Answer Key

Heat Transfer

1

$$Q = \frac{A(t_2 - t_1)}{\frac{X_1}{K_1}}$$

$$\Delta F = \frac{9}{5}\Delta C$$

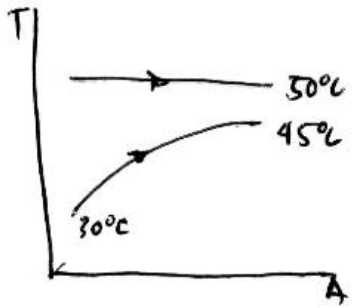
$$25F = \frac{9}{5}\Delta C$$

$$\Delta C = 13.8889\ ^\circ C$$

$$\left(\frac{480\ kJ}{5\ hrs}\right)\left(\frac{1\ hr}{3600\ s}\right) = \frac{(5m^2)(13.8889^\circ C)}{\frac{0.030m}{K_1}}$$

$$K_1 = 1.1519 \times 10^{-5}\ kW/m\text{-}^\circ C$$

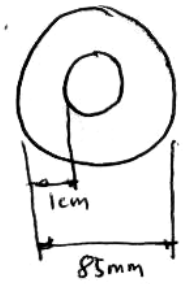
$$K_1 = 0.011519\ W/m\text{-}^\circ C$$



$$LMTD = \frac{\left[(50-30)-(50-45)\right]°C}{\ln\left(\frac{20}{5}\right)}$$

$$LMTD = 10{,}820°C$$

4



$$Q = hA(t_2 - t_1)$$

$$600\,W = h(2\pi)(0.065\,m)(6\,m)(120 - 25)\,^{\circ}C$$

$$h = 2.5774\ \frac{W}{m^2 - K}$$

Inside & outside surface area:

$$A_i = \pi D_i L = \pi (5.761\,in)\left(\frac{1\,ft}{12\,in}\right)(20\,ft) = 30.1645\,ft^2$$

$$A_o = \pi D_o L = \pi (6.625\,in)\left(\frac{1\,ft}{12\,in}\right)(20\,ft) = 34.6884\,ft^2$$

$$Q = \frac{t_1 - t_2}{\frac{1}{A_i h_i} + \frac{\ln(D_o/D_i)}{2\pi k L} + \frac{1}{A_o h_o}}$$

$$Q = \frac{(390 - 90)°F}{\frac{1}{(30.1645\,ft^2)\left(1000\,\frac{Btu}{hr\,ft^2\text{-}°F}\right)} + \frac{\ln\left(\frac{6.625\,in}{5.761\,in}\right)}{2\pi\left(30\,\frac{Btu}{hr\text{-}ft\text{-}°F}\right)(20\,ft)} + \frac{1}{(34.6884\,ft^2)\left(2\,\frac{Btu}{hr\text{-}ft^2\text{-}°F}\right)}}$$

$$Q = 20712.1400\ Btu/hr$$

Hence; for the annual cost of heat lost

$$cost = \frac{20712.1400\,\frac{Btu}{hr}\left(\frac{8760\,hr}{yr}\right)}{(0.80)(10^6)\,Btu} * ₱230$$

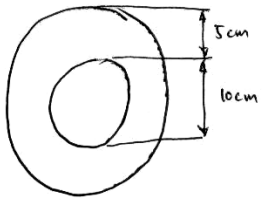
$$cost = ₱52163.5246$$

$$\frac{Q}{A} = \frac{k\,(t_a - t_b)}{X}\;;\quad t_a - t_b = (60°C)\left(\frac{9}{5}\right) = 108°F$$

$$\frac{Q}{A} = \frac{\left(0.68\ \frac{Btu}{hr\text{-}ft\text{-}°F}\right)(108°F)}{\left(\frac{7}{12}\ ft\right)}$$

$$\frac{Q}{A} = \left(125.8971\ \frac{Btu}{hr\text{-}ft^2}\right)\left(\frac{3.28\,ft}{1m}\right)^2\left(\frac{1hp}{2545\ Btu/hr}\right)\left(\frac{746\ W}{1hp}\right)$$

$$\frac{Q}{A} = 397.0219\ \frac{W}{m^2}$$



$$Q = \frac{(t_i - t_o)}{\frac{\ln(r_2/r_1)}{2\pi kL} + \frac{1}{A_o h_o}}$$

$$Q = \frac{(213.15 - 24)^\circ C}{\frac{\ln\left(\frac{0.1\,m}{0.05\,m}\right)}{2\pi\left(0.069\,\frac{W}{m-K}\right)(150\,m)} + \frac{1}{2\pi(0.1\,m)(150\,m)\left(9.45\,\frac{W}{m^2-K}\right)}}$$

$$Q = 16054.8170\ W$$

$$Q = 16.0548\ kW$$

and from;

