

Calculations

NOTES

① didn't use

$$\frac{T_c - T_\infty}{T_i - T_\infty} = e^{-\frac{hA_c}{\rho V c_p} t} \quad -0.5$$

$$\alpha = \frac{k}{\rho c_p} = \frac{0.19 \text{ W/m}\cdot\text{K}}{(1190 \text{ kg/m}^3)(1465 \text{ J/kg}\cdot\text{K})}$$

$$\alpha = 1.0898 \times 10^{-7} \text{ m}^2/\text{s}$$

$$\theta_o = \frac{T(0,t) - T_\infty}{T_i - T_\infty} = \frac{30 - 25}{70 - 25} = 0.1111$$

$$Bi = \frac{hr_o}{k} \rightarrow r_o = \frac{Bi \cdot k}{h}$$

$$T = T_o = \frac{\alpha t}{r_o^2} = \frac{\alpha t h^2}{k^2 Bi^2}$$

$$\frac{\alpha t h^2}{k^2} = \frac{(1.0898 \times 10^{-7})(1338)(20.42)}{0.19} = 1.6843$$

$$\text{So, } T = \frac{1.6843}{Bi^2}$$

$$\theta_o = C_1 \exp(-\zeta_1^2 \tau) = 0.1111$$

Table for cylinders $Bi = S_1 \frac{j_1(\zeta_1)}{j_0(\zeta_1)}$
 $C_1 = 2j_1(\zeta_1)$
 $\zeta_1 \sqrt{j_0^2(\zeta_1) + j_1^2(\zeta_1)}$

$$Bi = 1.08165 \rightarrow S_1 = 1.2963 \quad C_1 = 1.2210 \quad \tau = 1.4268$$

$$\theta_o = 1.2210 \exp(-(1.2963)^2 \cdot 1.4268) = 0.1111 \quad \checkmark$$

$$\tau = T_o = 1.4268 > 0.2 \quad \checkmark$$

$$r_o = \frac{Bi \cdot k}{h} = \frac{(1.08165)(0.19)}{20.42} = 0.01011 = 10.11 \text{ mm}$$

$$D = 2r_o = 20.22 \text{ mm}$$

$$\text{Temp @ } \frac{1}{2} r = \theta = \theta_o j_0(\zeta_1 r) \rightarrow (1.2963)(0.5) = 0.64815$$

$$j_0(0.64815) = 0.8977$$

$$\theta(0.5) = (0.1111)(0.8977) = 0.09974$$

$$T(\frac{1}{2} r_o, 1338) = T_\infty + \theta(0.5)(T_i - T_\infty)$$

$$(25) + (0.09974) \cdot (70 - 25) = 29.49^\circ\text{C}$$