Mech 262
Assignment #8
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TUESDAY

10/10

Given: A heat exchanger with a 1/2" copper central pipe and a 1 1/2" sched 40 outer pipe. Inner is cold water, outer is hot water.

Type k copper 1/2"
$OD = 0.01588\ m$
$ID = 0.01339\ m$
$A = 1.407 \times 10^{-4}\ m^2$

Sched 40 1 1/2"
$OD = 0.0483\ m$
$ID = 0.0409\ m$
$A = 1.314 \times 10^{-3}\ m^2$

$T_{c,in} = 5°C$, $T_{c,out} = 60°C$, $T_{H,in} = 90°C$ ← From rooftop heater

$U = 1250\ W/m^2 \cdot K$, $Q_H = 110\ L/min = 0.001833\ m^3/s$, $\dot{m}_H = (0.001833\ m^3/s)(990\ kg/m^3) = 1.815\ kg/s$

✓

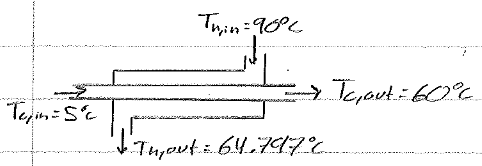
Five shower heads each requiring 10 L/min

$Q_C = (5)(10\ L/min) = 50\ L/min = 0.000833\ m^3/s$, $\dot{m}_c = (0.000833\ m^3/s)(996\ kg/m^3) = 0.83\ kg/s$

<u>Counter Flow</u>

$$Q_c = \dot{m}C_p(T_{out} - T_{in}) = (0.83\,kg/s)(4.3)(60-5) = \boxed{196.295\,kW}$$ ✓

$$Q_H = \dot{m}C_p(T_{out} - T_{in}) \rightarrow T_{out} = T_{in} - \frac{Q}{\dot{m}C_p} = 90°C - \frac{196.295\,kW}{(1.815\,kg/s)(4.3)} = \boxed{64.797°C}$$ ✓



$$\Delta T_1 = T_{h,in} - T_{c,out} = 90 - 60 = 30°C$$

$$\Delta T_2 = T_{h,out} - T_{c,in} = 64.797 - 5 = 59.797°C$$

$$\Delta T_{LM} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)} = \frac{30 - 59.797}{\ln(30/59.797)} = \boxed{43.1993°C}$$ ✓

$$Q = UA_s\Delta T_{LM} \Rightarrow A_s = \frac{Q}{U\Delta T_{LM}} = \frac{196295}{(1250)(43.1993)} = 3.635\,m^2 = \boxed{39.13\,ft^2}$$ ✓

$$A_s = \pi D L \rightarrow L = \frac{A}{\pi D} = \frac{3.635\,m^2}{\pi(0.01588\,m)} = \boxed{72.8656\,m}$$ ✓

$$C_h = \dot{m}_h C_{ph} = (1.815\,kg/s)(4.3) = 7.805\,kW/°C$$

$$C_c = \dot{m}_c C_{pc} = (0.83\,kg/s)(4.2) = 3.486\,kW/°C$$

$$C_{min} = C_c = 3.486\,kW/°C$$

$$C = \frac{C_{min}}{C_{max}} = \frac{3.486}{7.805} = 0.4467$$

$$NTU = \frac{UA}{C_{min}} = \frac{(1250)(3.635)}{3.486 \times 10^3} = \boxed{1.3034}$$ ✓

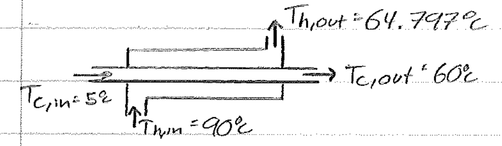
From Fig 16-26 (b)

$\epsilon = \boxed{65\%}$ ✓

Not Practical!

