

1. Problem 27.2-1

A is acetic acid.

B is water.

C is isopropyl ether.

x is aqueous phase.

y is organic phase.

Fit 4th order polynomials to equilibrium data in Appendix A.3-24. Then,

$$x_B = f_1(x_A)$$

$$x_C = f_2(x_A)$$

$$y_A = f_3(x_A)$$

$$y_B = f_4(x_A)$$

$$y_C = f_5(x_A)$$

The compositions in the two phases are related by functions of the composition of acetic acid in the aqueous phase.

Assume that the two outlets are in equilibrium. Write component mass balances.

$$x_{A,0}L_0 = x_{A,N}L_N + y_{A,1}V_1$$

$$x_{B,0}L_0 = x_{B,N}L_N + y_{B,1}V_1$$

$$y_{C,N+1}V_{N+1} = x_{C,N}L_N + y_{C,1}V_1$$

$$x_{A,0} = 0.35$$

$$x_{B,0} = 0.65$$

$$y_{C,N+1} = 1$$

$$L_0 = 400$$

$$V_{N+1} = 400$$

Put mass balances in terms of $x_{A,N}$, V_1 , and L_N and solve.

$$0.35 \cdot 400 = x_{A,N}L_N + f_3(x_{A,N})V_1$$

$$0.65 \cdot 400 = f_1(x_{A,N})L_N + f_4(x_{A,N})V_1$$

$$400 = f_2(x_{A,N})L_N + f_5(x_{A,N})V_1$$

Solve the system of equations

$$\begin{array}{l}
L_N = 342.8 \text{ kg} \\
V_1 = 457.2 \text{ kg} \\
x_{A,N} = 0.254 \\
x_{B,N} = 0.714 \\
x_{C,N} = 0.032 \\
y_{A,1} = 0.115 \\
y_{B,1} = 0.033 \\
y_{C,1} = 0.845
\end{array}$$

Percent removed

$$\eta = \frac{x_{A,0}L_0 - x_{A,N}L_N}{x_{A,0}L_0}$$

$$\eta = \frac{140 - 87}{140}$$

$$\eta = 37.8\%$$

2. Problem 27.4-2

Naming conventions are the same as the solution to Problem 2 (27.2-1).

Fit 4th order polynomials to equilibrium data in Appendix A.3-24. Then,

$$x_B = f_1(x_A)$$

$$x_C = f_2(x_A)$$

$$y_B = f_3(y_A)$$

$$y_C = f_4(y_A)$$

The outlet streams leave at equilibrium.

$$x_{A,0}L_0 = x_{A,N}L_N + y_{A,1}V_1$$

$$x_{B,0}L_0 = x_{B,N}L_N + y_{B,1}V_1$$

$$L_0 + V_{N+1} = L_N + V_1$$

$$x_{A,0} = 0.25$$

$$x_{B,0} = 0.75$$

$$x_{A,N} = 0.03$$

$$y_{C,N+1} = 1$$

$$L_0 = 200$$

$$V_{N+1} = 600$$

Rearrange mass balances in terms of L_N , V_1 , and $y_{A,1}$

$$0.25 \cdot 200 = 0.03L_N + y_{A,1}V_1$$

$$0.75 \cdot 200 = f_1(0.03)L_N + f_3(y_{A,1})V_1$$

$$200 + 600 = L_N + V_1$$

Solve the system of equations

$$L_N = 130.3 \text{ kg/h}$$

$$V_1 = 669.7 \text{ kg/h}$$

$$x_{B,N} = 0.957$$

$$x_{C,N} = 0.013$$

$$y_{A,1} = 0.354$$

$$y_{B,1} = 0.194$$

$$y_{C,1} = 0.504$$

3. 27.4-9

A - nicotine

B - kerosene

C - water

Assume dilute and that kerosene and water are perfectly immiscible.

$$V_{N+1} = 100$$

$$y_{A,N+1} = 0.014$$

$$y_{B,N+1} = 0.986$$

$$V' = V_{N+1}(1 - y_{B,N+1}) = 100 \cdot (1 - 0.986)$$

$$V' = 98.6$$

90% removal of nicotine

$$x_{A,N}L_N = 0.9 \cdot 1.4$$

$$y_{A,1}V_1 = 0.1 \cdot 1.4$$

$$y_{B,1}V_1 = 98.6$$

Solve V_1 mass balance

$$y_{A,1} = 0.00142$$

Organic inlet and aqueous outlet are in equilibrium.

