1. Problem 26.5-1

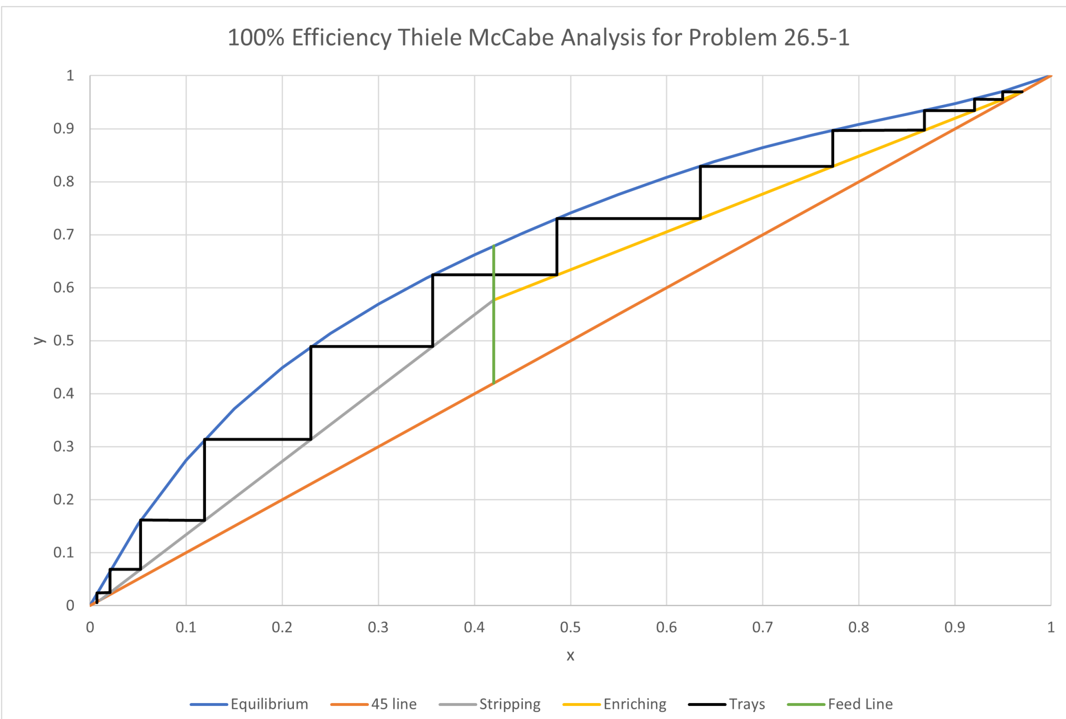
   Using data from Problem 26.4-2, fit a polynomial for $y = f(x)$.

   Enriching Line:

$$y = \frac{R}{R+1}x + \frac{x_D}{R+1}$$
$$R = 2.5$$
$$x_F = 0.42$$
$$x_D = 0.97$$
$$x_W = 0.011$$
$$q = 1$$

   Find stripping line from intersection between feed line and enriching line.

   Plot equilibrium, enriching, and stipping lines and step off the trays to find the ideal number of trays.

