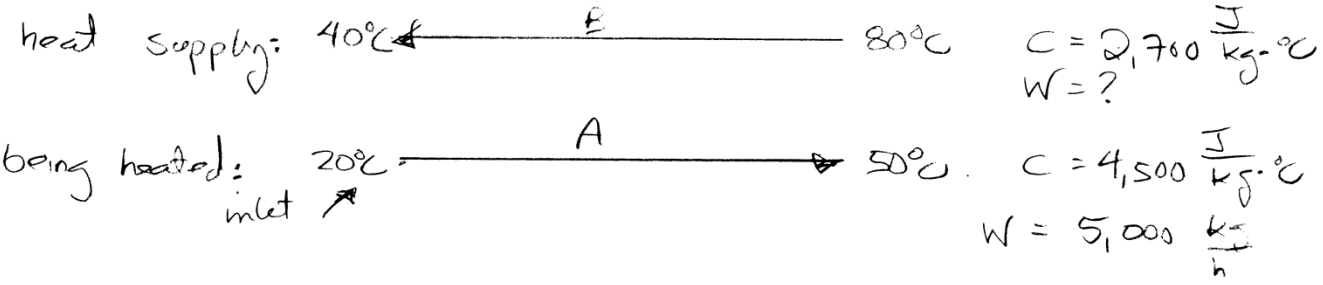
ENGI 9630 - Heat Exchanger Problems

5.8 Heat exchanger to raise temp. of 5,000 kg/h stream (A) from 20°C to 50°C using stream (B) that will be cooled from 80°C to 40°C. Heat capacities of streams A and B are 4,500 J/kg·°C and 2,700 J/kg·°C, respectively. How much of stream B is needed?



A: $H = W \cdot C \cdot \Delta T$

$= (5{,}000\ kg/h)(4{,}500\ J/kg\cdot°C)(50 - 20\ °C)$

$= 675{,}000{,}000\ J/h$

B: $H = W \cdot C \cdot \Delta T$

$675{,}000{,}000\ J/h = W\ (2{,}700\ J/kg\cdot°C)(80 - 40°C)$

$$W = \frac{675{,}000{,}000\ J/h}{(2{,}700\ J/kg\cdot°C)(40°C)} = 6{,}250\ \frac{kg}{h}$$

6,250 kg/h of stream B is needed

5.9 A system has a $\Theta_m = 80°C$, an overall heat transfer coefficient $U = 2.6\ KW/m^2 \cdot °C$ and a heat transfer requirement $= 3 \times 10^8\ J/h$. What heat exchanger surface area is needed?

$$Q = U \cdot A \cdot \Delta T_m$$

$$A = \frac{Q}{U \cdot \Delta T_m}$$

$$= \frac{(3 \times 10^8\ J/h)(1\ h/3600\ s)}{(2.6\ KW/m^2 \cdot °C)(80°C)(1000\ W/KW)}$$

$$= 0.4\ m^2$$

Surface area of heat exchanger needed = $\underline{0.4\ m^2}$

Comparing to problem in notes:

$Q = (300{,}000{,}000\ J/h)(1\ h/3{,}600\ s) = 83{,}333\ W = 83.\dot{3}\ KW$

$U = 2.6\ KW/m^2 \cdot °C$

$\Theta_m = 80°C.$

5.10 20 kg/s of H_2NO_4 is to be cooled from 60 to 30°C. Cooling water at 8°C and mass flow rate of 30 kg/s is to be used. Overall heat transfer coefficient $U = 500\ W/m^2 \cdot K$. Heat capacities of water and H_2NO_4 are 4,200 J/kg·K and 6,000 J/kg·K, respectively. What area of countercurrent flow through heat exchanger is needed?

need to find θ_m and ΔT of water

$$H = W \cdot C \cdot \Delta T = H_{water} = H_{H_2NO_4}$$

$$\Delta T_{water} = \frac{W \cdot C \cdot \Delta T \text{ (for } H_2NO_4)}{W \cdot C \text{ (for water)}}$$

$$= \frac{(20\ kg/s)(6{,}000\ J/kg \cdot K)(60-30°C)}{(4{,}200\ J/kg \cdot K)(30\ kg/s)} = 28.6°C$$

source of cooling: 36.6°C ← water ← 8°C

being cooled: 60°C (inlet) → H_2NO_4 → 30°C

$$\theta_m = \frac{\theta_1 - \theta_2}{\ln\left(\frac{\theta_1}{\theta_2}\right)} = \frac{23.4°C - 22°C}{\ln\left(\frac{23.4°C}{22°C}\right)} = \frac{1.4°C}{0.061} = 22.7°C$$

5.10 continued

$$H = W \cdot C \cdot \Delta T = U \cdot A \cdot \theta_m = Q$$

$$A = \frac{W \cdot C \cdot \Delta T}{U \cdot \theta_m}$$

$$= \frac{(20\ kg/s)(6{,}000\ J/kg \cdot K)(30°C)}{(500\ W/m^2 \cdot K)(22.7°C)}$$

$$= 317\ m^2$$

The surface area for countercurrent flow through the heat exchanger = $\underline{317\ m^2}$