CCS. 27/05/04.
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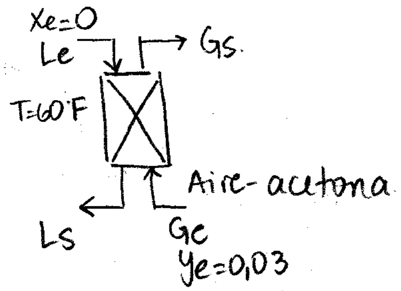
IF-3332 Sec. 01.

"Columnas Empacadas".-
Tarea N° 2.

6.37



$\frac{Ls \cdot Xs}{Ge \cdot ye} = 0,97$ $\quad Ge = 50\,ft^3/min$ $\quad P = 1atm$ $\quad Ug = 2,4\,ft/s = 144\,ft/min.$ $\quad Y^* = 1,75\,X$

$PM_{aire} = 27$ $\quad PM_{Ac} = 58.$ $\quad \rho_{aire} = 0,0808\,lb/ft^3$ $\quad T = 60°F = 288,7\,K$

$R = 82,06\,\frac{cm^3 atm}{K \cdot mol} = 1,314\,\frac{ft^3 \cdot atm}{K \cdot lbmol}$

a) $\left(\frac{L'}{G'}\right)_{min} = ?$ ⇒ para $X_s = Y_e/1,75$ (x salida en equilibrio con y entrada).

$Y_e = \frac{y_e}{1-y_e} = \frac{0,03}{1-0,03} \rightarrow Y_e = 0,03093 \rightarrow X_s = 0,01767$ Haciendo balance de masa (libre) ⇒

$L'\cancel{X_e}^{0} + G'Y_e = L' \cdot X_s + G'Y_s \Rightarrow Y_e = (L'/G') \cdot X_s + Y_s \Rightarrow \left(\frac{L'}{G'}\right) = \frac{Y_e - Y_s}{X_s} \Rightarrow Y_s = Y_e(1-0,97)$

$\Rightarrow Y_s = 0,03093\,(0,03) \rightarrow Y_s = 9,279 \cdot 10^{-4} \Rightarrow \left(\frac{L'}{G'}\right)_{min} = \frac{0,03093 - 9,279 \cdot 10^{-4}}{0,01767}$ $\boxed{\left(\frac{L'}{G'}\right)_{min} = 1,698}$

b) $X_s^* = \frac{X_s^*}{1+X_s^*} = \frac{0,01767}{1+0,01767} = 1,74 \cdot 10^{-2}\,\frac{mol\ sto}{mol\ sln}$ $\quad [\ ]_s^* = X_s^* \cdot \rho_{H_2O} = 1,74 \cdot 10^{-2} \cdot 998 \cdot \frac{1}{18} \cdot \frac{2,2}{1000} \cdot \left(\frac{1}{3,28}\right)^3 \cdot 1000 = \boxed{6,02 \cdot 10^{-2}\,\frac{lbmol}{ft^3}}$

c) $\left(\frac{L'}{G'}\right) = 1,4\left(\frac{L'}{G'}\right)_{min}$ $\quad \left(\frac{L'}{G'}\right) = 1,4 \cdot 1,698 = 2,3772$ $\quad N = \frac{\ln\left(\left(\frac{Q-1}{Q}\right) \cdot \frac{1}{\varphi} + \frac{1}{Q}\right)}{\ln Q}$ $\quad Q = \frac{\text{corriente recibe}}{\text{corriente da} \cdot m}$

$m = 1,75 \Rightarrow Q = \frac{L}{G \cdot m} = \frac{2,3772}{1,75} \Rightarrow Q = 1,3584$ $\quad \varphi = \frac{Y_s - \cancel{X_s}^{0}}{Y_e - \cancel{X_s}^{0}} = \frac{9,279 \cdot 10^{-4}}{0,03093} \rightarrow \varphi = 0,03$

