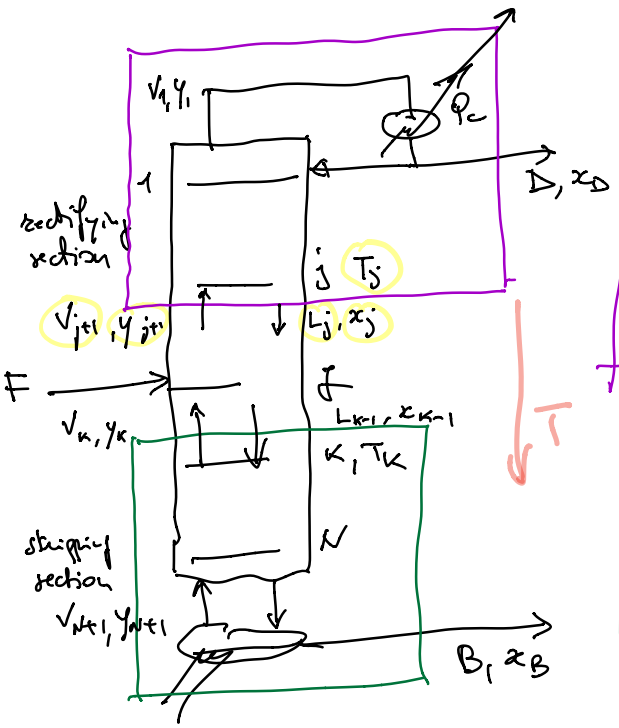
Internal balances

CMO



mat. bal. $\begin{cases} V_{j+1} = L_j + D \\ V_{j+1} y_{j+1} = L_j x_j + D x_D \end{cases}$ ✗ ✓

en. bal. $V_{j+1} H_{j+1} + Q_c = L_j h_j + D h_D$ ✗

LVE on stage j $\begin{cases} y_j = K_{1,j}\, x_j \\ (1-y_j) = K_{2,j}\,(1-x_j) \end{cases}$ ✓ ✓

$L_{K-1} = V_K + B$ ✗

$L_{K-1} x_{K-1} = V_K y_K + B x_B$ ✓

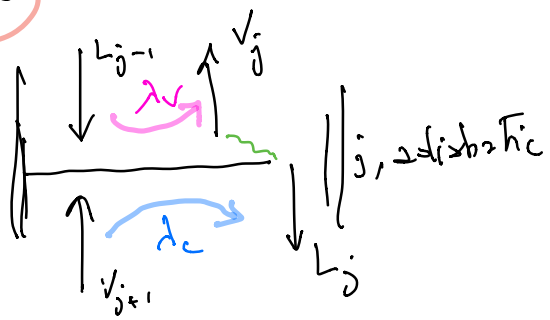
$Q_R + L_{K-1} h_{K-1} = V_K H_K + B h_B$ ✗

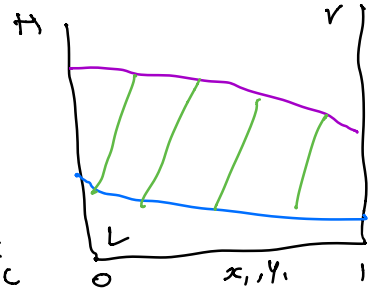
$y_K = K_{1,K}\, x_K$ ✓

$(1-y_K) = K_{2,K}\,(1-x_K)$ ✓

Mc-Cabe Thiele

CMO





Ponchon-Savarit

$\lambda_c \cong \lambda_V \iff \Delta V_{j+1} \cong \Delta L_{j-1} \iff V_{j+1} \cong V_j$, $L_{j-1} \cong L_j$

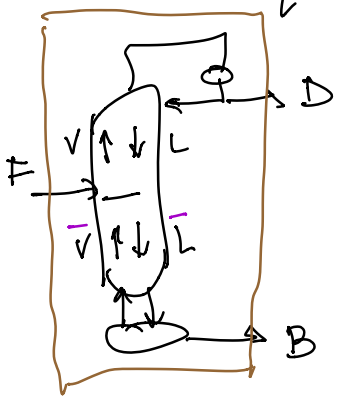
Key assumpt.: specific (molar) heat of vaporization $\cong$ specific heat (molar) of condensation

under the CMO assumption : what happens

overall material balances

$V = L + D$ rectifying section

$\bar{L} = \bar{V} + B$ stripping section



$D = V - L$

$B = L - V$

$F = D + B = 0$!!! wrong

$L \neq \bar{L}$

$V \neq \bar{V}$ in principle

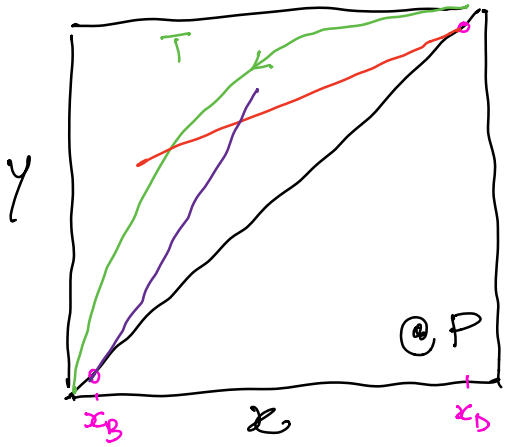
2 isopleth conditions $\longrightarrow$ $y = f(x)$ @ P

