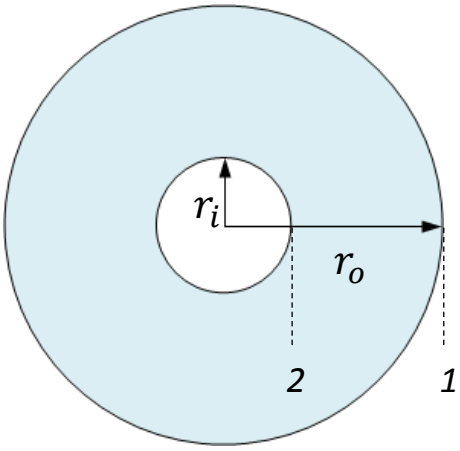
Exercise 11

A pilot rotating packed-bed reactor containing a new type of packing was tested by stripping a low-solubility solute from an organic liquid stream in order to characterize the separation efficiency. Calculate the F-factor, ATU and $HETP$ from the experimental data provided.

Rotor dimensions:

Inner diameter	$2r_i$	0.15 m
Outer diameter	$2r_o$	0.4 m
Height	h	0.01 m



Physical properties

$\rho_G = 3.5\ kg\ m^{-3}$

Equilibrium line

$y = 2.5\ x$

Experimental data

Inlet gas flowrate	G_1	1.6 10^{-3} m^3/s
Mol fraction of solute in liquid feed	x_2	0.02
Mol fraction of solute in exit gas	y_2	0.030
Mol fraction of solute in exit liquid	x_1	0.0050
Mol fraction of solute in gas feed	y_1	0

Solution

1. **F-Factor**

$Dilute\ system: G_1 = G_2 = G$

$u_{G,2} = \frac{G_{G,2}}{2\pi r_i h} = \frac{G}{2\pi r_i h} = 0.35\ m/s \quad ; \quad \boldsymbol{F = u_{G,2}\sqrt{\rho_{G,2}} = u_{G,2}\sqrt{\rho_G} = 0.65\ Pa^{0.5}}$

2. **ATU**

Stripping of poorly soluble solute → liquid film controls

$ATU = A_{OL}; \quad NTU = N_{OL}$

$x^*(y_2) = \frac{y_2}{m} = 0.012 \quad ; \quad x^*(y_1) = \frac{y_1}{m} = 0$

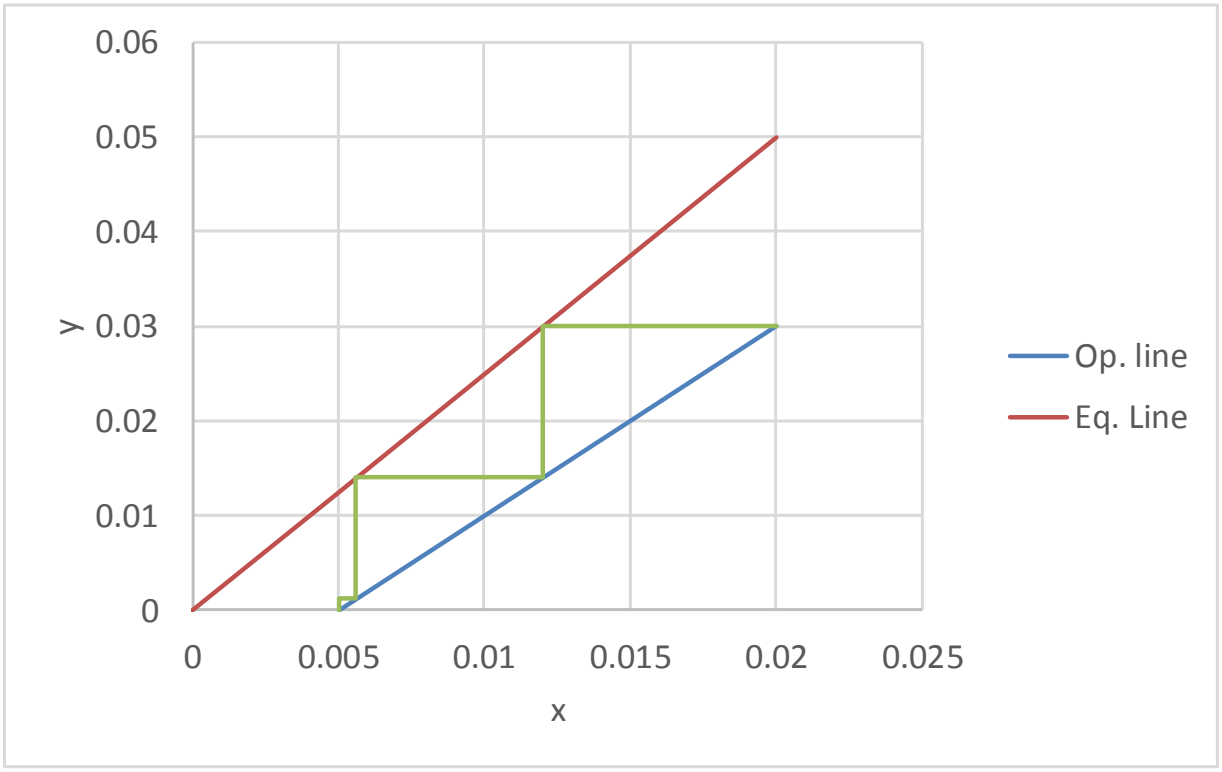
$\overline{(x - x^*)_{LM}} = \frac{[x_2 - x^*(y_2)] - [x_1 - x^*(y_1)]}{ln\left(\frac{x_2 - x^*(y_2)}{x_1 - x^*(y_1)}\right)} = 6.38 \cdot 10^{-3}$

$$N_{OL} = \frac{x_2 - x_1}{(x - x^*)_{LM}} = 2.35$$

$$\boldsymbol{ATU = A_{OL} = \frac{\pi(r_o{}^2 - r_i{}^2)}{N_{OL}} = 0.046\ m^2}$$

3. HETP

Graphically using McCabe-Thiele diagram:



$$\rightarrow NTP = 2 + \frac{0.0012}{0.0125} = 2.1$$

$$\boldsymbol{HETP = \frac{(r_o - r_i)}{NTP} = \frac{(0.2 - 0.075)}{2.1} = 0.06\ m}$$