$N = \frac{\ln\left(\left(\frac{1,3584-1}{1,3584}\right) \cdot \frac{1}{0,03} + \frac{1}{1,3584}\right)}{\ln(1,3584)} \Rightarrow \boxed{N = 7,36 \text{ etapas}}$

d) $NTU' = \frac{\ln\left[\left(\frac{Q-1}{Q}\right)\frac{1}{\varphi} + \frac{1}{Q}\right]}{\left(\frac{Q-1}{Q}\right)} = \frac{\ln\left[\left(\frac{1,3584-1}{1,3584}\right)\frac{1}{0,03} + \frac{1}{1,3584}\right]}{\left(\frac{1,3584-1}{1,3584}\right)} \Rightarrow \boxed{NTU' = 8,545 \text{ unidades de transferencia}}$

e) $K_y \cdot a = 12,0\,lbmol/h \cdot ft^3 \cdot (\Delta Y)$ $\quad Z = NTUOG' \cdot HTUOG'$ $\quad HTUOG' = G'/K_y \cdot a \cdot A$ $\quad G_{max} \cdot A = G \Rightarrow$

$A = G/G_{max} = \frac{50\,ft^3/min \cdot 1min/60s}{2,4\,ft/s} \Rightarrow A = 0,3472\,ft^2$ $\quad$ De gas ideal... ⇒ $PV = nRT$

$\frac{n}{V} = \frac{P}{RT} = \frac{1atm}{1,314\,ft^3 \cdot atm/K \cdot lbmol \cdot 288,7K} = 2,635 \cdot 10^{-3}\,\frac{lbmol}{ft^3}$ $\quad Ge = 50\,\frac{ft^3}{min} \cdot 2,635 \cdot 10^{-3}\,\frac{lbmol}{ft^3}$

$Ge = 0,1318\,lbmol/min$ $\quad G' = (1-y_e) \cdot Ge = 0,1318\,(1-0,03) \rightarrow G' = 0,1278\,lbmol/min$

$$HTUOG' = \frac{0{,}12784\ \cancel{lbmol}/min}{12{,}01\ \frac{\cancel{lbmol}}{h \cdot ft^3} \cdot 0{,}3472\ ft^2} \cdot \frac{60\ min}{1\ h} = 1{,}84\ ft \qquad HTUOG' = 1{,}84\ ft. \qquad Z = NTUOG' \cdot HTUOG' \Rightarrow$$

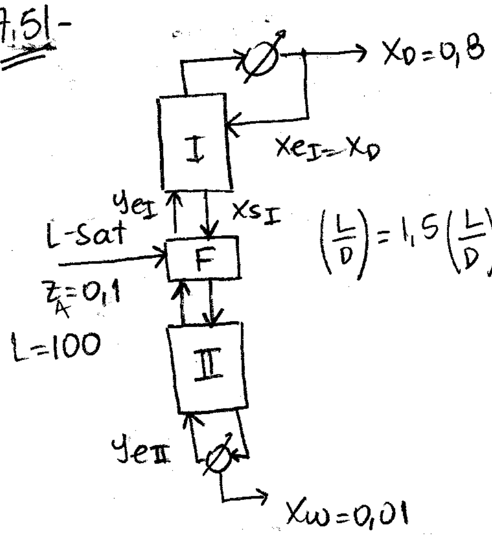
$$Z = 8{,}545 \cdot 1{,}84\ ft \Rightarrow \boxed{Z = 15{,}73\ ft}$$

f) $Z = HTUOG \cdot NTUOG$

$$Z = 1{,}84 \cdot \frac{\ln\left[\left(\frac{\Phi' - 1}{\Phi'}\right) \cdot \frac{1}{\varphi} + \frac{1}{\Phi'}\right]}{\frac{\Phi' - 1}{\Phi'}} \Rightarrow \boxed{Z = \frac{1{,}84 \ln\left[\left[\frac{\left(\frac{L'}{1{,}75 G'}\right) - 1}{(L'/1{,}75G')}\right]\frac{1}{0{,}03} + \frac{1}{L'/1{,}75G'}\right]}{\left[\frac{(L'/1{,}75G') - 1}{(L'/1{,}75G')}\right]}}$$

7,51-

Base cálculo: L=100.



$\left(\frac{L}{D}\right) = 1,5 \left(\frac{L}{D}\right)_{mín}$

X	Y
0,0190	0,1700
0,0721	0,3391
0,0966	0,4375
0,1238	0,4704
0,1661	0,5089
0,2337	0,5445
0,2608	0,5580
0,3273	0,5826
0,3965	0,6122
0,5079	0,6564
0,5198	0,6599
0,5732	0,6841
0,6763	0,7385
0,7472	0,7815
0,8943	0,8943

$X_F = Z_F \Rightarrow$ Posición óptima!

