

TRANSIENT HEAT TRANSFER

Governing Equation

$$\frac{\partial T}{\partial t} = \alpha \frac{\partial^2 T}{\partial x^2}$$

RELATIVE IMPORTANCE OF INTERNAL AND EXTERNAL RESISTANCE TO HEAT TRANSFER

Biot Number

$$N_{Bi} = \frac{hD}{k}$$

Negligible internal resistance $N_{Bi} <$

Negligible surface resistance $N_{Bi} >$

Finite internal and surface resistance $<N_{Bi}<$

NEGLECTIBLE INTERNAL RESISTANCE TO HEAT TRANSFER

$$\ln(T_a - T) = \frac{hAt}{\rho c_p V}$$

$$\frac{T_a - T}{T_a - T_o} = e^{-\left(\frac{hAt}{\rho c_p V}\right)}$$

NEGLECTIBLE SURFACE RESISTANCE TO HEAT TRANSFER

Infinite Slab

series solution

similar expressions for infinite cylinder and sphere

use Figures 4.35, 4.36, 4.37

FINITE SURFACE AND INTERNAL RESISTANCE TO HEAT TRANSFER

series solution

Expressions similar to above are available in literature

Use Figures 4.35, 4.36, 4.37

Fourier Number

$$N_{Fo} = \frac{\alpha t}{D^2} = \frac{k \left(\frac{1}{D} \right)}{\left(\frac{\rho c_p D^3}{t} \right)}$$

$$\frac{\text{Rate of heat conduction across D in volume } D^3 \text{ (W/C)}}{\text{Rate of heat storage in volume } D^3 \text{ (W/C)}}$$

Large value of N_{Fo} indicates deeper penetration of heat into solid in a given period of time.

FINITE OBJECTS

FINITE SLAB

$$\left(\frac{T_a - T}{T_a - T_i} \right) = \left(\frac{T_a - T}{T_a - T_i} \right)_{\text{length}} \times \left(\frac{T_a - T}{T_a - T_i} \right)_{\text{width}} \times \left(\frac{T_a - T}{T_a - T_i} \right)_{\text{depth}}$$

Finite Cylinder

$$\left(\frac{T_a - T}{T_a - T_i} \right)_{\text{finite cylinder}} = \left(\frac{T_a - T}{T_a - T_i} \right)_{\text{inf inite cylinder}} \times \left(\frac{T_a - T}{T_a - T_i} \right)_{\text{inf inite slab}}$$