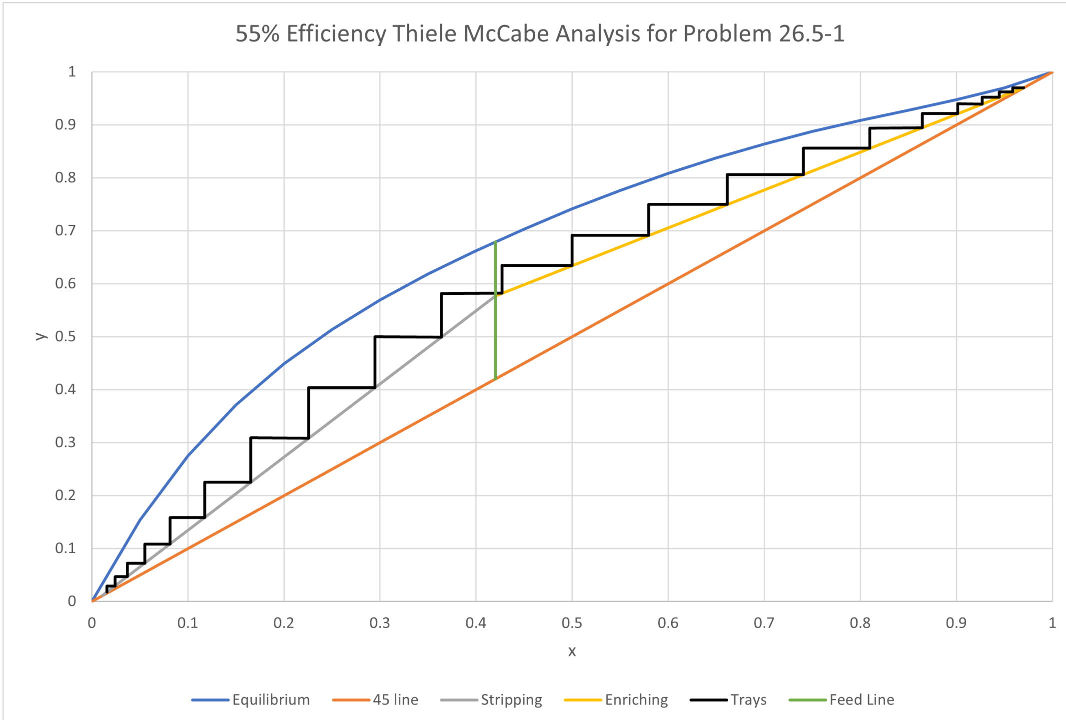


   The ideal number of trays is 11 plus a reboiler.

   Murphree tray efficicency= 0.55

$$E_M = \frac{y_n - y_{n+1}}{y^* - y_{n+1}}$$

   Step off tray again with the 55% efficient trays.



The actual number of trays is 21 plus a reboiler.

Overall efficicency:

$$E_O = \frac{\text{ideal number of trays}}{\text{actual number of trays}}$$

$$E_O = \frac{12}{22} = \boxed{0.54}$$

2. Problem 26.8-4

(a)

Species material balance around B and C

$$D_B = 23.75 \text{ mol/h}$$
$$D_C = 1 \text{ mol/h}$$
$$W_B = 1.25 \text{ mol/h}$$
$$W_C = 19 \text{ mol/h}$$

Assume that there is no D in the distillate and no A in the worm

$$\boxed{D = 64.75 \text{ mol/h}}$$
$$\boxed{W = 35.25 \text{ mol/h}}$$

(b)

Antoine's Equation

$$\ln P^*_{sat} = A - \frac{B}{T + C}$$

Antoine paramters:

	A	B	C
Butane	13.6608	2154.7	238.789
Pentane	13.7667	2451.88	232.014
Hexane	13.8193	2696.04	224.317
Heptane	13.8622	2910.26	216.432

In the distillate:

Calculate vapor pressure for each species, guess temperature

$$K_i = \frac{x_i}{P}$$

C is heavy key

$$\alpha_i = \frac{K_i}{K_C}$$
$$P = \sum \frac{x_i}{\alpha_i}$$

Solve for dew point temperature

$$\boxed{T_D = 65.8\ ^\circ\mathrm{C}}$$

In the worm:

Calculate K_i and α_i

$$P = \sum x_i \alpha_i$$

Solve for bubble point temperature

$$\boxed{T_W = 129.8\ ^\circ\mathrm{C}}$$

(c)

$$\begin{aligned}
\alpha_{avg} &= \sqrt{\alpha_D \alpha_W} \\
\alpha_{B,avg} &= 2.45 \\
N_m &= \frac{\log\left[\left(\frac{x_{LD}}{x_{HD}}\right)\left(\frac{x_{HW}}{x_{LW}}\right)\right]}{\log\left(\alpha_{B,avg}\right)} \\
& \boxed{N_m = 6.57}
\end{aligned}$$

