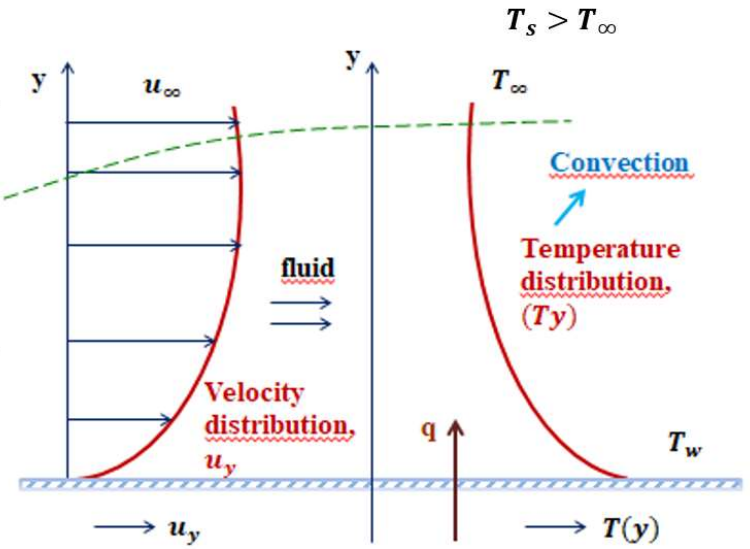
$$q/A = h(T_w - T_\infty)$$

T_w = Surface (wall) temperature,	K, °C
T_∞ = bulk temperature of fluid,	K, °C
h = heat transfer coefficient,	W/m^2K
q = heat transfer rate,	$J/s = W$
A = heat transfer area,	m^2



Convection heat transfer may be classified according to the nature of the flow.

- **Forced convection:** flow is caused by external means, such as by a fan, a pump or atmospheric winds.
- **Natural convection (free convection):** the flow is induced by bounyancy forces, which are due to difference caused by temperature variations in the fluids.



Boundary layer development in convection heat transfer