$X_D = y_{sI} = 0,8$

Balance Global: $L = W + D \Rightarrow W = L - D$

$W = 100 - D$

Bal. por componente:

$Z \cdot L = X_D \cdot D + X_W \cdot W$

$0,1 \cdot 100 = 0,8 \cdot D + 0,01(100 - D) \Rightarrow 10 = 0,8 \cdot D + 1 - 0,01 \cdot D \Rightarrow 9 = 0,79 \cdot D \Rightarrow D = 11,39 \wedge W = 88,61$

$\left(\frac{L}{D}\right)_{min}$ para la zona I: y_{eI} en equilibrio con X_{sI} $\quad X_{sI} = 0,1 \Rightarrow y_{eI} = 0,4416$ (Interpol.)

$\Rightarrow$ Balance en la zona I: $V = D + L \quad L \cdot X_{sI} + D \cdot X_D = V \cdot y_{eI}^* \rightarrow L \cdot X_{sI} + D \cdot X_D = D \cdot y_{eI}^* + L \cdot y_{eI}^*$

$\frac{L}{D}(X_{sI} - y_{eI}^*) = y_{eI}^* - X_D \Rightarrow \left(\frac{L}{D}\right) = \frac{y_{eI}^* - X_D}{X_{sI} - y_{eI}^*} \Rightarrow \left(\frac{L}{D}\right)_{min} = \frac{0,4416 - 0,8}{0,1 - 0,4416} \Rightarrow \left(\frac{L}{D}\right)_{min} = 1,0492$

$\Rightarrow L_{min} = 1,0492 \cdot 11,39 \rightarrow L_{min} = 11,95$

$\rightarrow L_{op} = 1,5 \cdot L_{min} = 17,925 \rightarrow (L/D)_{op} = 1,574 \rightarrow V = 29,38$. $\quad \left(\frac{L}{D}\right)_{op} = \frac{y_{eI} - X_D}{X_{sI} - y_{eI}} \Rightarrow$

$\left(\frac{L}{D}\right) \cdot (X_{sI} - y_{eI}) = y_{eI} - X_D \rightarrow y_{eI}(1 + L/D) = (L/D) \cdot X_{sI} + X_D$. $\quad y_{eI} = 0,3719 \Rightarrow X_{eII} = 0,068$ (Eq.)

$X_W = 0,01 \rightarrow y_{eII} = 90895$.

$\rightarrow$ Bal. en el Rehervidor: $W \cdot X_W + V \cdot y_{eII} = L \cdot X_{sII} \quad ; \quad L = L_I + 100 = 117,925 \Rightarrow$

$88,61 \cdot 0,01 + 29,38 \cdot 0,0895 = 117,925 \cdot X_{sII} \Rightarrow X_{sII} = 0,0298$.

$\rightarrow$ Bal. zona II: $V \cdot y_{eII} + L \cdot X_{eII} = V \cdot y_{sII} + L \cdot X_{sII} \quad 29,38 \cdot 0,0895 + 117,925 \cdot 0,068 = 29,38 \cdot y_{sII} + 117,925 \cdot 0,0298$

$y_{sII} = 0,243$.

$\rightarrow$ Porque HTOG es dato!

$\rightarrow$ Zona I: Definiendo el gas como la fase que da... $Q_I = L_I / m \cdot V_I$

$m \rightarrow$ X varía entre 0,1 a 0,8. Se calcula m entre esos valores de X...

$y = 0,4912 \cdot x + 0,4196 \Rightarrow m = 0,4912$. $\quad Q_I = 17,925 / 0,4912 \cdot 29,38 \Rightarrow Q_I = 1,242$

con $X_{seq} = -8,693 \cdot 10^{-2} \longrightarrow \frac{X_{seq}}{y_{eI}} \cdot \frac{L}{V} = -0,143 = Q_F \Rightarrow \varphi_I = \frac{y_{sI} \cdot V - (X_{eI} \cdot L / Q_F)}{y_{eI} \cdot V - (X_{eI} \cdot L / Q_F)}$

