

Egg Problem

NOTES FOR OFFICE HOURS
2/7/2018

(1)

$$\frac{T_i - T_{\infty}}{T_i - T_{\infty}} = \exp \left[- \frac{UA}{MC} t \right] \quad ? \quad U \approx h$$

↓
showed below.

$$h = 5.2 \text{ W/m}^2\text{K}$$



$$V_{\text{egg}} = 250 \text{ cm}^3$$

$$\rho_{\text{egg}} = 1035 \frac{\text{kg}}{\text{m}^3}$$

$$C_{\text{egg}} = 3350 \frac{\text{J}}{\text{kgK}}$$

$$K_{\text{egg}} = 0.62 \frac{\text{W}}{\text{m.K}}$$

$$T_{\text{air}} = T_{\infty} = 38^\circ\text{C}$$

U : overall heat transfer coefficient

↑ Include resistance ~~convection~~ + resistance to ~~conduction~~

$$Bi = \frac{hLA}{KA} = \frac{\frac{L}{KA}}{\frac{1}{hA}} = \frac{\text{Resistance of conduction}}{\text{Resistance of convection}}$$

$$Bi < 0.1 \text{ [or } 0.2]$$

for small Bi all resistance are due to convection
 $U \approx h$

$$Bi = \frac{hL}{K} = \frac{\frac{L}{KA}}{\frac{1}{hA}} \quad (2)$$

For calculation

$$Bi = \frac{5.2 \text{ W/m}^2\text{K} \times R_{egg}}{0.62 \text{ W/mK}} = 0.33 \quad \left[\begin{array}{l} \text{A little} \\ \text{large} \end{array} \right]$$

$$V_{egg} = 250 \text{ cm}^3 = \frac{4}{3} \pi R_{egg}^3$$

$$R_{egg} = \sqrt[3]{\frac{3 \times 250}{4\pi}} = \left(\frac{3 \times 250}{4\pi} \right)^{1/3} = 3.9 \text{ cm}$$

$$R_{egg} = 0.039 \text{ m}$$

Conservatively we are going to use the model.

to calculate $\rightarrow \frac{T - T_{\infty}}{T_i - T_{\infty}} = \exp \left[- \frac{h A_{egg} t}{m_{egg} C_{egg}} \right]$

$\uparrow \quad \uparrow \quad \uparrow$
 $20 \quad 38^\circ\text{C} \quad 38$

$\uparrow \quad \uparrow$
 $5.2 \quad 0.019 \text{ m}^2$

$\uparrow \quad \uparrow$
 $3350 \frac{\text{J}}{\text{kg K}} \quad 2$

$A_{egg} = 4\pi R_{egg}^2 = 4\pi \times 0.039^2$

$A_{egg} = 0.019 \text{ m}^2$

$$M_{egg} = V_{egg} \times \rho_{egg} = 250 \text{ cm}^3 \frac{1 \text{ m}^3}{(100 \text{ cm})^3} \times (3) \times 1035 \text{ kg/m}^3$$

$$M_{egg} = 250 \times 10^{-6} \cancel{\text{m}^3} \times 1035 \frac{\text{kg}}{\cancel{\text{m}^3}} = 0.26 \text{ kg}$$

$$\frac{T - T_0}{T_0 - T_c} = \exp \left[- \frac{5.2 \times 0.019 \times 3600 \text{ s}}{0.26 \times 3350 \frac{\text{J}}{\text{kgK}}} \right]$$

$$T = 37.6^\circ \text{C}$$