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MECH 262 ASSIGNMENT #3 MAXIME RICHARD

8-98 GIVEN: $T_\infty = 25°C$, $h = 10\ W/(m^2 \cdot °C)$, $T_f = 35°C$, $T_i = 3°C$, $T = 10°C$, $C_p = 4190\ J/kg \cdot °C$, $\rho = 1000\ kg/m^3$

* ASSUME FLOATING IN SPACE

$$\text{SURFACE AREA} = \frac{2\pi D^2}{4} + h\pi D \therefore = \frac{2\pi(0.06)^2}{4} + 0.125\pi 0.06$$

$$A_s = 0.0292\ m^2$$

$$\text{VOLUME} = \pi \frac{D^2}{4} \cdot h = \pi \frac{0.06^2}{4} \cdot 0.125 \qquad V = 0.0003534\ m^3$$

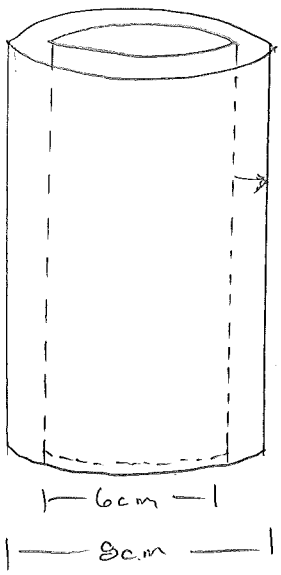
$$\frac{T - T_\infty}{T_i - T_\infty} = e^{\left(\frac{-hA_s}{\rho V C_p} \cdot t\right)} \Rightarrow \ln\left(\frac{T - T_\infty}{T_i - T_\infty}\right) = \frac{-hA_s}{\rho V C_p} \cdot t$$

$$t = \ln\left(\frac{T - T_\infty}{T_i - T_\infty}\right) \cdot \frac{-\rho V C_p}{hA_s}$$

$$t = \ln\left(\frac{10 - 25}{3 - 25}\right) \cdot \frac{-(1000\ kg/m^3)(0.0003534\ m^3)(4190\ J/kg\,°C)}{(10\ W/m^2\,°C)(0.0292\ m^2)}$$

$$t = 1942\ s = 32.37\ \text{MINUTES}$$

IT TAKES ABOUT 32.37 MINUTES FOR THE CAN TO REACH 10°C



$$R_{COND} = \frac{\ln(r_o/r_i)}{2\pi k L}$$

$$R_{CONV\ SIDE} = \frac{1}{h \cdot 2\pi \cdot r \cdot L}$$

$$R_{CONV\ TOP\ BOTTOM} = \frac{1}{hA_s}$$

$L = 0.125\ m$, $r_o = 0.04$, $r_i = 0.03$, $k = 0.13\ W/m\,°C$

$r = 0.04\ m$, $L = 0.125\ m$, $h = 10\ W/(m^2 \cdot C°)$, $A_s = 2\pi r^2 = 0.00565\ m^2$

8-98 CONTINUED

INS

$$R_{COND} = \frac{\ln(0.04/0.03)}{2\pi(0.13\,W/m°C)(0.125\,m)} = 2.82\,°C/W$$

$$R_{CONV} = \frac{1}{10\,W/(m^2°C)(0.04)(0.125)2\pi} = 3.18°C/W$$

CAN

$$R_{CONV\ TOP\ BOTTOM} = \frac{1}{(10\,W/m^2·C°)(0.00565\,m^2)} = 17.7\,°C/W$$

$$\frac{1}{R_o} = \frac{1}{R_{CAN}} + \frac{1}{R_{COND+CONV\ INSULATION}} = \frac{1}{17.7} + \frac{1}{3.18+2.82}$$

$$R_o = \left[\frac{1}{R_o}\right]^{-1} = 4.48\,°C/W \quad ✓$$

$$\tau = R_o \cdot C_T$$

WHERE $C_t = \rho V C_p$

$= (1000)(0.0003534)(4190) = 1481$

$$\tau = 4.48 \times 1481 = 6634$$

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

$$t = -\tau_T \cdot \ln\left(\frac{T-T_\infty}{T_i-T_\infty}\right) = -6634 \cdot \ln\left(\frac{-15}{-22}\right) = 2540s$$

$t = 42.35$ MINUTES ✓

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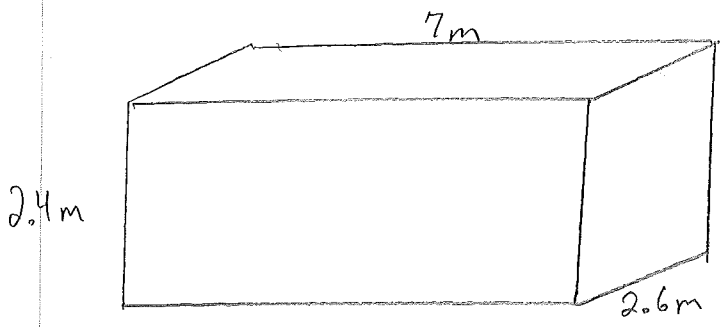
10-29 $T_\infty = 30°C$ VELOCITY 85 km/h



