

Kreusser equation

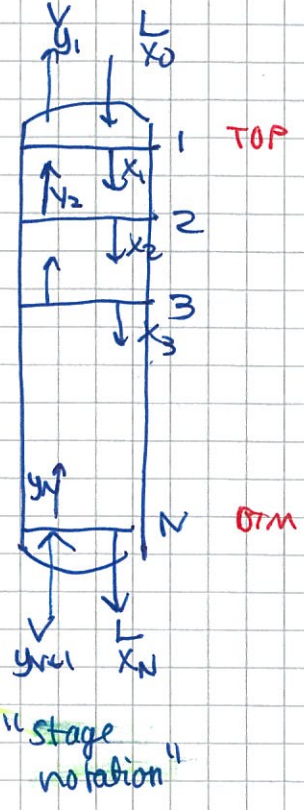
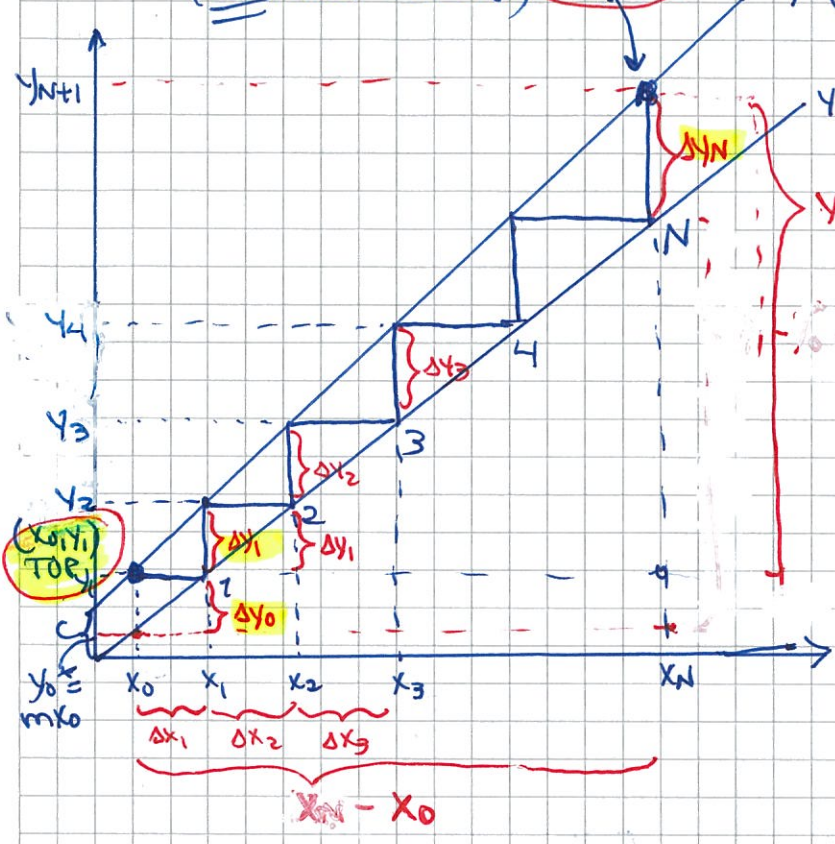
11/9-2013

Sigurd's derivation

(MUCH easier than book!)

(x_N, y_{N+1})
BTM

1



From figure

$$\left. \begin{aligned} \frac{\Delta y_1}{\Delta x_1} &= \frac{L}{V} \\ \frac{\Delta y_0}{\Delta x_1} &= m \end{aligned} \right\} \frac{\Delta y_1}{\Delta y_0} = \frac{L/V}{m}$$

Similar

$$\frac{\Delta y_2}{\Delta y_1} = \frac{L/V}{m}$$

$$\frac{\Delta y_3}{\Delta y_2} = \frac{L/V}{m}$$

$$\frac{\Delta y_3}{\Delta y_0} = \left(\frac{L/V}{m}\right)^3$$

General

$$\frac{\Delta y_N}{\Delta y_0} = \left(\frac{L/V}{m}\right)^N$$

$$\Delta y_N = y_{N+1} - y_N = y_{N+1} - m x_N$$

$$\Delta y_0 = y_1 - y_0^* = y_1 - m x_0$$

$$\frac{y_{N+1} - m x_N}{y_1 - m x_0} = \left(\frac{L/V}{m}\right)^N$$

$$\Rightarrow N = \frac{\ln \frac{y_{N+1} - m x_N}{y_1 - m x_0}}{\ln \left(\frac{L/V}{m}\right) A} \quad (1)$$

VERY EASY TO DERIVE!



Also note that

$$A = \frac{L/V}{m} = \frac{y_{N+1} - y_1}{m(x_N - x_0)} \quad (\text{from figure}) \quad (2)$$

Can then write

$$N = \frac{\ln \frac{y_{N+1} - y_N^*}{y_1 - y_0^*}}{\ln \frac{y_{N+1} - y_1}{y_N^* - y_0^*}}$$

(*)

where

$$y_N^* = m x_N$$

$$y_0^* = m x_0$$

(2)

Some comments.

- Same equations apply for absorption and stripping.
- Can also use for exact calculations of "corners" in distillation, where equilibrium and operating lines are straight, and then McCabe-Thiele is used in middle section.

Example 10.3-3

$$y_1 = 0.00101$$

$$y_{N+1} = 0.01$$

$$x_N = 0.003 \Rightarrow y_N^* = 2.53 \cdot 0.003 = 0.00759$$

$$x_0 = 0 \Rightarrow y_0^* = 0$$

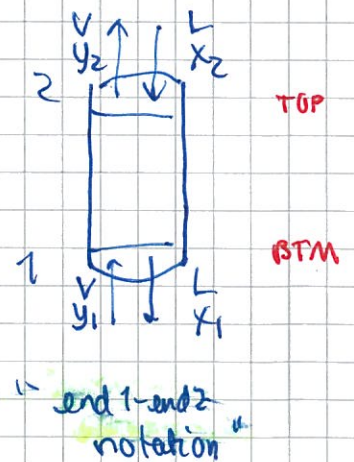
$$N = \frac{\ln \frac{0.01 - 0.00759}{0.00101 - 0}}{\ln \frac{0.01 - 0.00101}{0.00759 - 0}} = \frac{\ln \frac{2.386}{7.574}}{\ln 1.184} = 5.15$$

Book gives 5.04 but this is because they use another value of L/V - note that L/V varies slightly.

Example 10.6-3 (end 1-end 2 notation)

$$N = \frac{\ln \frac{y_1 - y_2^*}{y_2 - y_2^*}}{\ln \frac{y_1 - y_2}{y_1^* - y_2^*}}$$

(*)



$$y_1 = 0.022$$

$$x_2 = 0 \Rightarrow y_2^* = 0$$

$$y_2 = 0.002244$$

$$x_1 = 0.0218 \Rightarrow y_1^* = 0.01482$$

$$(m = 0.68)$$

$$N = \frac{\ln \frac{0.022 - 0.01482}{0.002244 - 0}}{\ln \frac{0.022 - 0.002244}{0.01482 - 0.002244}} = \frac{\ln 3.1996}{\ln \frac{1.5709}{1.333}} = \underline{\underline{4.05}}$$

(same as book)