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level 6

THERMO

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f) Baffles are used to direct flow in a desired pattern to maximise heat exchange whilst also creating a turbulent flow which makes the heat exchanger more efficient.

Two

a)

$$L = 10 \text{ m}$$

$$d = 50 \text{ mm} = 0.05 \text{ m}$$

$$D = 200 \text{ mm} = 0.2 \text{ m}$$

$$T_{H_i} = 150^\circ \text{C}$$

$$\dot{V}_H = 130 \text{ l/min}$$

$$\dot{V}_C = 450 \text{ l/min}$$

$$T_{C_i} = 8^\circ \text{C}$$

$$U = \frac{1}{RA}$$

$$R = \frac{1}{h_H A} + \frac{1}{h_C A}$$

$$h_H = 2600 \text{ W/m}^2 \text{K}$$

$$h_C = 8.5 \text{ W/m}^2 \text{K}$$

$$A = 0.05 \text{ m} \times 10 = 0.5 \text{ m}^2$$

$$R = \frac{1}{2600 \times 0.5} + \frac{1}{8.5 \times 0.5} = 0.075$$

$$U = \frac{1}{0.075 \times 0.5} = \underline{\underline{8.47 \text{ W/m}^2 \text{K}}}$$

due to the thinness of the tube and high conductivity the heat transfer by conduction is so small it can be ignored.

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b)

$$\dot{Q} = U A F \Delta T_{LM}$$

$$\Delta T_{LM} = \frac{\Delta T_o - \Delta T_i}{\ln\left(\frac{\Delta T_o}{\Delta T_i}\right)}$$

$$\Delta T_i = T_{H,in} - T_{C,o} = 135 - 96.68 = 38.32$$

$$\Delta T_o = T_{H,o} - T_{C,i} = 100 - 15 = 85$$

$$\frac{85 - 38.32}{\ln\left(\frac{85}{38.32}\right)} = 58.59$$

$$A = \frac{\dot{Q}}{U F \Delta T_{LM}} = \frac{14612.5}{425 \times 0.93 \times 58.59} = 0.63 \text{ m}^2$$

c)

$$C = \dot{m} \times c_p$$

$$C_H = \dot{m}_H \times c_{p,H} = 0.25 \times 1670 = 417.5$$

$$C_C = \dot{m}_C \times c_{p,C} = 0.178 \times 1005 = 178.89$$

$$C_c = C_{min}$$

$$NTU = \frac{U A}{C_{min}} = \frac{425 \times 0.63}{178.89} = 1.497$$

$$C_r = \frac{C_{min}}{C_{max}} = \frac{178.89}{417.5} = 0.428$$

$$\epsilon = \frac{1 - e^{-NTU(1-C_r)}}{1 - C_r e^{-NTU(1-C_r)}}$$

$$\frac{1 - e^{-1.497(1-0.428)}}{1 - 0.428 e^{-1.497(1-0.428)}} = 0.703$$

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c)

$$\dot{Q}_{act} = \epsilon \cdot \dot{Q}_{max}$$

$$\epsilon = \frac{1 - e^{-NTU \cdot (1 - Cr)}}{1 - Cr e^{-NTU \cdot (1 - Cr)}}$$

$$Cr = \frac{C_{min}}{C_{max}} = 1.095 \times 10^{-3}$$

$$\frac{1 - e^{-1.406 \cdot (1 - 1.095 \times 10^{-3})}}{1 - 1.095 \times 10^{-3} e^{-1.406 \cdot (1 - 1.095 \times 10^{-3})}} = 0.755$$

$$\dot{Q}_{max} = C_{min} \cdot (T_{hi} - T_{ci})$$

$$9.4594 (150 - 8) = 1343.258 \text{ W}$$

$$1343.26 \times 0.755 = \underline{1013.918 \text{ W}}$$

e)

$$\dot{Q}_{act} = C_H (T_{hi} - T_{ho})$$

$$\dot{Q}_{act} = C_c (T_{co} - T_{ci})$$

$$T_{ho} = T_{hi} - \frac{\dot{Q}_{act}}{C_H} = 150 - \frac{1013.9}{8641.227} = \underline{149.88^\circ \text{C}}$$

$$T_{co} = T_{ci} + \frac{\dot{Q}_{act}}{C_c} = 8 + \frac{1013.9}{9.459} = \underline{115.18^\circ \text{C}}$$

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$$d) \dot{Q}_{max} = C_{min} (T_{hi} - T_{ci})$$

$$178.89 \times (135 - 15) = 21466.8 \text{ W}$$

$$\dot{Q}_{act} = \epsilon \dot{Q}_{max}$$

$$\text{if } \epsilon = 0.75$$

$$0.75 \times 21466.8 = \underline{16100.1 \text{ W}}$$

$$\dot{Q}_{act} = C_c (T_{co} - T_{ci})$$

$$T_{co} = \frac{\dot{Q}_{act}}{C_c} + T_{ci}$$

$$\frac{16100.1}{178.89} + 15^\circ\text{C} = \underline{\underline{105^\circ\text{C}}}$$

