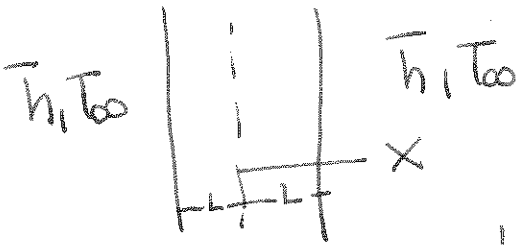
CANKAYA UNIVERSITY
FACULTY OF ENGINEERING AND ARCHITECTURE
MECHANICAL ENGINEERING DEPARTMENT

ME 313 Heat Transfer
Quiz 4

FALL 2018

A large slab of aluminum 100 mm thick is originally at a temperature of $500\,^{0}C$. It is suddenly immersed in a liquid bath at $100\,^{0}C$ resulting in a heat transfer coefficient of $1200\,W/m^2K$. Determine the temperature at the center and the surface of the plate 1 min after the immersion. Also calculate the total heat removed per unit area of the slab during this period. The properties of aluminum at the given conditions may be taken as
$\rho = 2700\,kg/m^3, c = 900\,J/kg.K, k = 215\,W/m.K$



$$Bi = \frac{hL}{k} = \frac{(1200\ W/m^2K)(10^{-3}m)(0.5)}{215\ W/mK} = 0.279 > 0.1$$

Use charts

$$\frac{1}{Bi} = 3.58$$

$$Fo = \frac{\alpha t}{L^2} = ?$$

$$\alpha = \frac{k}{\rho c}$$

$$\text{so } Fo = \frac{t}{L^2} \cdot \frac{k}{\rho c}$$

$$Fo = \frac{60s}{(50/1000)^2} \cdot \frac{215}{(2700)(900)} = 2.12$$

Centerline temperature:

$\frac{1}{Bi} = 3,58$, $Fo = 2,12$] $\frac{T_o - T_\infty}{T_i - T_\infty} \approx 0,7$

$T_o = 0,7(T_i - T_\infty) + T_\infty = 0,7(500 - 100) + 100$

$= 380°C$

Surface temperature

$\frac{x}{L} = 1$, $\frac{1}{Bi} = 3,58$] $\frac{T - T_\infty}{T_o - T_\infty} \simeq 0,86$

$T = T_\infty + 0,86(T_o - T_\infty)$

$= 100 + 0,86(380 - 100) \simeq 340°C$

Heat removal

$Bi = 0,279$

$Bi^2 Fo = (0,279)^2(2,12) = 0,165$] $\frac{Q}{Q_o} \simeq 0,4$

$Q_o = \rho [cV(T_i - T_\infty)] = \rho c (2L)(T_i - T_\infty)$

$= [2700 \times 900 \times \frac{100}{1000}(500 - 100)]$

$= 97200 \ kJ/m^2$

$Q = (0,4)(97200) = 38880 \ kJ/m^2$