$\Rightarrow$

$$\varphi_I = \frac{0{,}8\cdot 29{,}38 - [0{,}8\cdot 17{,}925/(-0{,}143)]}{0{,}3719\cdot 29{,}38 - [0{,}8\cdot 17{,}928/(-0{,}143)]} \Rightarrow \varphi_I = 0{,}0402 \qquad N_I = \frac{\ln\left[\left(\frac{Q_I - 1}{Q_I}\right)\frac{1}{\varphi_I} + \frac{1}{Q_I}\right]}{\ln Q_I} \Rightarrow$$

$$N_I = \frac{\ln\left[\left(\frac{1{,}242-1}{1{,}242}\right)\cdot\frac{1}{0{,}0402} + \frac{1}{1{,}242}\right]}{\ln(1{,}242)} \Rightarrow \boxed{N_I = 8{,}45 \cong 9} \Rightarrow \text{\# platos Ideales!!!}$$

→ Zona II: Definiendo el vapor como la fase que da... $Q_{II} = L_{II}/m\cdot V_{II}$

$m \rightarrow$ entre $0{,}0966 \wedge 0{,}019 \Rightarrow y = 3{,}135\cdot x_{eq} + 0{,}118 \Rightarrow m = 3{,}135$

$Q_{II} = 117{,}295/29{,}38\cdot 3{,}135 \Rightarrow Q_{II} = 1{,}28 \quad Q_F = \frac{L}{V}\cdot\frac{x_{eII}}{y_{e\,eq}} \Rightarrow Q_F = 0{,}8258$

$$\varphi_{II} = \frac{y_{sII}\cdot V - (x_{eII}\cdot L/Q_F)}{y_{eII}\cdot V - (x_{eII}\cdot L/Q_F)} = \frac{0{,}243\cdot 29{,}38 - (0{,}068\cdot 117{,}925/0{,}8258)}{0{,}0895\cdot 29{,}38 - (0{,}068\cdot 117{,}925/0{,}8258)} \Rightarrow \varphi_{II} = 0{,}184$$

$$N_{II} = \frac{\ln\left[\left(\frac{Q_{II}-1}{Q_{II}}\right)\frac{1}{\varphi_{II}} + \frac{1}{Q_{II}}\right]}{\ln Q_{II}} = \frac{\ln\left[\left(\frac{1{,}28-1}{1{,}28}\right)\cdot\frac{1}{0{,}184} + \frac{1}{1{,}28}\right]}{\ln(1{,}28)} \Rightarrow \boxed{N_{II} = 2{,}5 \cong 3}$$

↳ # platos ideales!!!

a) $N_{\text{platos ideales}} = 9 + 3 = 12 \rightarrow N_{real} = \frac{N_{ideal}}{e_{fic}} = \frac{12}{0{,}8} \Rightarrow \boxed{N_{real} = 15 + R}$

b) $$NTU_I = \frac{\ln\left[\left(\frac{Q_I - 1}{Q_I}\right)\cdot\frac{1}{\varphi_I} + \frac{1}{Q_I}\right]}{[(Q_I - 1)/Q_I]} = \frac{\ln\left[\left(\frac{0{,}805-1}{0{,}805}\right)\cdot\frac{1}{0{,}0402} + \frac{1}{1{,}242}\right]}{[(0{,}805-1)/0{,}805]} \Rightarrow \boxed{NTU_I = 9{,}31}$$

$$NTU_{II} = \frac{\ln\left[\left(\frac{Q_{II}-1}{Q_{II}}\right)\frac{1}{\varphi_{II}} + \frac{1}{Q_{II}}\right]}{[(Q_{II}-1)/Q_{II}]} = \frac{\ln\left[\left(\frac{1{,}28-1}{1{,}28}\right)\frac{1}{0{,}184} + \frac{1}{1{,}28}\right]}{[(1{,}28-1)/1{,}28]} \Rightarrow \boxed{NTU_{II} = 2{,}95}$$

c) Para calcular la altura de la torre: se resta 1 plato por el espaciado y sabiendo que el espacio entre plato y plato es 18 in = 1,5 ft... $Z = (15-1)\cdot 1{,}5 \Rightarrow \boxed{Z = 22{,}88\ ft}$

d) Sabiendo que $H_{OG} = 1{,}2\ ft \wedge$ que $Z = H_{OG}\,(NTU_I + NTU_{II}) \Rightarrow Z = 1{,}2\,(9{,}31 + 2{,}95) \Rightarrow$

$\boxed{Z = 14{,}71\ ft}$