Victor van Schaik

Thermo 2: Mech262 – Assignment #1

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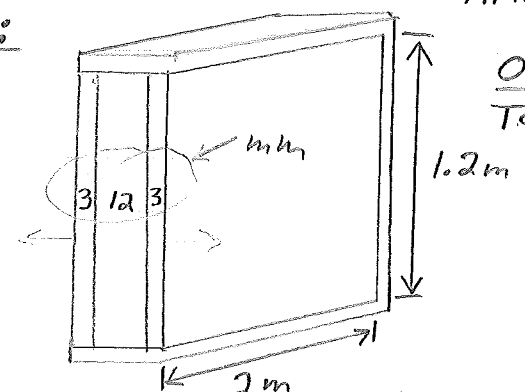
APR. 11/12

① **Find:**
$q = ?$
$T_1 = ?$

Given:

Room:
$T_{\infty 1} = 24°C$



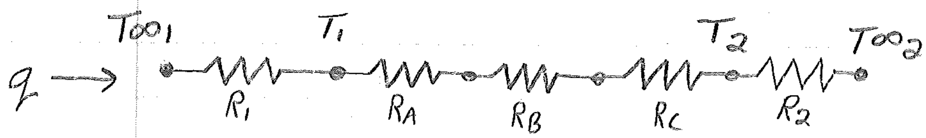
Outside:
$T_{\infty 2} = -5°C$

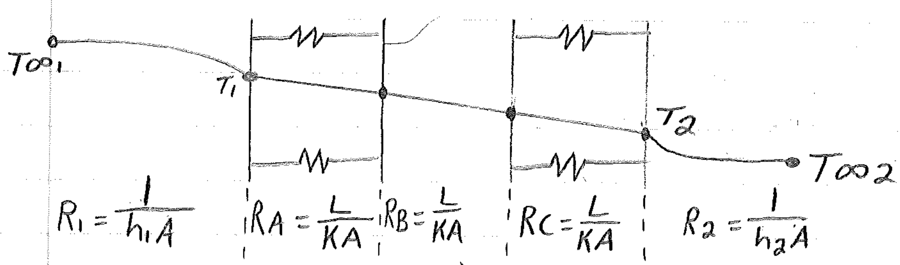
$R_{conv} = \frac{1}{hA}$

$R_{cond} = \frac{L}{KA}$

$A = (1.2m)(2m) = 2.4m^2$

$K_{Air\,Space} = 0.026\ W/(m\cdot°C)$
$K_{glass} = 0.78\ W/(m\cdot°C)$
Inner: $h_1 = 10\ W/(m^2\cdot°C)$
Outer: $h_2 = 25\ W/(m^2\cdot°C)$





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$R_1 = \frac{1}{h_1 A}$ | $R_A = \frac{L}{KA}$ | $R_B = \frac{L}{KA}$ | $R_C = \frac{L}{KA}$ | $R_2 = \frac{1}{h_2 A}$

$$R_1 = \frac{1}{(10\frac{W}{m^2\cdot°C})(2.4m^2)} = \underline{0.0417\ °C/W}$$ ✓

$$R_{12} = R_A + R_B + R_C = \frac{0.003m}{(0.78\frac{W}{m\cdot°C})(2.4m^2)} + \frac{0.012m}{(0.026\frac{W}{m\cdot°C})(2.4m^2)} + \frac{0.003m}{(0.78\frac{W}{m\cdot°C})(2.4m^2)} \simeq \underline{0.1955\ °C/W}$$

$$R_2 = \frac{1}{(25\frac{W}{m^2\cdot°C})(2.4m^2)} = \underline{0.0167\ °C/W}$$

$$\therefore R_o = \Sigma R_i = \underline{0.2539\ °C/W} \Rightarrow q = \frac{T_{\infty 1} - T_{\infty 2}}{R_o} = \underline{114\ W}$$ ✓

$$q = \frac{T_{\infty 1} - T_1}{R_1} \Rightarrow T_1 = T_{\infty 1} - q R_1 = 24°C - (114W)(0.0417\tfrac{°C}{W}) = \underline{19.2°C}$$ ✓

(2) Given: 5 Layers ($t = 0.1mm$)/($K = 0.13 \frac{W}{m \cdot °C}$)

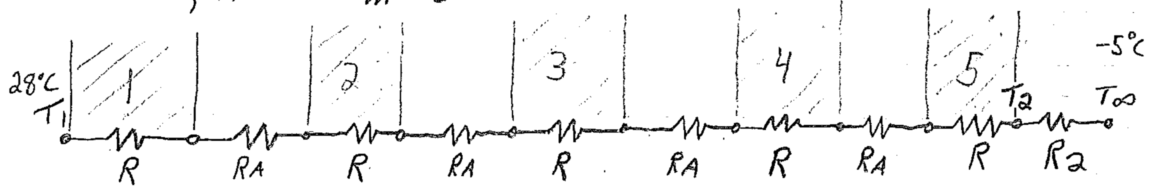
Airspaces between ($t = 1.5mm$)/($K = 0.026 \frac{W}{m \cdot °C}$)

$T_1 = 28°C$

$A = 1.1 m^2$

$T_\infty = -5°C$, $h = 25 \frac{W}{m^2 \cdot °C}$

A) Find: $q = ?$



$\therefore R_o = 5R + 4R_A + R_2$

Layer: $R = \frac{L}{KA} = \frac{(0.1 \times 10^{-3} m)}{(0.13 \frac{W}{m°C})(1.1 m^2)} = 6.993 \times 10^{-4}\ °C/W$ ✓

