Cankaya University
Faculty of Engineering
Mechanical Engineering department
ME 313 Heat transfer

Quiz 5

Oranges are usually refregerated as a preservative measure. However, some people prefer to eat oranges that are little cooler than room temperature but not bas cold as the refregerator makes them. Determine the time it takes for the center of an orange from the refregerator to reach 20 °C. Use the following conditions:

Refrigerated temperature = 4°C
Ambient room temperature = 23°C
Surface conductance = 6 W/(m²·K)
Thermal conductivity of an orange = 0.431 W/(m·K)
Density of orange = 998 kg/m³
Specific heat of orange = 2 kJ/(kg·K)
Orange diameter = 105 mm

Also, estimate the heat transferred to the ambient temperature during this time.

(surface conductance means surface heat transfer coefficient)

$$Bi = \frac{\bar{h} L_c}{K} = \frac{\bar{h}(\forall/A_s)}{K} = \frac{\bar{h}(\pi D^3/6)}{K\pi D^2} = \frac{\bar{h}D}{6K}$$

$$= \frac{6(0.105)}{6(0.431)} = 0.243 > 0.1 \quad \text{use chart}$$

$$Bi = \frac{\bar{h}r_o}{K} = \frac{(6)(0.105)}{0.431} = 0.731$$

$$\frac{1}{Bi} = 1.36$$

$$F_o = \frac{\alpha t}{r_o^2} = 1.05$$

$$\frac{T_o - T_\infty}{T_i - T_\infty} = \frac{20-23}{4-23} = 0.158$$

$$\alpha = \frac{K}{\rho c} = \frac{0.431}{(998)(2000)} = 2.159 \times 10^{-7}\ m^2/s$$

$$\therefore t = F_o\left(\frac{r_o^2}{\alpha}\right) = 1.34 \times 10^4 s \approx 3.7\ hr$$

b) $Bi^2 F_o = (0.731)^2(1.05) = 5.61 \times 10^{-1}$ | $\frac{Q}{Q_i} = 0.7$

~~$Bi = 0.731$~~

$Q = (\rho V C)(T_i - T_\infty)(0.7)$

$= 0.7(998)\left(\frac{\pi}{6}\right)(0.105)^3(4.23) = -1.609 \times 10^4$

Heat transferred into orange