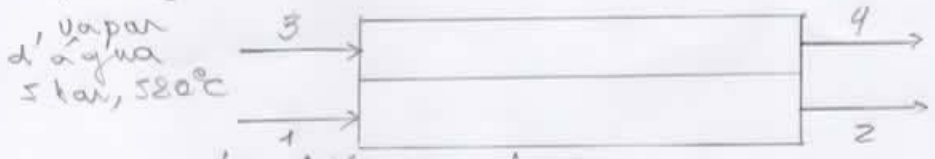
a) 3,6 Kg/min



3,6 Kg/min

$T_{saturação\ da\ água,\ 5\ bar}$: 151,8°C

$T_{saída\ da\ água}$: $T_4 = 151,8 - 103,8 = 48°C$

$\dot{m}_1 = \dot{m}_2 = \dot{m}_{EtOH} = 12\ Kg/min$

$\dot{m}_3 = \dot{m}_4 = \dot{m}_{H_2O} = 1200\ \cancel{g} \cdot \frac{1}{20\ \cancel{s}} \cdot \frac{60\ \cancel{s}}{1\ min} \cdot \frac{1\ Kg}{10^3\ \cancel{g}} = 3,6\ \frac{Kg}{min}$

b) BE, estado estacionário:

$$\sum_{s=1}^{S} \left[\sum_{j=1}^{J} \dot{m}_{s,j} \hat{H}_{s,j} - \sum_{k=1}^{K} \dot{m}_{s,k} \hat{H}_{s,k} \right] + \cancel{\dot{Q}} - \cancel{\dot{W}_s} = 0$$

$$\dot{m}_{EtOH,1} \cdot \hat{H}_{EtOH,1} - \dot{m}_{EtOH,2} \cdot \hat{H}_{EtOH,2} + \dot{m}_{H_2O,3} \cdot \hat{H}_{H_2O,3} - \dot{m}_{H_2O,4} \cdot \hat{H}_{H_2O,4} = 0$$

$\dot{m}_{EtOH,1} = \dot{m}_{EtOH,2} = \dot{m}_{EtOH}$

$\dot{m}_{H_2O,3} = \dot{m}_{H_2O,4} = \dot{m}_{H_2O}$

$$\dot{m}_{EtOH} \cdot (\hat{H}_{EtOH,1} - \hat{H}_{EtOH,2}) + \dot{m}_{H_2O} \cdot (\hat{H}_{H_2O,3} - \hat{H}_{H_2O,4}) = 0$$

$$\frac{\dot{m}_{EtOH}}{M_{EtOH}} \cdot \left(\tilde{H}_{EtOH}(T_1, P_1, \Pi_1) - \tilde{H}_{EtOH}(T_2, P_2, \Pi_2) \right) + \dot{m}_{H_2O} \cdot \left(\hat{H}_{H_2O}(T_3, P_3, \Pi_3) - \hat{H}_{H_2O}(T_4, P_4, \Pi_4) \right) = 0$$

$$\frac{\dot{m}_{EtOH}}{M_{EtOH}} \cdot \left(\tilde{H}_{EtOH}(T_1, P_1, \text{líq. sub ref}) - \tilde{H}_{EtOH}(T_2, P_2, \text{vap. sup. aq.}) \right)$$

$$+ \dot{m}_{H_2O} \cdot \left(\hat{H}_{H_2O}(T_3, P_3, \text{vap. sup. aq.}) - \hat{H}_{H_2O}(T_4, P_4, \text{líq. sub ref.}) \right) = 0$$

$$- \frac{\dot{m}_{EtOH}}{M_{EtOH}} \cdot \left(\tilde{H}_{EtOH}(T_2, P_2, \text{vap. sup. aq.}) - \tilde{H}_{EtOH}(T_1, P_1, \text{líq. sub ref.}) \right)$$

$$+ \dot{m}_{H_2O} \cdot \left(\hat{H}_{H_2O}(T_3, P_3, \text{vap. sup. aq.}) - \hat{H}_{H_2O}(T_4, P_4, \text{líq. sub ref.}) \right) = 0$$

$$- \frac{\dot{m}_{EtOH}}{M_{EtOH}} \cdot \left[\int_{T_1}^{T_b} \tilde{C}_{p,EtOH(\ell)} \, dT + \Delta\tilde{H}_{LV}(T_b) + \int_{T_b}^{T_2} \tilde{C}_{p,EtOH(g)} \, dt \right]$$

$$+ \dot{m}_{H_2O} \cdot \left(\hat{H}_{H_2O}(T_3, P_3, \text{vap. sup. aq.}) - \hat{H}_{H_2O}(T_4, P_4, \text{líq. sub ref.}) \right) = 0$$

Dos tablas:

$$\hat{H}_{H_2O}(T_3, P_3, \text{vap. sup. aq.}) = \hat{H}_{H_2O}(520^\circ C, 5\,bar, \text{vap. sup. aq.}) = \hat{H}_3$$

550°C	3592 KJ/Kg
580°C	$\hat{H}_3$
600°C	3702 KJ/Kg

$$\hat{H}_3 = 3592 + \frac{(3702 - 3592)}{(600 - 550)} \cdot (580 - 550) = 3658 \frac{KJ}{Kg}$$

$\hat{H}_{H_2O}(T_4, P_4, \text{líq. subresf}) = \hat{H}_{H_2O}(48°C, 5\,bar, \text{líq. subresf})$

$= \hat{H}_4 \sim \hat{H}_{H_2O}(48°C, \text{líq. sat.}) = 200,9 \frac{KJ}{Kg}$.