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Air Space: $R_A = \frac{L}{KA} = \frac{(1.5 \times 10^{-3} m)}{(0.026 \frac{W}{m°C})(1.1 m^2)} = 5.245 \times 10^{-2}\ °C/W$

Conv: $R_2 = \frac{1}{hA} = \frac{1}{(25 \frac{W}{m^2 °C})(1.1 m^2)} = 3.636 \times 10^{-2}\ °C/W$

$\therefore R_o = 5(6.993 \times 10^{-4} \frac{°C}{W}) + 4(5.245 \times 10^{-2} \frac{°C}{W}) + 3.636 \times 10^{-2} \frac{°C}{W} = 0.250 \frac{°C}{W}$

$q = \frac{T_1 - T_\infty}{R_o} = \frac{28°C - (-5°C)}{0.250 \frac{°C}{W}} = 132 W$ ✓

B) If only one 0.5mm thick layer:

$\therefore R' = \frac{L}{KA} = \frac{(0.5 \times 10^{-3} m)}{(0.13 \frac{W}{m°C})(1.1 m^2)} = 3.497 \times 10^{-3}\ °C/W$

$\therefore R_o = R' + R_2 = 3.986 \times 10^{-2} \frac{°C}{W}$, $\Rightarrow q = 828 W$ ✓

C) Wool Fabric:

• (based on part B)

$[K_W = 0.035 \frac{W}{m°C}]$

$L = R'KA = (3.497 \times 10^{-3}\ °C/W)(0.035 \frac{W}{m°C})(1.1 m^2) = 0.135 mm$

(Single 0.5mm eq.)

• (based on part A) For 5 layer equivalent: $R_o = 0.250 \frac{°C}{W}$, $\therefore R_o - R_2 = R_{wool}$

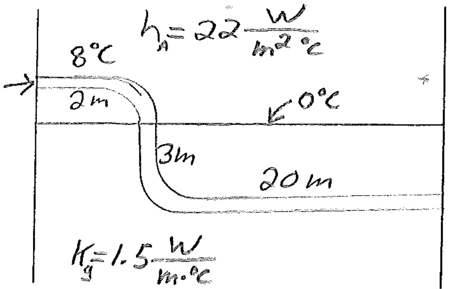
$L_W = (R_{wool})(K_W)(A) = (0.2136\ °C/W)(0.035 \frac{W}{m°C})(1.1 m^2) = 8.2 mm$ ✓

3.(

$q = \frac{HOT - Cold}{R}$ $\qquad q = \frac{(T_1 - T_2)}{R_{cond}} = SK(T_1 - T_2)$ $\qquad SK = \frac{1}{R}$

③ Given: $V = 1.5\,m/s$

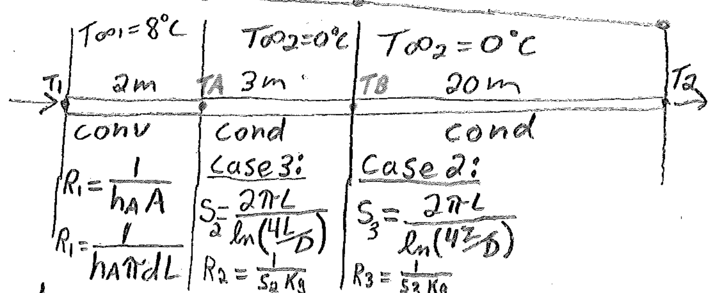
$D_o = 5\,cm = D_i$ (Maple Pipe)



Find: a) $q_{Total} = ?$

b) $\Delta T = ?$

a)



Surface Area: $L \times 2\pi r = \pi d \times L$

$$R_1 = \frac{1}{(22\frac{W}{m^2 \cdot °C})(\pi)(0.05m)(2m)} = 0.145\,°C/W \Rightarrow q_1 = \frac{T_1 - T_{\infty 1}}{R_1} = \frac{(80°C - 8°C)}{(0.145\,°C/W)} = 496.6\,W$$

$$S_2 = \frac{2\pi(3m)}{\ln\left(\frac{4(3m)}{0.05m}\right)} = 3.44\,m \Rightarrow R_2 = \frac{1}{S_2 K_g} = \frac{1}{(3.44m)(1.5\frac{W}{m \cdot °C})} = 0.194\,°C/W$$

$$S_3 = \frac{2\pi(20m)}{\ln\left(\frac{4(3m)}{0.05m}\right)} = 22.93\,m \Rightarrow R_3 = \frac{1}{S_3 K_g} = \frac{1}{(22.93m)(1.5\frac{W}{m \cdot °C})} = 0.029\,°C/W$$

$$q_2 = \frac{T_1 - 0°C}{R_2} = \frac{80°C}{0.194\,°C/W} = 412.4\,W$$

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$$q_3 = \frac{T_1 - 0°C}{R_3} = \frac{80°C}{0.029\,°C/W} = 2758.6\,W$$

$$q_T = \Sigma q_i = 3667.6\,W = 3.7\,KW$$ ✓

Water Table:

$$\dot{m} = \frac{\dot{Q}}{v} = \frac{AV}{v} = (AV)\rho = \frac{\pi}{4}(0.05m)^2(1.5\,m/s)(971.8\,Kg/m^3) = 2.862\,Kg/s$$

$$q_T = \dot{m}\,C_p\,\Delta T, \Rightarrow \Delta T = \frac{q_T}{(\dot{m})(C_p)} = \frac{3.668\,KW}{(2.862\frac{Kg}{s})(4.19\frac{KJ}{Kg \cdot K})} = 0.31°C$$ ✓