MENG 263 #6

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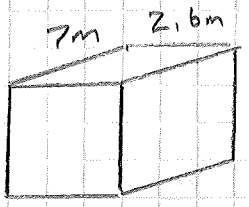
#1



$V = 85 \frac{Km}{h} \cdot \frac{1000m}{1Km} \cdot \frac{1hr}{3600s} = 23.6 \frac{m}{s}$

$\dot{Q}_r = 633 \frac{KJ}{min}$ Operating @ $316.5 \frac{K\cancel{J}}{min}$

$\Rightarrow 5.275 \frac{KJ}{s}$

$T_\infty = 30^\circ C$

$A = 2[(2.4)(7) + (2.6)(7) + (2.6)(2.4)]$

$= 82.48 m^2$

Air @ 30°C

$\rho = 1.164 \frac{kg}{m^3}$ $\quad Pr = 0.7282$

$C_p = 1007 \frac{J}{kg \cdot K}$ $\quad \eta = 1.872(10^{-5}) \frac{kg}{m \cdot s}$

$K = 0.02588 \frac{W}{mK}$ $\quad \nu = 1.608(10^{-5}) \frac{m^2}{s}$

$Nu_L = \frac{h_L L}{K}$ $\quad Re_L = \frac{V \rho L}{\eta} = \frac{VL}{\nu}$

$Re_L = \frac{VL}{\nu} = \frac{23.6 \frac{m}{s} \cdot 7m}{1.608(10^{-5}) \frac{m^2}{s}} = 10278468.77$

$\rightarrow Nu_L = 0.037 Pr^{1/3} Re_L^{0.8} \Rightarrow 0.037(0.7282)^{1/3} \cdot 10278468.77^{0.8}$

$\Rightarrow 13544.86$ ✓

$h_L = \frac{Nu_L \cdot K}{L} \Rightarrow \frac{13544.86 \cdot 0.02588 \frac{W}{mK}}{7m} = 50.077 \frac{W}{m^2 K}$ ✓

$T_s = 30^\circ C - \frac{\dot{Q}_r}{h_L A}$

$= 30^\circ C - \frac{5275 \cancel{J/s}}{50.077 \frac{W}{m^2 \cancel{^\circ C}} \cdot 82.48 \cancel{m^2}}$ $\rightarrow 28.72^\circ C$ ✓

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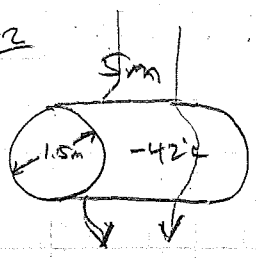
#2



$P = 581 \frac{kg}{m^3}$ $\quad C_{p_A} = 425 \, kJ/kg$

$T_\infty = 25°C$ (ambient) $\quad T_{AVG} = \frac{-42°C + 25}{2} = -8.5°C \approx -10°C$

$P = 1 atm$

Air @ -10°C

$P = 1.341 \, kg/m^3$
$C_{p_A} = 1006 \, J/kg°C$
$K = 0.02288 \, W/m°C$
$\eta = 1.69(10^{-5}) \, kg/ms$
$\nu = 1.252(10^{-5}) \, m^2/s$
$Pr = 0.7387$

Volume: $\frac{\pi}{4} D^2 h = \pi/4 (1.5m)^2 (5m) = 8.836 m^3$

$$Gr = \frac{g \beta (T_s - T_\infty) D^3}{\nu^2}$$

$$= \frac{9.81 \, m/s^2 (-42°C - 25°C)(1.5m)^3}{(-10 + 273.15)\left(1.252(10^{-5}) \, m^2/s\right)^2} = 5.3778(10^{10})$$

$Gr Pr = 5.3778(10^{10})(0.7387) = 3.97258917(10^{10})$ ✓

$Nu = 0.13(3.97258917 \cdot 10^{10})^{1/3} = 443.57558605$

$Nu = \frac{hD}{k} \Rightarrow h = \frac{Nu \, k}{D} = \frac{443.57558605 \cdot 0.02288 \, W/mC}{1.5m}$ ✓

$h = 6.766...$

$\dot{Q}_h = hA(T_s - T_\infty)$

$A = 2(\frac{\pi}{4} D^2) + \pi D L = \pi/2 (1.5)^2 + \pi(1.5)(5) = 27.096 m^2$

$= 6.766 \left(\frac{W}{m^2 °C}\right)(27.096 m^2)(-42°C - 25°C)$

$= 12283.33917 W$ ✓

$Q_p = C_{p_A} \cdot m_p \qquad m_p = \rho V = 581 \, kg/m^3 \cdot 8.836 m^3 = 5133.716 kg$

$= 425 \, kJ/kg \cdot 5133.716 kg = 2181829.3 \, kJ$

$\dot{Q}_{in} \cdot t_{evap} = Q_p \Rightarrow t_{evap} = \frac{Q_p}{\dot{Q}_{in}}$ ✓ 5/5

$\Rightarrow \frac{2181829.3 \, kJ}{12.28333917 \, kJ/s} = 177625.0961 s$

$177625.0961 \, s \cdot \frac{1 \, min}{60 \, s} \cdot \frac{1 \, day}{1440 \, min} = 2.0558 \, days$

(a) #3

$T_s = 3^\circ C$ $\quad h = 10 \frac{W}{m^2 C}$

$T_\infty = 25^\circ C$

$T_i = 10^\circ C$

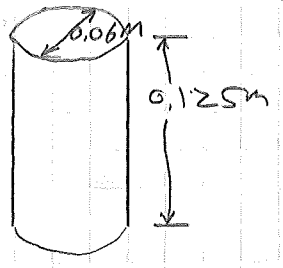
$SA = 2\pi r h + 2\pi r^2$

$= 0.029222\ m^2$

$V = \pi r^2 h$

$= \pi (0.03)^2 (0.125)$

$= 0.000353\ m^3$



$$\frac{T(t) - T_\infty}{T_i - T_\infty} = e^{-bt}$$

"PoP" (water)

$\rho = 1000\ kg/m^3$

$C_p = 4205\ J/kgK$

$$b = \frac{hA_s}{\rho V C_p} = \frac{(10 \frac{W}{m^2 C})(0.029222 m^2)}{1000 \frac{kg}{m^3} \cdot (3.53 \cdot 10^{-4} m^3)(4205 \frac{J}{kgK})}$$

$= 1.968520 (10^{-4}) \frac{1}{s}$ ✓

$$\frac{T(t) - T_\infty}{T_i - T_\infty} = e^{-bt} \Rightarrow \ln\left(\frac{T(t) - T_\infty}{T_i - T_\infty}\right) = -bt$$

$$\Rightarrow t = \frac{\ln\left(\frac{T(t) - T_\infty}{T_i - T_\infty}\right)}{-b}$$

$$= \frac{\ln\left(\frac{10 - 25}{3 - 25}\right)}{-1.96852 (10^{-4})} = 1945.58 s$$

$\Rightarrow t = 32.43$ mins ✓

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