NTU is less than 3 $\therefore$ Good design! ✓

Parallel Flow



$\Delta T_1 = T_{h,in} - T_{c,in} = 90 - 5 = 85°C$

$\Delta T_2 = T_{h,out} - T_{c,out} = 64.797 - 60 = 4.797°C$

$$\Delta T_{LM} = \frac{\Delta T_1 - \Delta T_2}{\ln(\Delta T_1/\Delta T_2)} = \frac{85 - 4.797}{\ln(85/4.797)} = \boxed{27.9003°C}$$

$$Q = U A_s \Delta T_{lm} \Rightarrow A_s = \frac{Q}{U \Delta T_{lm}} = \frac{196295}{(1250)(27.9003)} = \boxed{5.6285\ m^2} = 60.58\ ft^2$$

$$A_s = \pi D L \Rightarrow L = \frac{A}{\pi D} = \frac{5.6285\ m^2}{\pi(0.01588)} = \boxed{112.821\ m}$$

$$NTU = \frac{UA}{C_{min}} = \frac{(1250)(5.6285)}{3.486 \times 10^3} = \boxed{2.0182}$$

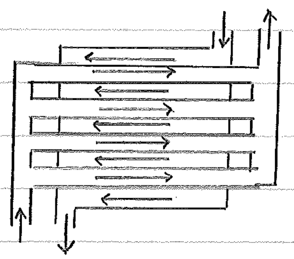
From Fig 16-26 (a)

$\epsilon = \boxed{67\%}$

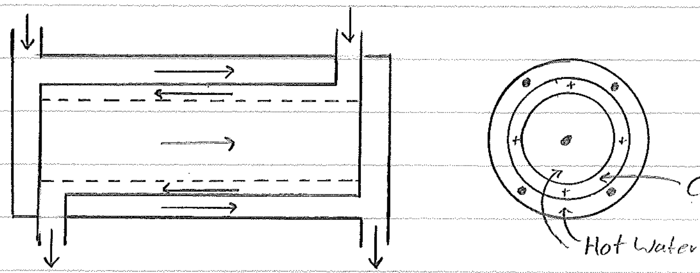
Not Practical!

NTU is less than 3 ∴ Good design!

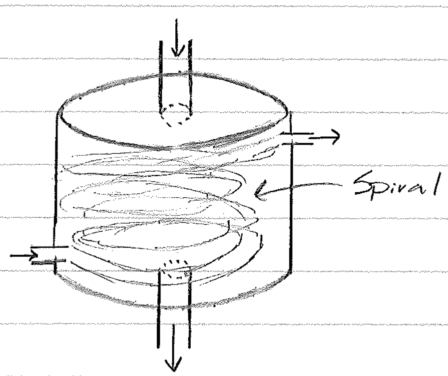
Alternate Designs



Cold flows throug multiple tobes in a Hot bath.



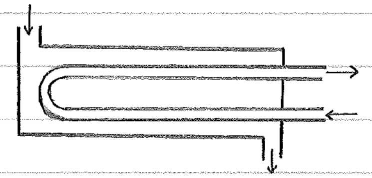
Hot flows around both sides of cold pipe.



Cold flows through upward spiral in a hot bath.

Good

U-Tube (1 shell pass, 2 tube pass, counter flow)



Start with data for counter flow

$\Delta T_{LM} = \boxed{43.1993°C}$

$t_1 = 5°C$ $t_2 = 60°C$ $T_1 = 90°C$ $T_2 = 64.797°C$

$P = \frac{t_2 - t_1}{T_1 - t_1} = \frac{60-5}{90-5} = 0.647$ ✓

$R = \frac{T_1 - T_2}{t_2 - t_1} = \frac{90-64.797}{60-5} = 0.458$

From Figure 16-18 (a)

$F = 0.85$ ✓

$\Delta T_{LM} = F \Delta T_{LM,CF} = (0.85)(43.1993) = \boxed{36.7194°C}$ ✓

$Q = U A_s \Delta T_{LM} \Rightarrow A = \frac{Q}{U \Delta T_{LM}} = \frac{196295}{(1250)(36.7194)} = 4.27665\, m^2 = \boxed{46.03\, ft^2}$ ✓

$A_s = \pi D L \rightarrow L = \frac{A}{\pi D} = \frac{4.27665}{\pi(0.01588)} = \boxed{85.7242\, m}$

Since two tube pass length will be 42.8621m

$NTU = \frac{UA}{C_{min}} = \frac{(1250)(4.27665)}{3.486 \times 10^3} = \boxed{1.533}$ ✓

From Fig 16-26 (c)

$\varepsilon = \boxed{65\%}$ ✓

10/10

From Taco Catalogue given $A = 46.0334\, ft^2$

E8212L, 2 Pass, $A = 51\, ft^2$, 72 inches long

Chosen because it's in the middle of the 8" range and has a slightly larger area. ✓

Better to buy! TACO heat exchanger is only 72 inches long. Also most likely cheaper and less concerns about improper assembly. ✓