$$Q = m_s(h_1 - h_2)$$

$$16.0548\ kW = \left(0.130\,kg/s\right)(2799.49 - h_2)$$

$$h_2 = 2675.9915\ kJ/kg$$

Hence;

$$h_2 = h_f + x_2 h_{fg}$$

$$2675.9915\ kJ/kg = 908.79\ kJ/kg + x_2\left(1890.7\ kJ/kg\right)$$

$$\boxed{x_2 = 93.47\%}$$

$$Q = hA(t_2 - t_1)$$

$$= \left(20 \frac{W}{m^2 - K}\right) \pi (0.05\,m)(2.8\,m)(110 - 18)^\circ C$$

$$Q = 809.2743\ W$$

$$Q = \frac{KA(t_1 - t_2)}{x}$$

$$= \frac{\left(1.9 \frac{W}{m-k}\right)(0.80\,m^2)(28-15)^\circ C}{0.008\,m}$$

$$Q = 2470\,W$$

$$Q = 2.470\,kW$$

$$Q = UA\,\Delta T$$

$$A = (12\,ft)(8\,ft)(2) + (10\,ft)(8\,ft)(2) = 352\,ft^2$$

$$= \left(0.13\,\frac{Btu}{ft^2 \cdot {}^\circ F \cdot hr}\right)(352\,ft^2)(60 - 9)\,{}^\circ F$$

$$Q = 2333.76\,Btu$$

$$Q = \frac{280\ kJ}{1hr} * 2.5\ hrs$$

$$Q = 700\ kJ$$

$Q = q_{conv} + Q_{rad}$

$\frac{Q_{conv}}{A} = h_c (t_2 - t_0)$

$= \left(18 \frac{W}{m^2 - k}\right)(100°C - 28°C)$

$q_{conv} = 1296 \frac{W}{m^2}$

$\frac{Q_{rad}}{A} = 20408.4 \times 10^{-8} F_e \left(T_2^4 - T_0^4\right)$; J/hr

$= 20408.4 \times 10^{-8} (0.82) \left(373^4 - 301^4\right) k^4$

$\frac{q_{rad}}{A} = \left(1865661.784 \frac{J}{hr - m^2}\right)\left(\frac{1 hr}{3600 s}\right)$

$\frac{q_{rad}}{A} = 518.2394 \frac{W}{m^2}$

then; substituting

$Q = \left(1296 + 518.2394\right) \frac{W}{m^2}$

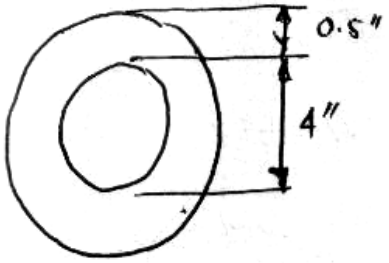
$Q = 1814.2394 \frac{W}{m^2}$

Hence;

$Q = \frac{kA(t_1 - t_2)}{x}$

$1814.2394 \frac{W}{m^2} = \frac{\left(1.3 \frac{W}{m-k}\right)(t_1 - 100°C)}{0.16 m}$

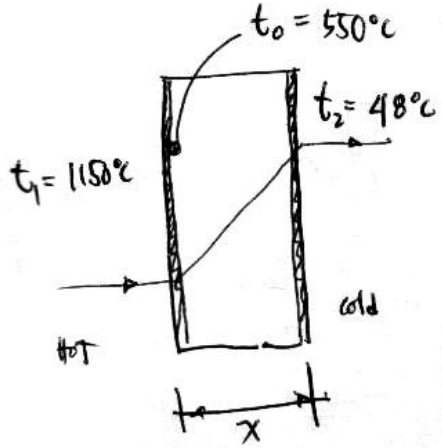
$t_1 = 323.2910°C$



$A = \pi D_o L$

$= \pi \left(\frac{5}{12} \text{ ft} \right) (18 \text{ ft})$

$A = 23.5619 \text{ ft}^2$



$$\frac{\phi}{A} = \frac{t_1 - t_2}{\frac{1}{h_1} + \frac{x}{k} + \frac{1}{h_2}}$$

Solving for $\frac{Q}{A}$;

$$\frac{Q}{A} = h_1 (t_1 - t_o)$$

$$= \left(240 \frac{W}{m^2 - k}\right)(1150 - 550)°C$$

$$\frac{\phi}{A} = 144000 \frac{W}{m^2}$$

Hence; Substituting:

$$144000 \frac{W}{m^2} = \frac{(1150 - 48)°C}{\frac{1}{240 \frac{W}{m^2 - k}} + \frac{x}{110 \frac{W}{m - k}} + \frac{1}{295 \frac{W}{m^2 - k}}}$$

$$x = 0.01059 \text{ m}$$

$$x = 10.5909 \text{ mm}$$