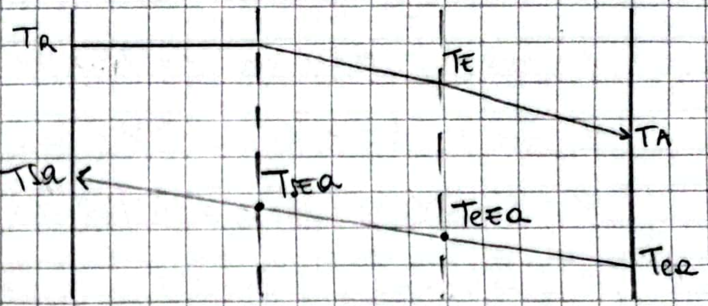
Problema 2



$\dot{M}_c = 896$ kg/h
$\Delta H_c = 23\,000$ kcal/kg

$T_R = 800°C = 1073,15$ K
$T_A = 400°C$
$T_t = 426°C = 699,15$ K

$\varepsilon_p = 0,02$

$\dot{M}_a = 19702$ kg/h
$C_{pa} = 1,5$ kcal/(kg °C)

$T_{ea} = 35°C$
$T_{sa} = 592°C$

$\dot{M}_p = 180$ tn/h
$C_{pp} = 0,56$ kcal/(h°C)

$T_{ep} = 212°C$
$T_{sp} = 400°C$

- $\dot{Q}_{generado} = \dot{M}_c \Delta H_c = 20\,608\,000$ kcal/h
- $\dot{Q}_{recuperado} = \dot{M}_p C_{pp}(T_{sp} - T_{ep}) = 18\,950\,400$ kcal/h $< \dot{Q}_{gen}$ ✓
- $\dot{Q}_{rec} / \dot{Q}_{gen} = \varepsilon_R + \varepsilon_E + \varepsilon_A = 0,92$
- $\varepsilon_{ch} = 1 - \varepsilon_R - \varepsilon_E - \varepsilon_A - \varepsilon_p = 0,06 \longrightarrow T_A < 200°C$ para cualquier % exceso aire

$\Rightarrow$ Como $T_A < T_{ep}$ la transferencia de calor va a ser en el sentido opuesto (del vapor a los humos), por lo tanto no es posible usar el horno. !

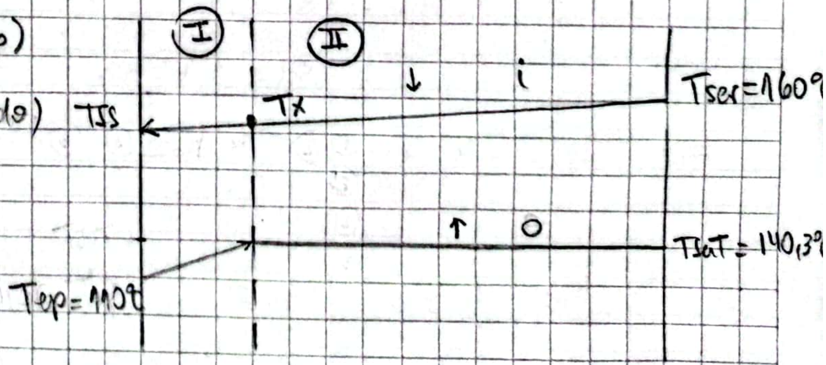
Problema 7

$N_{TU} = 226$, $N_t = 452$
$D_o = 0,75$ plg } $D_i = 0,62$ plg
BWG 16
□
$P_T = 1$ plg
$L_t = 4,8$ m (tramo recto)

} $D_s = 25,375$ plg

n heptano = p = casco (o)
aceite térmico = ser = tubos (i)

C_p, μ, ρ, K tabla



$\dot{M}_p = 30\,000$ kg/h ($\dot{M}_{e,p}$)
$P_{ep} = 3$ bar(a)
$T_{ep} = 110°C$ (subenfriado)

$\dot{M}_{svp} = 20\,500$ kg/h
$\Delta H_{vap\,p} = 720\,000$ J/kg

$T_{ser} = 160°C$
$h_i = 10000$ W/(m² K)
$T_{ss} = 155°C$

- $\log(P_{vap}) = A - \dfrac{B}{T+C} \curvearrowright T_{vap} = T_{SaT} = \dfrac{B}{A - \log(P_{vap})} - C = 140,3\ °C$

NOTA

a) $R_f = 1/U_{servicio,m} - 1/U_{limpio,m}$ ⤳ $R_f = 4,179 \times 10^{-4}\ m^2 K/W$