material balances

$$V y_{j+1} = L x_j + D x_D$$

$$\bar{L} x_{K-1} = \bar{V} y_K + B x_B$$

$$y_{j+1} = \frac{L}{V} x_j + \frac{D}{V} x_D$$



$$y = \frac{L}{V} x + \frac{D}{V} x_D = \frac{R}{R+1} x + \frac{1}{R+1} x_D$$

↑ Known !!

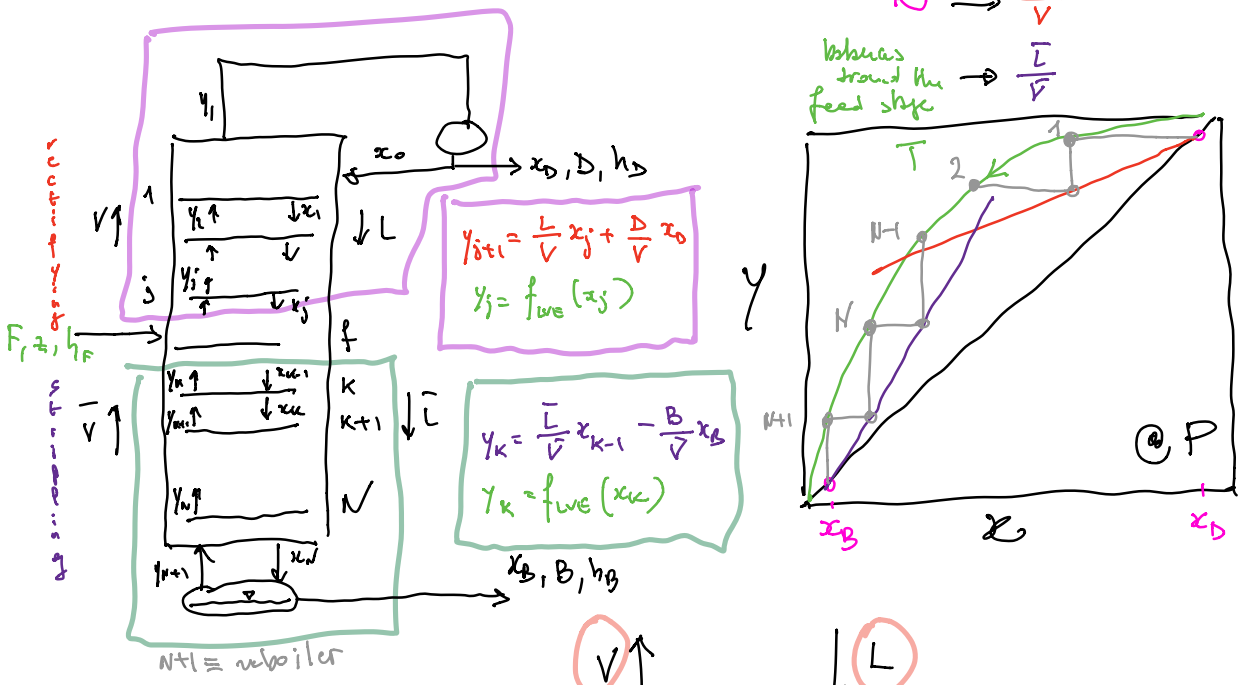
$R = \frac{L}{D} =$

$V = L + D$ $\quad \frac{V}{D} = \frac{L}{D} + 1 = R + 1$ $\quad \frac{L}{V} = \frac{L/D}{V/D} = \frac{R}{R+1} < 1$

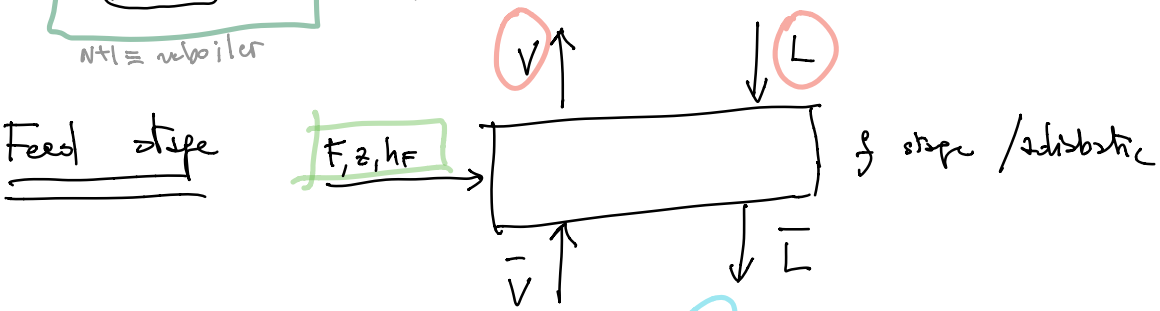
$$y = \frac{\bar{L}}{\bar{V}}_K x - \frac{B}{\bar{V}} x_B$$

slope $= \frac{\bar{L}}{\bar{V}} > 1$

unknown !!



