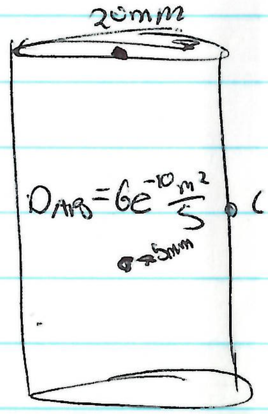
04/17/2018

PROBLEM ONE

$C_i = 0.15\frac{kg}{m^3}$



infinite cylinder

h_m

$C_s = C_\infty = 0$

$t = 20$hours

$Bi = \frac{h_m D}{D_{AB}}$ char. length

CHECK

a) $Fo > 0.2$

$Fo = \frac{D_{AB}t}{R^2} \rightarrow 0.19$

$Bi \to \infty$

$\gamma_1 = 2.405 \quad C_1 = 1.6018$

$$\frac{C(r,t) - C_\infty}{C_i - C_\infty} = C_1 e^{-\gamma_1^2 Fo} J_0(\gamma_1 \frac{r}{R})$$

$$\frac{C_c - 0}{0.15 - 0} = 1.6\, e^{-2.4^2 \cdot 0.14} J_0(0) = 1$$

$C_c =$ ______

$\boxed{\text{SPHERE}}$

$$\frac{C_c - C_\infty}{C_i - C_\infty} = C_1 e^{-\gamma^2 Fo} \frac{1}{\cancel{\gamma_1}} \frac{\sin(\gamma_1 \frac{r}{R})}{\frac{r}{R}}$$

$J_0(2.4 \cdot \frac{5mm}{20mm})$

$$\lim_{\frac{r}{R}\to 0} = \gamma_1$$

$$\frac{C_c - C_\infty}{C_i - C_\infty} = C_1 e^{-\gamma_1^2 Fo}$$

Differnt

b) $$\frac{C(5mm, 20h)}{C_i - C_\infty} = C_1 e^{-\gamma_1^2 Fo} \overbrace{J_0(\gamma_1 \frac{r}{R})}^{\text{Differnt}}$$

Heisler Charts

$$\frac{C_c - C_\infty}{C_i - C_\infty}$$

PROBLEM TWO

$$\frac{C_c - C_i}{C_\infty - C_i} = 0.80$$

$$\underbrace{\frac{C_c - C_i}{C_\infty - C_i}}_{0.8} = 1 - \underbrace{\frac{C_c - C_\infty}{C_i - C_\infty}}_{\text{simplify}}$$

$$\frac{C_i - C_\infty - (C_c - C_\infty)}{C_i - C_\infty} = \frac{C_i - C_c}{C_i - C_\infty} = \frac{\cancel{(-1)}(C_c - C_i)}{\cancel{(-1)}(C_\infty - C_i)} \checkmark$$

$$\frac{C_c - C_\infty}{C_i - C_\infty} = 1 - 0.8$$

$$\boxed{\frac{C_c - C_\infty}{C_i - C_\infty} = 0.2}$$

$$0.2 = C_1 e^{-\gamma_1^2 Fo} \qquad \frac{1}{\cancel{\gamma_1}} \cdot \cancel{\gamma_1}$$

Biot $\to \infty$ $\qquad C_1 = 2 \qquad \gamma_1 = 3.14$

$$0.2 = 2e^{-3.14^2 Fo}$$

$$Fo = \frac{D_0 t}{r^2}$$

PROBLEM THREE

$$\ln \frac{C_{avg} - C_s}{C_i - C_s} = \ln \frac{8}{\pi^2} - D_d\left(\frac{\pi}{2R}\right)^2 t$$

$$A = D_d\left(\frac{\pi}{2R}\right)^2 \quad D_{new} = \frac{D_d}{2} \quad R_{new} = \frac{R}{\sqrt{2}}$$

PROBLEM FOUR

$N = 50\,RPM$

$u = \underbrace{2\pi N R}$ → distance from impellar

a) 10cm away

$$u_1 = \underbrace{50\frac{rev}{min}}_{N} \cdot \frac{1\,min}{60s} \cdot \frac{2\pi\,rad}{rev} \cdot 0.1m = 0.52\frac{m}{s}$$

u = velocity

L = distance away

h_m

① $Re = \dfrac{uL\rho}{\mu} = \dfrac{0.52(0.01)(1000)}{0.8e^{-3}} = 6500$

PHYSICAL CHAR:

LAMINAR

$$Sc = \frac{\mu(\text{viscocity})}{\rho D_{AB}} = \frac{0.8e^{-3}\,Pa \cdot S}{1000\frac{kg}{m^3} \cdot 1.5e^{-9}\frac{m}{s}} = \boxed{533.3}$$

$$Sh_1 = 0.664 \cdot (6500)^{\frac{1}{2}} (533)^{\frac{1}{3}}$$

$$Sh_1 = \frac{h_m L}{D_{AB}} \rightarrow h_{m1}$$

$$\frac{h_{m_1}}{h_{m_2}} = \frac{\cancel{0.664}\left(\frac{V_1 \cancel{\rho} L}{\cancel{\mu}}\right)^{\frac{1}{2}} \cdot \cancel{S_c}^{\frac{1}{3}}}{0.664\left(\frac{V_2 \rho L}{\mu}\right)^{\frac{1}{2}} \cdot S_c^{\frac{1}{3}}} = \left(\frac{V_1 \cancel{L_1}}{V_2 \cancel{L_2}}\right)^{\frac{1}{2}}$$

$$V_1, V_2 = f(N)$$

PROBEM FIVE

a) $q = hA[T_{air} - T_{sh}]$ $\qquad q = \frac{W}{m^2 K} \cdot m^2 \cdot K = \text{watts}$

b) $q_m = h_m A[C_{w,s} - C_{w,air}]\Delta H_{vap}$

$$q_m = \frac{m}{s} \cdot m^2 \left(\frac{kg}{m^3}\right)\left(\frac{J}{kg}\right) = \text{watts}$$

$$q = q_m$$

all the vaporization energy = energy lost to convection

$$h[T_{air} - T_{sh}] = h_m[C_{w,s} - C_{w,air}]$$

$$T_{sh} = T_{air} - \frac{h_m}{h}[C_{w,s} - C_{w,air}]H_{vap}$$

$\rho_{air} = \frac{\text{kg dry air}}{\text{m}^3 \text{ dry air}}$ $\qquad C_{w,air} = \frac{\text{kg water in air}}{\text{m}^3 \text{ dry air}}$

$$\bar{H} = \frac{\text{kg water in air}}{\text{kg dry air}} \cdot \rho_{air} = \frac{\text{kg water in air}}{\text{m}^3 \text{ dry air}}$$

$$C_{w,air} = \bar{H}\rho_{air}$$

$$T_{shirt} = T_{air} - \frac{h_m}{h} \cdot H_{vap} \cdot \rho\left[\bar{H}_s - \bar{H}_{air}\right]$$

$$\frac{h_{m_1}}{h_{m_2}} = \frac{\cancel{0.664}\left(\frac{V_1 \cancel{\rho} L}{\cancel{\mu}}\right)^{\frac{1}{2}} \cdot \cancel{S_c}^{\frac{1}{3}}}{\cancel{0.664}\left(\frac{V_2 \cancel{\rho} L}{\cancel{\mu}}\right)^{\frac{1}{2}} \cdot \cancel{S_c}^{\frac{1}{3}}} = \left(\frac{V_1 \cancel{L_1}}{V_2 \cancel{L_2}}\right)^{\frac{1}{2}}$$

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