From equilibrium data in Example 27.4-3, at $y_{A,N+1} = 0.014$

$$x_{A,N} = 0.015$$

Mass balance for L'_{\min}

$$L'_{\min} \frac{x_0}{1 - x_0} + V' \frac{y_{N+1}}{1 - y_{N+1}} = L'_{\min} \frac{x_N}{1 - x_N} + V' \frac{y_1}{1 - y_1}$$

$$L'_{\min} \frac{0}{1 - 0} + 98.6 \cdot \frac{0.014}{1 - 0.014} = L'_{\min} \frac{0.015}{1 - 0.015} + 98.6 \cdot \frac{0.00148}{1 - 0.00148}$$

$$L'_{\min} = 81.8 \text{ kg/h}$$

$$L' = 1.5L'_{\min}$$

$$L' = 122.7 \text{ kg/h}$$

From mass balance at L'

$$x_0 = 0$$

$$y_{N+1} = 0.014$$

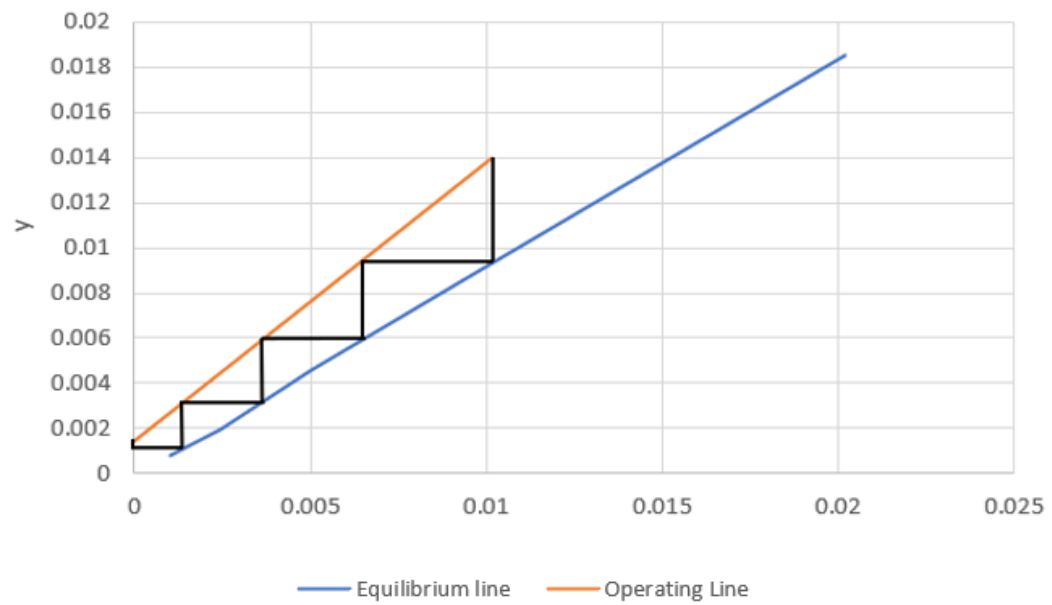
$$x_N = 0.0102$$

$$y_1 = 0.00142$$

Assume dilute and a straight operating line.

Plot operating and equilibrium line at step off stages.

Problem 27.4-9 McCabe Thiele Analysis



Last stage does not fully reach operating line. $N \approx 3.8$

4. Problem 31.2-2

5. Problem 31.3-1