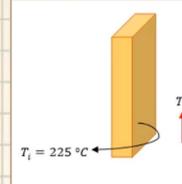
Exercício 4. Calcule:

Considere uma placa de dimensões: 2L1=5cm; 2L2=10cm E 2L3=8cm

- A temperatura no centro, em t= 90 s; T(x,y,z,t)=T(0,0,0,90)=?1)
- A energia removida da placa por unidade de área (1m2) durante t = 90 s. 2)



$$C_p = 460 \, J. \, kg^{-1} \circ C^{-1} \qquad \rho = 7850 \; kg.m^{-3}$$

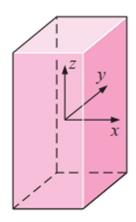
$$T_{--} = 25^{\circ}C$$

$$h = 500 \ W. m^{-2} \circ C^{-1}$$

$$T_{\infty}, h$$
 $T_{\infty} = 25^{\circ}C$ $h = 500 W.m^{-2}{\circ}C^{-1}$ $\alpha = 1,6.10^{-3}m^2.s^{-1}$ $K = 215 W.m^{-1}{\circ}C^{-1}$

$$K = 215 W.m^{-1} \circ C^{-1}$$

$$2L = 5 cm$$



$$\begin{aligned} &\theta(x,y,z,t) = \\ &\theta_{\text{wall}}\left(x,t\right)\theta_{\text{wall}}\left(y,t\right)\theta_{\text{wall}}\left(z,t\right) \end{aligned}$$

Rectangular parallelepiped

1º

$$2L_1 = 5cm$$

$$\frac{1}{Bi} = \frac{k}{hL} = \frac{215 \, W. \, m^{-1}. \, {}^{\circ}C^{-1}}{500 \, W. \, m^{-2}. \, {}^{\circ}C^{-1}. \, 2,5.10^{-2}m} = 17,2$$

$$\tau = \frac{\alpha t}{L^2} = \frac{1,6.10^{-3} m^2. \, s^{-1}. \, 90 \, s}{(2,5.10^{-2}m)^2} = 230,4$$

Pelas cartas, $\theta_{o,1} = 0.001$.

2º

$$2L_2 = 10cm$$

$$\frac{1}{Bi} = \frac{k}{hL} = \frac{215 \, W. \, m^{-1}. \, {}^{\circ}C^{-1}}{500 \, W. \, m^{-2}. \, {}^{\circ}C^{-1}. \, 5.10^{-2}m} = 8,6$$

$$\tau = \frac{\alpha t}{L^2} = \frac{1,6.10^{-3} m^2. \, s^{-1}. \, 90 \, s}{(5.10^{-2} m)^2} = 57,6$$

Pelas cartas, $\theta_{o,2} = 0.0017$.

3º

$$2L_3 = 8cm$$

$$\frac{1}{Bi} = \frac{k}{hL} = \frac{215 W. m^{-1}. {}^{\circ}C^{-1}}{500 W. m^{-2}. {}^{\circ}C^{-1}. 4.10^{-2}m} = 10,75$$

$$\tau = \frac{\alpha t}{L^2} = \frac{1,6.10^{-3} m^2. s^{-1}. 90 s}{(4.10^{-2}m)^2} = 90$$

Pelas cartas, $\theta_{o,3} = 0.001$.

$$\theta_0 = \theta_{o,1}.\theta_{o,2}.\theta_{o,3}$$

$$\theta_o = 0.001.0.0017.0.001 = 1.7.10^{-9}$$

$$T(x,y,z,t) = \theta_o.(T_i - T_\infty) + T_\infty$$

$$T(x,y,z,t) = 1.7.10^{-9}.(225°C - 25°C) + 25°C$$

$$T(x,y,z,t) = 25.00000034$$

Cálculo do calor

$$\begin{split} \left(\frac{Q}{Q_{\text{max}}}\right)_{\text{total, 3D}} &= \left(\frac{Q}{Q_{\text{max}}}\right)_1 + \left(\frac{Q}{Q_{\text{max}}}\right)_2 \left[1 - \left(\frac{Q}{Q_{\text{max}}}\right)_1\right] \\ &+ \left(\frac{Q}{Q_{\text{max}}}\right)_3 \left[1 - \left(\frac{Q}{Q_{\text{max}}}\right)_1\right] \left[1 - \left(\frac{Q}{Q_{\text{max}}}\right)_2\right] \end{split}$$

Pela carta do calor (Bi^2 . $\tau = \frac{h^2 \alpha t}{k^2} = 0.78$)

P/
$$L_1$$
: $Bi = 0.058 \rightarrow \left(\frac{Q}{Qm\acute{a}x}\right)_1 = 1$

P/
$$L_2$$
: $Bi = 0.116 \rightarrow \left(\frac{Q}{Qm\acute{a}x}\right)_2 = 0.93$

P/
$$L_3$$
: $Bi = 0.093 \rightarrow \left(\frac{Q}{Qm\acute{a}x}\right)_2 = 0.96$

$$\left(\frac{Q}{Q_{m\acute{a}x}}\right)_{tota} \ = \left(\frac{Q}{Q_{m\acute{a}x}}\right)_1 + \left(\frac{Q}{Q_{m\acute{a}x}}\right)_2 \left[1 - \left(\frac{Q}{Q_{m\acute{a}x}}\right)_1\right] + \left(\frac{Q}{Q_{m\acute{a}x}}\right)_3 \left[1 - \left(\frac{Q}{Q_{m\acute{a}x}}\right)_1\right] \left[1 - \left(\frac{Q}{Q_{m\acute{a}x}}\right)_2\right]$$

$$\left(\frac{Q}{Q_{m\acute{a}x}}\right)_{total} = 1 + 0.93.(1 - 1) + 0.96.(1 - 1).(1 - 0.93)$$

$$\left(\frac{Q}{Q_{m\acute{a}x}}\right)_{total} = 1$$

$$Q_{m\acute{a}x}=m.\,C_p.\,(T_\infty-T_i)$$

$$Q_{m\acute{a}x}=(2,5.10^{-2}m.\,5.10^{-2}m.\,4.10^{-2}m.\,7850\,kg.\,m^{-3}).460\,J.\,kg^{-1}.\,^{\circ}C^{-1}.\,(25^{\circ}C-225^{\circ}C)$$

$$Q_{m\acute{a}x}=-36110\,J$$

$$Q = Q_{m\acute{a}x} = -36110 J$$

Gráficos utilizados:

