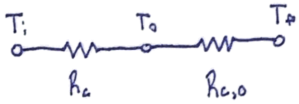
1) $r_i = 3cm$ $T_i = 400K$ $h_f = 27 \frac{W}{m^2 \cdot K}$

$r_o = 5cm$ $T_o = 326K$ $K = ?$

$T_f = 300K$



↳ all variables are Known, use this for q

↳ Since q is constant, use the $q = -K \cdot A \cdot \Delta T$

$$q = h_f \cdot A_s \cdot (T_o - T_f)$$

$$q = -K \cdot A \cdot \nabla T \longrightarrow \text{Alternate form for cylinder} \longrightarrow q = \frac{(T_i - T_o)}{\left(\ln\left(\frac{r_o}{r_i}\right) / 2\pi K \cdot L\right)}$$

$$h_f \cdot \cancel{2} \cdot \cancel{\pi} \cdot r_o \cdot \cancel{L} \cdot (T_o - T_f) = \frac{(T_i - T_o)}{\left(\ln\left(\frac{r_o}{r_i}\right) / \cancel{2\pi} K \cdot \cancel{L}\right)}$$

$$K = \frac{h_f \cdot r_o \cdot (T_o - T_f) \cdot \ln\left(\frac{r_o}{r_i}\right)}{(T_i - T_o)}$$

$$K = \frac{27 \frac{W}{m^2 \cdot K} \cdot 0.05 \cancel{m} \cdot (326 - 300) \cancel{K} \cdot \ln\left(\frac{0.05}{0.03}\right)}{(400 - 326) \cancel{K}}$$

$$K = 0.242297 \frac{W}{m \cdot K}$$

2) $T_{sur} = 473.15K$ $\varepsilon = 0.8$

$T_s = 323.15K$ $h_r = ?$

$$q'' = \varepsilon \cdot \sigma \cdot (T_s^4 - T_{sur}^4)$$

$$q'' = \varepsilon \cdot \sigma \cdot (T_s^2 + T_{sur}^2)(T_s^2 - T_{sur}^2)$$

$$q'' = \underbrace{\varepsilon \cdot \sigma \cdot (T_s^2 + T_{sur}^2)(T_s + T_{sur})}_{h_r}\underbrace{(T_s - T_{sur})}_{\Delta T}$$

$$q'' = h_r \cdot \Delta T$$

↳ where $h_r = \varepsilon \cdot \sigma \, (T_s^2 + T_{sur}^2)(T_s + T_{sur})$

$$h_r = 0.8\left(5.67 \times 10^{-8} \frac{W}{m^2 \cdot K^4}\right)(323.15K^2 + 473.15K^2)(323.15K + 473.15K)$$

$$h_r = 11.858 \frac{W}{m^2 \cdot K}$$

3) $K = 0.139 \frac{W}{m \cdot K}$ $\nu = 4.1 \times 10^{-5} \frac{m^2}{s}$ $l = 0.1m$ $D_h = 4 \cdot \frac{A_c}{P} = 4 \cdot \frac{0.01 \cdot 0.04}{(2 \cdot 0.01) + (2 \cdot 0.04)} = 0.016$

$\rho = 854 \frac{Kg}{m^3}$ $G = 45.25 \frac{Kg}{m^2 \cdot s}$ $\omega = 0.04m$

$c_p = 2120 \frac{J}{Kg \cdot K}$ $q'' = 100 \frac{W}{m^2}$ $h = 0.01m$

a) mass flow rate

$\dot{m} = G \cdot A$

$\dot{m} = 45.25 \frac{Kg}{m^2 \cdot s}(0.01 \times 0.04)m^2$

$\dot{m} = 0.0181 \frac{Kg}{s}$

b) volumetric flow rate

$\dot{Q} = \dot{m}/\rho$

$\dot{Q} = 0.0181 \, {}^{Kg}/_{s} \Big/ 854 \, {}^{Kg}/_{m^3}$

$\dot{Q} = 2.119 \times 10^{-5} \, {}^{m^3}/_{s}$

c) Velocity

$V = \dot{Q}/A$

$V = 2.119 \times 10^{-5} \, {}^{m^3}/_{s} \Big/ (0.01 \times 0.04)m^2$

$V = 0.053 \, {}^{m}/_{s}$

d) Reynold's

$Re = V \cdot D_h / \nu$

$Re = \frac{0.053 \frac{m}{s}(0.016m)}{4.1 \times 10^{-5} \frac{m^2}{s}}$

$Re = 20.68$, Laminar

e) Convective HT, $\mu = 4.36$

$h_c = \mu \frac{K}{D_h}$

$h_c = 4.36 \left(0.139 \, {}^{W}/_{m \cdot K} \Big/ 0.016m\right)$

$h_c = 37.8775 \frac{W}{m^2 \cdot K}$

F) ΔT wall $\rightarrow$ fluid

$\Delta T = q''/h_c$

$\Delta T = 100 \, {}^{W}/_{m^2} \Big/ 37.8775 \frac{W}{m^2 \cdot K}$

$\Delta T = 2.64K$

g) ΔT inlet $\rightarrow$ outlet

$\Delta T = q'' \cdot A / \dot{m} \cdot c_p$

$\Delta T = 100 \frac{W}{m^2} \cdot (0.01 \times 0.04)m^2 \Big/ 0.0181 \frac{Kg}{s}\left(2120 \frac{J}{Kg \cdot K}\right)$

$\Delta T = 0.02606K$

h) Pressure Drop, $Re \cdot f = 73$

$\Delta P = \frac{1}{2} \rho \cdot V^2 \cdot f \cdot \frac{L}{D_h}$

$\Delta P = \frac{1}{2}\left(854 \frac{Kg}{m^3}\right)\left(0.053^2 \frac{m^2}{s^2}\right)\left(\frac{73}{20.68}\right) \cdot \left(\frac{0.1 \cancel{m}}{0.016 \cancel{m}}\right)$

$\Delta P = 26.46 \frac{Kg}{m \cdot s^2}$

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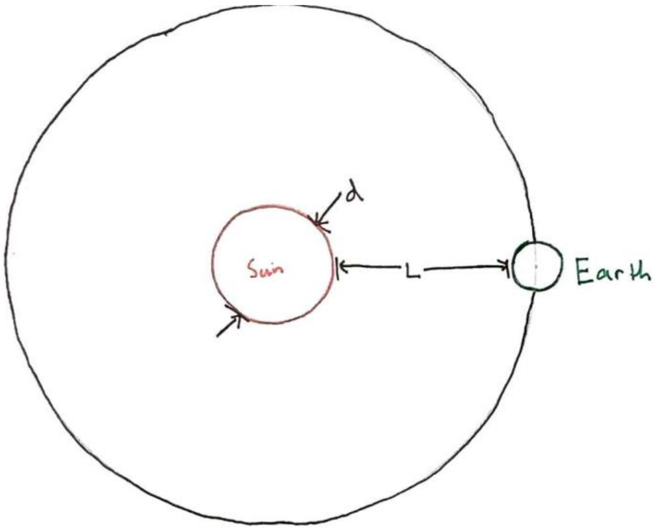


$d = 1.39\times10^{6}\,Km$

$\varepsilon = 0.98$

$L = 1.495\times10^{8}\,Km$

$T_E = 288.15\,K$

$q'' = 1353\,\frac{W}{m^2}$

$$1353\,\frac{W}{m^2} = \frac{q}{4\pi L^2}$$

$$q = 3.8\times10^{26}\,W$$

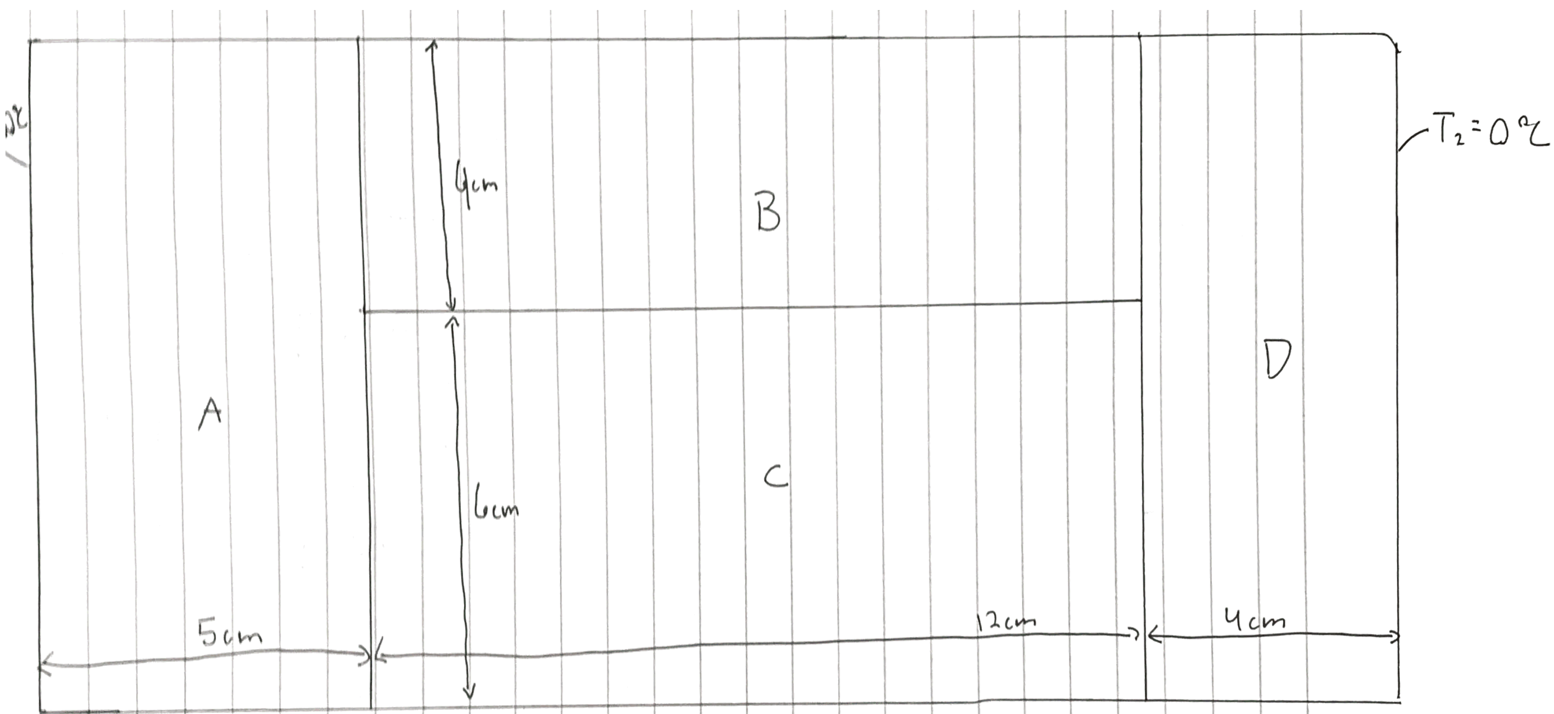
$$q = \varepsilon\cdot\sigma\cdot A_s\left(T_s^4 - T_E^4\right)$$

$$\frac{3.8\times10^{26}}{4\cdot\pi\cdot(6.95\times10^{8})^2} = 0.98(5.67\times10^{-8})(T_s^4 - 288.15K^4)$$

$$\sqrt[4]{\frac{6.26\times10^{7}\,\frac{W}{m^2}}{0.98(5.67\times10^{-8}\,\frac{W}{m^2\cdot K^4})} + 288.15K^4} = T_s$$

$$\boxed{T_s = 5793.63\,K}$$

5)



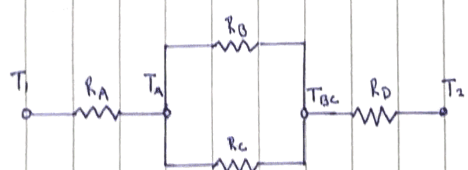
$K_A = 1 \frac{W}{m \cdot K}$

$K_B = 0.2 \frac{W}{m \cdot K}$

$K_C = 0.6 \frac{W}{m \cdot K}$

$K_D = 6 \frac{W}{m \cdot K}$

$t = 1m$



$$R_A = \frac{0.05m}{1\frac{W}{m \cdot K}(0.1m^2)} = 0.5\frac{K}{W}$$

$$R_B = \frac{0.12m}{0.2\frac{W}{m \cdot K}(0.04m^2)} = 15\frac{K}{W}$$

$$R_C = \frac{0.12m}{0.6\frac{W}{m \cdot K}(0.06m^2)} = 3.3\frac{K}{W}$$

$$R_D = \frac{0.04}{6\frac{W}{m \cdot K}(0.1m^2)} = 0.067\frac{K}{W}$$

$$q = \Delta T / R_T = (T_1 - T_2) / (R_A + R_{B-C} + R_D)$$

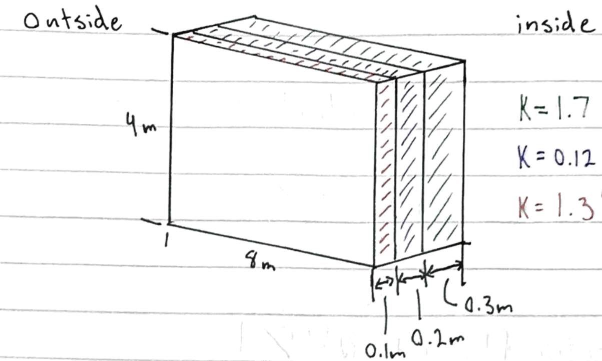
$$= (T_1 - T_2) / \left(\frac{L}{K \cdot A} + \left(\frac{1}{R_B} + \frac{1}{R_C}\right)^{-1} + \frac{L}{K \cdot A}\right)$$

$$= (100K) / \left(0.5 + \left(\frac{1}{15} + \frac{1}{3.3}\right)^{-1} + 0.067\right)\frac{K}{W}$$

$$= \frac{100K}{3.2939\frac{K}{W}}$$

$$q = 30.3588W$$

6)



$K = 1.7\ W/m\cdot K$

$K = 0.12\ W/m\cdot K$

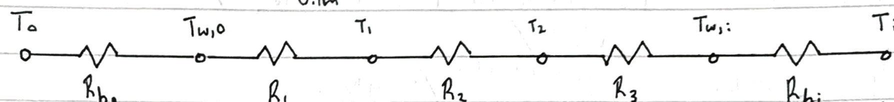
$K = 1.3\ W/m\cdot K$

$T_i = 1400K$ $\quad h_i = 100\ W/m^2\cdot K$

$T_{w,i} = ?$ $\quad h_o = 15\ W/m^2\cdot K$

$T_{w,o} = ?$

$T_o = 310K$



$R_{h_o} = 1/h_o\cdot A = 1/(15\ W/m^2\cdot K)(32m^2) = 0.002083\ K/W$

$R_1 = L/K\cdot A = 0.1m/(0.3\ W/m\cdot K)(32m^2) = 0.002404\ K/W$

$R_2 = L/K\cdot A = 0.2m/(0.12\ W/m\cdot K)(32m^2) = 0.052083\ K/W$

$R_3 = L/K\cdot A = 0.3m/(1.7\ W/m\cdot K)(32m^2) = 0.005514\ K/W$

$R_{h_i} = 1/h_i\cdot A = 1/(100\ W/m^2\cdot K)(32m^2) = 0.000313\ K/W$

$R_T = 0.062398\ K/W$

$q = \Delta T/R_T = (T_i - T_o)/(R_{h_o} + R_1 + R_2 + R_3 + R_{h_i})$

$q = (1400-310)K/(0.062398\ K/W)$

$q = 17.469\ KW$

To determine the thickness we must make the equation look like:

$q = (T_i - T_o)/(R_{h_i} + R_3 + R_2 + R_1)$

$R_{h_i} + R_3 + R_2 + R_1 = \Delta T/q \rightarrow R_2 = (\Delta T/q - R_{h_i} - R_3 - R_1)$

$L_2 = (\Delta T/q - R_{h_i} - R_3 - R_1)(k_2\cdot A)$

Everything else is known, plug in values:

$L_2 = ((1400-320K)/17469W - 0.000313\frac{K}{W} - 0.005514\ K/W - 0.002404\ K/W)(0.12\ W/m\cdot K)(32m^2)$

$L_2 = (0.0536\frac{K}{W})(0.12\frac{W}{m\cdot K})(32m^2)$

$L_2 = 0.205802m$