Find composition of A in the worm and D in the distillate

$$\begin{aligned}
\frac{x_{iD}}{x_{iW}} &= \left(\alpha_{i,avg}\right)^{N_m} \frac{x_{HD}}{x_{HW}} \\
& \boxed{x_{AW} = 1.25 \cdot 10^{-4}} \\
& \boxed{x_{DD} = 4.2 \cdot 10^{-5}}
\end{aligned}$$

Correct overall composition for new trace compositions

(d)

$$\begin{aligned}
1 - q &= \sum \frac{\alpha_i x_{iF}}{\alpha_i - \theta} \\
q &= 1 \\
\theta &= 1.22 \\
R_m + 1 &= \sum \frac{\alpha_i x_{iD}}{\alpha_i - \theta} \\
R_m + 1 &= 1.42 \\
& \boxed{R_m = 0.426}
\end{aligned}$$

(e)

Use figure 26.8-3

$$\text{y-axis} = \frac{R}{R+1}$$
$$\text{tie lines} = \frac{R_m}{R_m+1}$$
$$R = 0.554$$
$$\text{y-axis} = 0.35$$
$$\text{tie lines} = 0.29$$
$$\text{x-axis} = 0.42$$
$$\text{x-axis} = \frac{N_m}{N}$$
$$\boxed{N = 15.6}$$

(f)

$$\log\left(\frac{N_e}{N_s}\right) = 0.206 \log\left[\left(\frac{x_{HF}}{x_{LF}}\right)\frac{W}{D}\left(\frac{x_{LW}}{x_{HD}}\right)^2\right]$$
$$N_e + N_s = 15.6$$

Solve for N_e and N_s

$$\boxed{N_e = 8.5}$$
$$\boxed{N_s = 7.15}$$

3. Problem 26.8-7

(a)

$$F_A = D_A$$
$$F_A = 4.7$$
$$x_{AD} = 0.126$$
$$D = \frac{4.7}{0.126}$$
$$\boxed{D = 37.3 \text{ mol/h}}$$
$$\boxed{W = 62.7 \text{ mol/h}}$$
$$N_m = \frac{\log\left[\left(\frac{x_{LD}}{x_{HD}}\right)\left(\frac{x_{HW}}{x_{LW}}\right)\right]}{\log\left(\alpha_{B,avg}\right)}$$
$$\alpha_B = 1.58$$
$$x_{Bw} = 0.001$$
$$x_{Cw} = 0.999$$
$$x_{BD} = 0.1913$$
$$x_{CD} = 0.6827$$
$$\boxed{N_m = 12.32}$$
$$\frac{x_{iD}}{x_{iW}} = (\alpha_{i,avg})^{N_m}\frac{x_{HD}}{x_{HW}}$$
$$\alpha_A = 4.19$$
$$x_{AD} = 0.126$$
$$\boxed{x_{AW} = 3.99 \cdot 10^{-9}}$$

(b)

$$1 - q = \sum \frac{\alpha_i x_{iF}}{\alpha_i - \theta}$$
$$q = 1$$
$$\theta = 1.51$$
$$R_m + 1 = \sum \frac{\alpha_i x_{iD}}{\alpha_i - \theta}$$
$$R_m + 1 = 3.24$$
$$\boxed{R_m = 2.24}$$

Use figure 26.8-3

$$\text{y-axis} = \frac{R}{R+1}$$
$$\text{tie lines} = \frac{R_m}{R_m+1}$$
$$R = 2.81$$
$$\text{y-axis} = 0.73$$
$$\text{tie lines} = 0.69$$
$$\text{x-axis} = 0.5$$
$$\text{x-axis} = \frac{N_m}{N}$$
$$\boxed{N = 24.6}$$