Feed stage



1 stage / adiabatic

overall mat. bal.

energy bal

$$F + \bar{V} + L = V + \bar{L}$$
$$F h_F + \bar{V} H_{f+1} + L h_{f-1} = V H_f + \bar{L} h_f$$

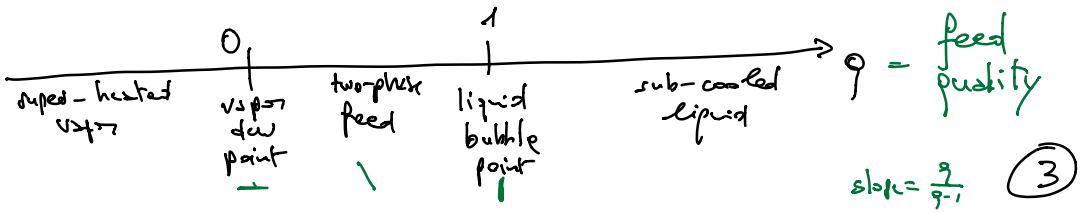
approximation

$$H_{f+1} = H_f = H(z, \text{saturated vapor}) = H$$
$$h_{f-1} = h_f = h(z, \text{saturated liquid}) = h$$

$$\frac{\bar{L} - L}{F} = q$$

$$\frac{\bar{V} - V}{F} = q - 1$$

$$q = \frac{H - h_F}{H - h}$$



3

intersection of the two operating lines

$$\begin{cases} \ominus & V y = L x + D x_D \\ \oplus & \bar{V} y = \bar{L} x - B x_B \end{cases}$$

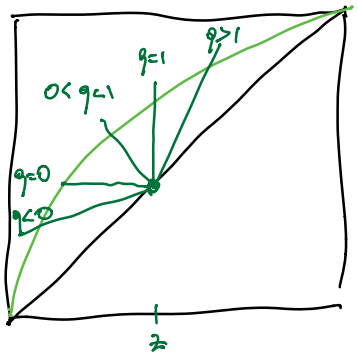
$$\underbrace{(\bar{V}-V)}_{(q-1)F}\, y = \underbrace{(\bar{L}-L)}_{qF} x - \underbrace{(B x_B + D x_D)}_{F z}$$

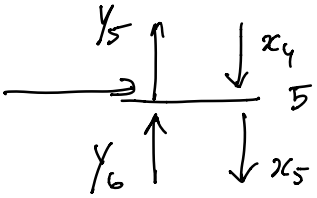
q-line

$$(q-1)\, y = q x - z$$

$$\boxed{y = \frac{q}{q-1} x - \frac{1}{q-1} z}$$

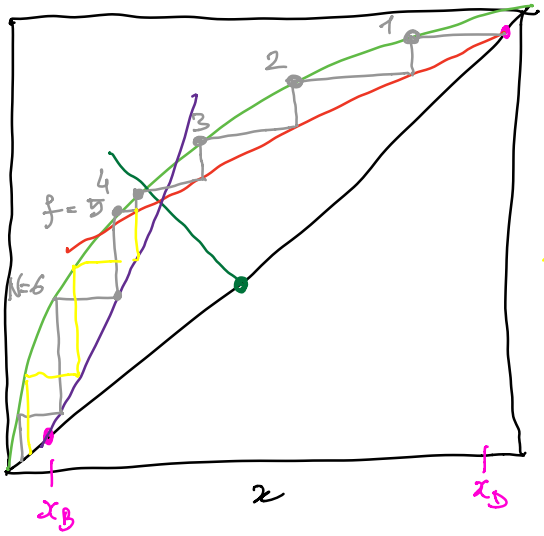
$y = x = z$





Summary Mc Cabe - Thiele

- data: feed, LVE
- specifications x_B, x_D
- z, q → q-line
- R → op. line rect. sec.
- op. line strip. sec. ← q-line and rect. op. line
- step-by-step construction (staircase) starting from top



is f=5 optimal?!

f=4 ⇓ N=5

f=3 not possible!

what is the criterion to choose $f_{optimal}$?

how to choose R

- isothermic
- multi-component

20.4