↳ admitindo efeito pequeno da pressão sobre a entalpia do líq.

$$-12\,\frac{Kg}{min}\cdot\frac{Kmol}{46\,Kg}\cdot\left[\int_{298}^{351,5}(-15,7+0,428T)\,dT + 38577,3 + \int_{351,5}^{T_2} 79,56\,dT\right]\frac{KJ}{Kmol} + 3,6\,\frac{Kg}{min}\cdot(3658-200,9)\,\frac{KJ}{Kg} = 0$$

(351,5 ← Tb)

$$-\frac{12}{46}\cdot\left[-15,7(351,5-298)+\frac{0,428}{2}(351,5^2-298^2)+38577,3+79,56(T_2-351,5)\right]+3,6(3658-200,9)=0$$

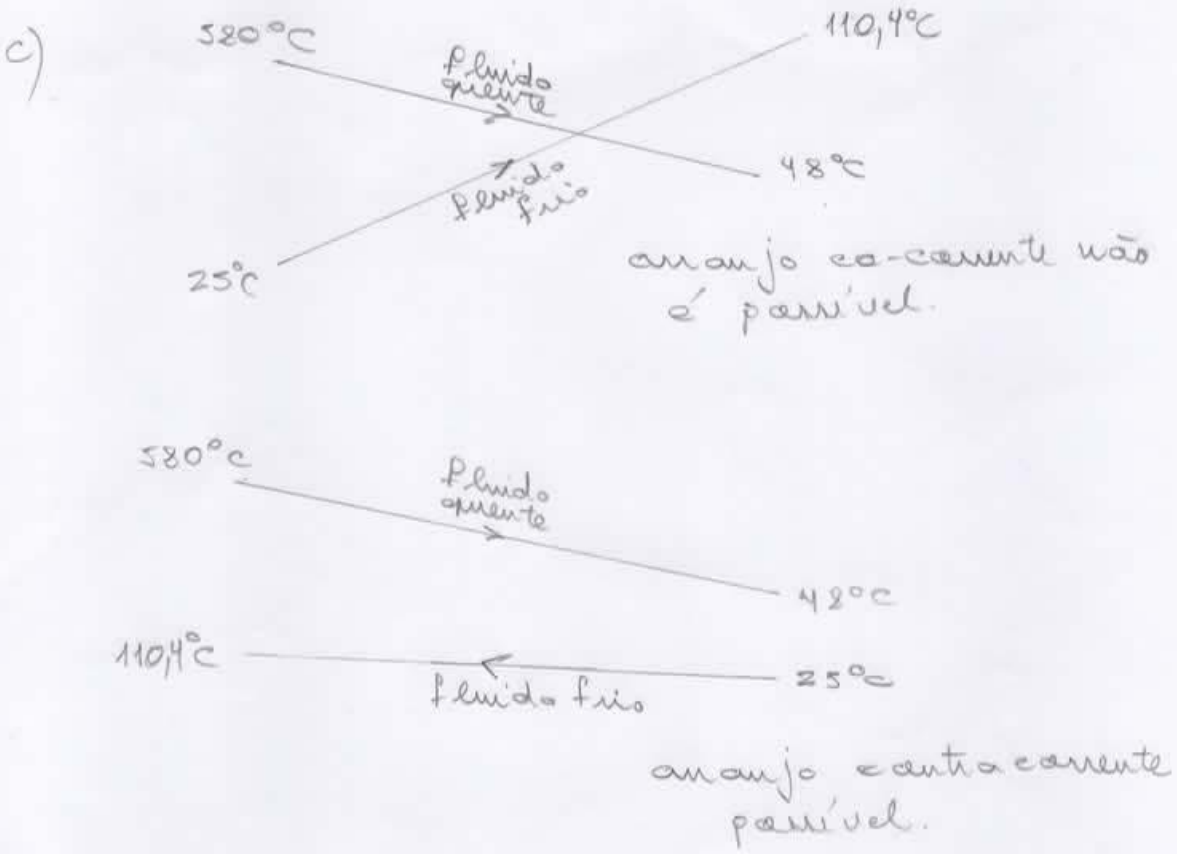
$$-\frac{12}{46}\cdot\left[-839,95+7436,13+38577,3+79,56T_2-27965,34\right]+3,6(3457,1)=0$$

$$-\frac{12}{46}\cdot\left[17208,14+79,56T_2\right]+3,6\cdot3457,1=0$$

$$-4489,08-20,755T_2+12445,56=0$$

$$T_2 \simeq 383,4K \quad (\sim 110,4°C)$$

c)



O arranjo possível é o contracorrente, pois a temperatura do fluido quente é sempre superior à do fluido frio em toda a extensão do trocador de calor.