$q_{OUT} = 663$ kJ/MINUTE

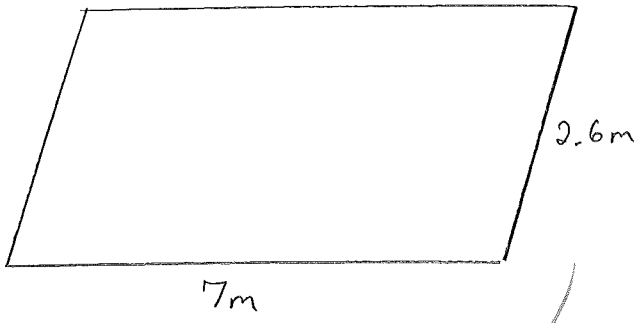
ASSUME: $h_{FRONT} = h_{REAR} = h_{SIDES}$ ALL TURBULENT

FIND T_{AVG} FOR SURFACE OF TRUCK BOX

AIR AT 30°C $k = 0.02588$ W/(m·C°)
$\nu = 1.608 \times 10^{-5}$ m²/s
$Pr = 0.7282$

SOLUTION:

$V = (85 \text{ km/hr})\left(\frac{1000 m}{1 km}\right)\left(\frac{1 hr}{3600 s}\right)$
$V = 23.61$ m/s
$q_{OUT} = (663 \text{ kJ/min})\left(\frac{1 min}{60 s}\right)(1/2)$
$q_{OUT} = 5.525$ kW



$Re = \frac{VL}{\nu} = \frac{(23.61 \text{ m/s})(7 m)}{1.608 \times 10^{-5} \text{ m}^2/\text{s}}$
$Re = 10.278 \times 10^6$

$Nu_L = 0.037\, Pr^{1/3}\, Re^{0.8} = 0.037(0.7282)^{1/3}(10.278 \times 10^6)^{0.8}$
$Nu_L = 13546.034$

$h = Nu\,\frac{k}{L} = \frac{(13546.034)(0.02588 \text{ W/m·C°})}{(7 m)}$

$h = 50.08$ W/(m²·°C)

TOTAL TRUCK AREA:
$2(7)(2.6) + 2(2.6)(2.4) + 2(2.4)(7) = 82.48 m^2$

$R_{TOTAL} = \frac{1}{h A_T} = \frac{1}{(50.08 \text{ W/m}^2\text{C°})(82.48 \text{ m}^2)} = 2.42 \times 10^{-4}$ °C/W

10.29 CONTINUED...

$$q = \frac{\Delta T}{R} = \frac{T_\infty - T_{TRUCK}}{R}$$

$$T_{TRUCK} = T_\infty - q \cdot R = 30\,^\circ C - (5525\,W)(2.42\times10^{-4}\,^\circ C/W$$

$$\boxed{T_{TRUCK} = 28.66\,^\circ C}$$

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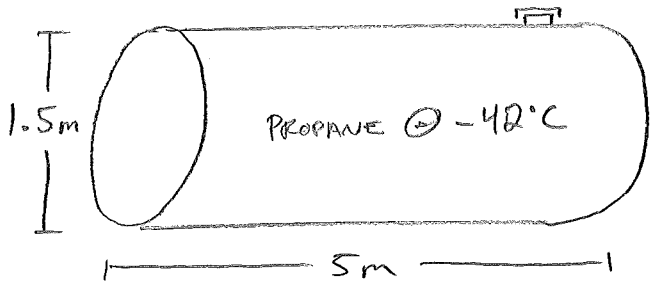
11-38 GIVEN:

$T_\infty = 25°C$



$V_{VOLUME} = \frac{\pi D^2}{4} L = \frac{\pi (1.5)^2}{4}(5)$

$V = 8.836\ m^3$ $\quad T_{AVG} = -8.5°C$

$P_R = \text{at } T_{AVG} = 0.7387$

PROPANE $\rho = 581\ kg/m^3$

$H_{VAP} = 425\ kJ/kg$

$T_{BOIL} = -42°C$

$\rho_{AIR} = 1.341\ kg/m^3$

AMOUNT OF PROPANE IN TANK

$(581\ kg/m^3)(8.836\ m^3) = 5133.72\ kg$

$m_{PROPANE} = 5133.72\ kg$

$H_{VAP} = (425\ kJ/kg)(5133.72\ kg) = 2.18 \times 10^6\ kJ$ TO EMPTY TANK

$GR = \frac{g\beta(T_{BOIL} - T_\infty) D^3 \rho^2}{\mu^2}$

$\mu = 1.68 \times 10^{-5}\ kg/m \cdot s$

$\beta = 1/T_{AVG}\,°K = (1/264.5)$

$\beta = 0.00378$

$GR = \frac{(9.81)(0.00378)(67)(1.5)^3(1.341)^2}{(1.68\times10^{-5})^2}$

$GR = 5.3425 \times 10^{10}$ $\quad GR\,PR = (5.3425\times10^{10})(0.7387)$

$GR\,PR = 3.95 \times 10^{10}$

$k_{FROM\ TABLE} = 0.02288\ \frac{W}{m \cdot °C}$ $\therefore C = 0.13$ AND $n = 1/3$

$Nu = C(GR\,PR)^n = 0.13(3.95\times10^{10})^{1/3} = 442.7$

$h = \frac{Nu\,k}{D} = \frac{(442.7)(0.02288)\ W/m°C}{1.5\ m} = 6.753\ W/m^2 °C$

$q = hA\Delta T = (6.753\ W/m^2 °C)\left(2\pi(0.75^2) + \pi(1.5)(5)\right)(67)°C$

$q = 12259.7\ W$ $\quad t = \frac{H_{VAP}}{q} = \frac{2.18\times10^9\ J}{12259.7\ J/s} = 177818\ s$

$t = 49.4$ HOURS FOR TANK TO EMPTY ✓

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