CHE318 L26

Packed absorption bed,

Last lecture introduced solution to tower height

Gas, using k_y':

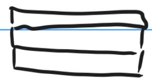
$$Z = \int_{y_2}^{y_1} \frac{V}{k_y' a S} \cdot \frac{(1-y)_{im}\, dy}{(1-y)(y-y_i)}$$

How to understand?

$$\frac{V}{k_y' a S} = \frac{\frac{kg\,mol}{s}}{\frac{kg\,mol}{m^2 \cdot s} \cdot \frac{m^2}{m^3} \cdot m^2} \Rightarrow \text{unit } m$$

usually $k_y' a$ given as single parameter (known)

Define $\frac{V}{k_y' a S} = H_G$ theoretical "transfer unit" for tower height

Analog: layered tower  plates

The rest part $\int_{y_2}^{y_1} \frac{(1-y)_{im}}{(1-y)(y-y_i)_m} dy = N_G$ "numbers of unit"

Simpler view: $Z = H_G \cdot N_G$

H_G: height of transfer unit
(similar to tray tower)
1 tray

N_G: theoretical unit based on gas phase

$$Z = H_G N_G = H_L N_L = H_{OG} N_{OG} = H_{OL} N_{OL}$$

H_{OG}: overall $K_y' a$

H_{OL}: overall $K_x' a$

Design of contentrated bed ?

1. Diagram — nonlinear
2. Determine O.L. & E.L.
3. If necessary, determine min L' or V'
4. Determine slope by k_x' k_y' (or $k_x'a$ $k_y'a$)

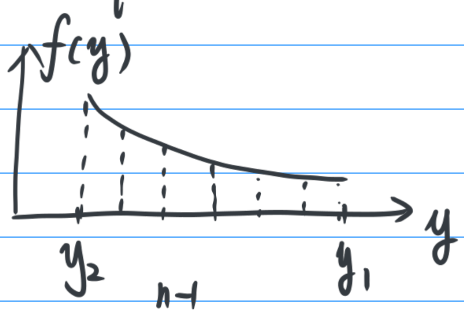
   (iterative ; threshold of error < 10 %
   or numerical solution)

5. Get all (y, y_i) points

   to solve
   $$\begin{cases} (1-y)_{im} \; ? \; ✓ \\ (1-y) \; ✓ \\ (y-y_i)_m \; ✓ \end{cases}$$

6. Get H_G & N_G ⇒ Z

   N_G: requires numerical integration



$$\text{integral} = \sum_{i=0}^{n-1} \frac{1}{2}(y_{i+1} - y_i) \cdot (f_{i+1} + f_i)$$

Example study ?

See online demo

Transfer Unit

H_G N_G for example

$$H_G = \frac{V}{k_y' a S} = \frac{3.852\times10^{-3}}{(3.78\times10^{-2})(0.186)} = 0.548\ m$$

dilute system

$$\int_{y_2}^{y_1} \frac{(1-y)_{im}}{(1-y)(y-y_i)_m}\,dy$$

$(1-y)_{im}/(1-y) \simeq 1$, only calculate $\int_{y_2}^{y_1} \frac{1}{(y-y_i)_m}\,dy$

$$\int_{y_2}^{y_1} \frac{1}{(y-y_i)}\,dy = \frac{y_1 - y_2}{(y-y_i)_m}$$

$$(y-y_i)_m = \frac{(y_1-y_{1i})-(y_2-y_{2i})}{\ln[(y-y_i)_1/(y-y_i)_2]} = 0.00602$$

$y_1 - y_2 = 0.026 - 0.005 \Rightarrow N_G = 3.488$ (trans. units)

$Z = H_G N_G = 1.911\ m$ (the same as in k_y')

If change to H

Practical estimation of $k_y'a$ or H_G

in packed beds are usually using correlation by N_{Re}, N_{Sc} ...

(should also know { type of packed beds D_p, ε ......

Example 10.7-1

$$k_y'a = 0.0594 \times G_y^{0.7} G_x^{0.25}$$

$$k_x'a = 0.152 \times G_x^{0.82}$$

G_x G_y: kg total liq/gas per m^2 per s

$[kg/m^2 \cdot s]$

Problem: G_x G_y depends on local V L

$$G_x = \frac{V' \cdot m_B + V_y \cdot m_A}{S} \qquad V_y = V \cdot y = V' \frac{y}{1-y}$$

$$G_y = \frac{L' \, m_{(BL)} + L_x \cdot m_A}{S} \qquad V_x = L \cdot x = L' \frac{x}{1-x}$$

Now we can solve G_x, G_y → $k_y'a$ $k_x'a$

they both change!

at each point (x, y) on O.L. → find G_x G_y

↓

find $k_y'a$ $k_x'a$

↓

Slope → (x_i, y_i)

↓

Solve integrated eq

(But H_G change!)

Other systems: give H_G as function of N_{Sc} G_x G_y

Example 10.8-1

$$H_G = H_y = \left(\frac{0.226}{f_p}\right)\left(\frac{N_{Sc}}{0.660}\right)^{0.5}\left(\frac{G_x}{6.782}\right)^{-0.5}\left(\frac{G_y}{0.678}\right)^{0.35}$$

$$H_L = \left(\frac{0.357}{f_p}\right)\left(\frac{N_{Sc}}{372}\right)^{0.5}\left(\frac{G_x/\mu}{6.782/0.8937\times10^{-3}}\right)^{0.3}$$

If known $\begin{cases} G_x G_y \\ \text{packing type} \end{cases} \Rightarrow$ H_G H_L (couple with driving force)