• $U_{servicio,m} = \dfrac{Q_T}{A_{disp}\ \Delta T_m} = 1908,7\ W/(m^2K)$

✓ $A_{disp} = \pi D_o N_T L_T = 132,6\ m^2$

✓ $Q_T = Q_I + Q_{II} = \dot{M}_o\ c_{pLo}\ (T_{sat} - T_{ep}) + x \dot{M}_o\ \Delta H_{vapo} = 1,64 \times 10^{10}\ J/h$

✓ $x = \dot{M}_{svo}/\dot{M}_o = 41/60 \simeq 0,68$

✓ $\Delta T_m = \left(\dfrac{1}{Q_T}\left(\dfrac{Q_I}{\Delta T_{mL\,I}} + \dfrac{Q_{II}}{\Delta T_{mL\,II}}\right)\right)^{-1} = 18,04\ °C$

• $\Delta T_{mL\,I} = \dfrac{(T_{ss} - T_{ep}) - (T_x - T_{sat})}{\ln\left(\dfrac{T_{ss} - T_{ep}}{T_x - T_{sat}}\right)} = 27,47\ °C$

(4) $\Delta T_{mL\,I}$, T_x, T_{ss}

• $U_{limpio,m} = \dfrac{1}{A_{ref\,T}}\left(U_{OL\,I}\ A_{ref\,I} + U_{OL\,II}\ A_{ref\,II}\right)$ → $U_{limpio,m} = U_{OL\,II}$

✓ $U_{OL\,I} = \left(\dfrac{1}{h_i}\dfrac{D_o}{D_i} + \dfrac{1}{h_{o\,I}}\right)^{-1}$: (Como no tenemos correlación para calor sensible estanco, lo despreciamos)

✓ $U_{OL\,II} = \left(\dfrac{1}{h_i}\dfrac{D_o}{D_i} + \dfrac{1}{h_{o\,II}}\right)^{-1} =$

✓ $h_{o\,II} = 0,00122\ F_b \underbrace{\left(\dfrac{K_{Lo}^{0,79}\ c_{pLo}^{0,45}\ \rho_{Lo}^{0,49}}{\sigma^{0,5}\ \mu_{Lo}^{0,29}\ (\Delta H_{vapo}\ \rho_{vo})^{0,24}}\right)}_{E = 0,6140} \Delta T_w^{0,24}\ \Delta P_w^{0,75}$ (3)

• $\Delta T_w = T_w - T_{sat}$
$\Delta P_w = P_w - P_{ep}$

• $P_w = 10^\wedge\left(A - \dfrac{B}{T_w + C}\right)$ (2)

• $T_w = \dfrac{C' T_{sat} + T_{ss}}{1 + C'}$ (1) , $C' = \dfrac{A_o\ h_{o\,II}}{A_i\ h_i} = \dfrac{D_o\ h_{o\,II}}{D_i\ h_i}$ (1)

• $F_b = 1 + 0,1\left(\dfrac{1-\varphi}{\varphi}\right)^{0,75}$, $\varphi = \dfrac{\pi D_b L_t}{A_{disp}} = 0,0749$

$F_b = 1,6592$

⟹ T_w ↷ P_w (2) ↷ $h_{o\,II}$ (3) ↷ C' (1) ↷ T_w (1')

T_w	P_w	$h_{o\,II}$	C'	T_w
150	3,72	4675,4	0,0144	159,7
159,7	4,57	9880,5	0,0304	159,4
159,4	4,54	9710,3	0,0298	159,4

$T_w = 159,4\ °C$

$h_{o\,II} = 9710,3\ W/(m^2K)$

$U_{limpio,m} = 9428,9\ W/(m^2K)$

NO $Q_{II}/A_{disp} = 3,09 \times 10^4\ W/m^2 = q$

$q_{crit} = 0,131\ \Delta H_{vapo}\ (\sigma(\rho_{Lo} - \rho_{vo})\ g\ \rho_{vo}^2)^{1/4} = 5,276\ W/m^2$ ✓ $q < q_{crit}$

b) $Q_I = M_0\, Cp_{l0}\, (T_{sat} - t_{op})$

$Q_{II} = M_0\, \Delta H_{vapo}\ (x = 1)$

$\Big\}\ Q_T = 6,4646 \times 10^6\ W$

$Q_{TL} = A_{disp}\ U_{limpio}\ m\, \Delta t_m = 2,255 \times 10^7\ W$

Como el calor que se intercambia con el equipo limpio (Q_{TL}) es mayor al calor que se necesita para evaporar (Q_T), se alcanza la vaporización completa c)