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b)

$$NTU = \frac{UA}{C_{min}}$$

$$C = \dot{m} \times c_p$$

$$\dot{m} = \dot{V} \times \rho$$

$$\dot{V}_H = \frac{130}{60,000} = 0.002167 \text{ m}^3/\text{s}$$

$$\dot{V}_C = \frac{430}{60,000} = 0.007167 \text{ m}^3/\text{s}$$

$$\dot{m}_H = 0.002167 \times 916.7 = 1.986 \text{ kg/s}$$

$$\dot{m}_C = 0.007167 \times 1285 = 9.2125 \times 10^{-3} \text{ kg/s}$$

$$C_H = 1.986 \times 4350 = 8641.227$$

$$C_C = 9.2125 \times 10^{-3} \times 1005 = 9.459$$

$$\therefore C_C = C_{min}$$

$$NTU = \frac{8.47 \times 0.51}{9.459} = 1.406$$

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c)

$$\dot{m}_c = ?$$

$$\dot{Q} = \dot{m}_c c_p (T_o - T_i)$$

$$\dot{m} = \frac{\dot{Q}}{c_p (T_o - T_i)}$$

$$\frac{120000}{4180 \times (85 - 22)} = 0.456 \text{ kg/s}$$

d) A = ?

$$Q = U A F \Delta T_{lm}$$

$$A = \frac{Q}{U F \Delta T_{lm}}$$

$$\Delta T_{lm} = \frac{\Delta T_o - \Delta T_i}{\ln\left(\frac{\Delta T_o}{\Delta T_i}\right)}$$

$$\Delta T_i = T_{Hi} - T_{Co} = 140 - 85 = 105$$

$$\Delta T_o = T_{Ho} - T_{Ci} = 150 - 22 = 128$$

$$\frac{128 - 105}{\ln\left(\frac{128}{105}\right)} = 116.12$$

$$A = \frac{120000}{400 \times 0.43 \times 116.12} = 2.778 \text{ m}^2$$

$$e) \dot{Q} = 1.0625 \times 2400 \times (150 - 190) = -102000 \text{ W}$$

$$A = \frac{102000}{400 \times 0.93 \times 116.12} = 2.361 \text{ m}^2$$

log

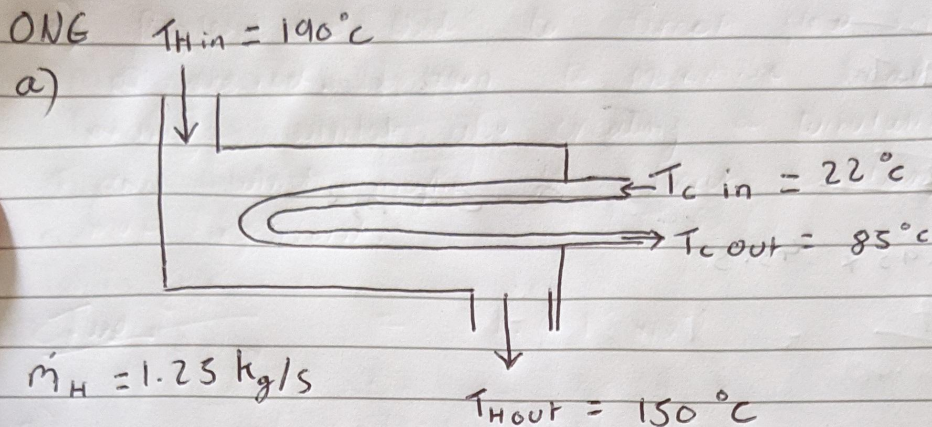
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14/05/21

ONG

a)



As can be seen in the schematic the hot stream would pass over the cold stream in the opposite direction of flow and therefore can be considered a counterflow system.

b) $\dot{Q} = ?$

$$U = 400 \text{ W/m}^2\text{K}$$

$$F = 0.93$$

$$c_{pH} = 2400 \text{ J/kgK}$$

$$c_{pC} = 4180 \text{ J/kgK}$$

$$\dot{Q} = \dot{m} c_p (T_o - T_i)$$

$$1.25 \times 2400 \times (150 - 190) = -120000 \text{ W}$$

$$\dot{Q}_H = -120 \text{ kW}$$

$$\therefore \dot{Q} = 120 \text{ kW}$$

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Three

a)

$$\dot{m}_H = 0.25 \text{ kg/s}$$

$$T_{Hi} = 135^\circ\text{C}$$

$$T_{Ho} = 100^\circ\text{C}$$

$$\dot{V}_c = 8.5 \text{ m}^3/\text{min}$$

$$T_{ci} = 15^\circ\text{C}$$

$$F = 0.93$$

$$T_{co} = ?$$

$$Q = \dot{m} c_p (T_o - T_i)$$

$$\dot{Q}_H = 0.25 \times 1670 \times (100 - 135)$$

$$\dot{Q}_H = -14612.5 \text{ W}$$

$$\dot{Q} = 14.613 \text{ Kw}$$

$$\frac{\dot{Q}}{\dot{m} c_p} + T_i = T_o$$

$$\dot{m} = \dot{V} \times \rho$$

$$\dot{V} = 8.5/60 = 0.14167$$

$$\dot{m} = 0.1416 \times 1.255 = 0.178 \text{ kg/s}$$

$$\frac{14612.5}{0.178 \times 1005} + 15 = 96.68^\circ\text{C}$$