Problema 2 - Parte 2:

a) · $\dot{Q}_{gen} = 20\ 608\ 000$ kcal/h

· $\dot{Q}_{reca} = \dot{m}_a\, Cp_a\, (T_{sa} - t_{ea}) = 16461021$ kcal/h

· $\varepsilon_R + \varepsilon_E + \varepsilon_A = \dot{Q}_{reca} / \dot{Q}_{gen} = 0,8$

· $\varepsilon_{ch} = 1 - \varepsilon_R - \varepsilon_E - \varepsilon_A - \varepsilon_p = 0,18$

· $\varepsilon_{ch} + T_A = 400°C \rightarrow$ **%E = 15%**

b) $M_{ft} = 32\ 000$ kg/h
$Cp_{ft} = 1,65$ kcal/(kg °C)
$T_{eft} = 40°C$

$T_R = 900°C = 1173,15\ K$
$t_A = 680°C$
$T_t = 510°C = 783,15\ K$

$\varepsilon_p = 0,02$
%E = 15%

· $T_A \rightarrow \varepsilon_{ch} = 0,33$

· $\varepsilon_R + \varepsilon_E + \varepsilon_A = 1 - \varepsilon_p - \varepsilon_{ch} = 0,65$

· $T_R \rightarrow \varepsilon_{ch} + \varepsilon_A + \varepsilon_E = 0,44 \rightarrow \varepsilon_A + \varepsilon_E = 0,11$

· $\varepsilon_R = 1 - \varepsilon_{ch} - \varepsilon_A - \varepsilon_E - \varepsilon_p = 0,54$

· $Q_R = \varepsilon_R\, \dot{Q}_{gen}$ ✓

$Q_R = \beta\, A_{cp}\, F \left[\sigma (T_R^4 - T_t^4) + \alpha (T_R - T_t)\right]$ ✓ ✓ ✓ ✓ ✓ ✓ $\rightarrow \sigma = 4,878 \times 10^{-8}\ \frac{kcal}{h\,m^2\,K^4}$

$\beta A_{cp} F$ [m²] dependen de la configuración del horno ↓ lo calculo con los datos originales

$\alpha = 35$

- $T_R = 800°C \rightarrow \varepsilon_{ch} + \varepsilon_A + \varepsilon_E = 0,38 \rightarrow \varepsilon_A + \varepsilon_E = 0,2$

  (ε_{ch} = 0,18)

- $\varepsilon_R = 1 - \varepsilon_{ch} + \varepsilon_A + \varepsilon_E + \varepsilon_p = 0,6$
- $Q_R = \varepsilon_R Q_{gen} = 12\,364\,800$ Kcal/h
- $Q_R = A\left(\sigma(T_R^4 - T_E^4) + \alpha(T_R - T_E)\right)$

  426°C

  datos originales

$A = 187\ m^2$

$\Rightarrow Q_R = A\left(\sigma(T_R^4 - T_E^4) + \alpha(T_R + T_E)\right) = 16\,399\,377,9$ Kcal/h

$Q_{gen} = Q_R / \varepsilon_R = 30\,369\,218,3$ Kcal/h ($> Q_{gen\,op}$ ✓ $\uparrow \dot{M}_c$)

$Q_{recFt} = (\varepsilon_A + \varepsilon_E + \varepsilon_R)\, Q_{gen} = \dot{M}_{Ft}\, Cp_{Ft}\,(T_{sFt} - t_{eFt})$

($\varepsilon_A + \varepsilon_E + \varepsilon_R$ = 0,65)

$$\boxed{T_{sFt} = 413,9°C}$$

c) $Q_{gen} = \dot{M}_c\, \Delta H_c \rightarrow \boxed{\dot{M}_c = 1320,4\ kg/h}$ de combustible

(*) $\Delta T_{ml\,II} = \dfrac{(T_x - T_{sat}) - (T_{rec} - T_{sat})}{\ln\left(\dfrac{T_x - T_{sat}}{T_{en} - T_{sat}}\right)} = 17,37°C$

$Q_T = \dot{M}_{rec}\, Cp_{rec}\,(T_{rec} - T_{ss}) \rightarrow \dot{M}_{rec} = 5,78 \times 10^5$ kg/h

$Q_I = \dot{M}_{rec}\, Cp_{rec}\,(T_x - T_{ss}) \rightarrow T_x = 155,51°C$