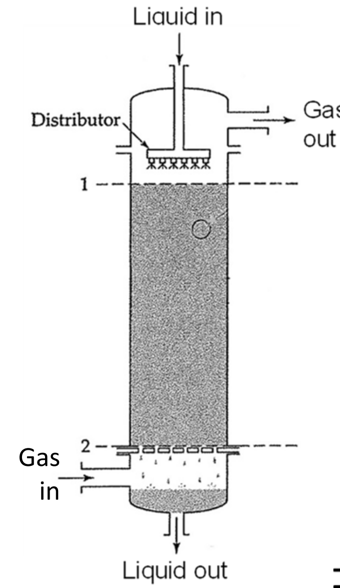
Example 6—concluded

Example 6 Solution:

"rate" equation (gas-side, species A mass balance)	$\frac{dy}{dz} = \frac{K_y a}{G}(y - Hx)$
"operating line" equation (overall, species A mass balance)	$y = \frac{L}{G}(x - x_1) + y_1$
"equilibrium line" equation (thermodynamic equilibrium, dilute mixtures)	$y^* = Hx^*$
Column height, $\boldsymbol{B}$ (result)	$\boldsymbol{B} = \frac{G}{K_y a}\left(\frac{1}{1 - \frac{G}{L}H}\right) \ln\left(\frac{y_2 - y_2^*}{y_1 - y_1^*}\right)$



$A_{xs} [=] m^2$

$y_2^* = y^*(x_2)$
$y_1^* = y^*(x_1)$

$G [=] \frac{mol}{m^2 s}$
$L [=] \frac{mol}{m^2 s}$

See Handnotes

HW 4.16

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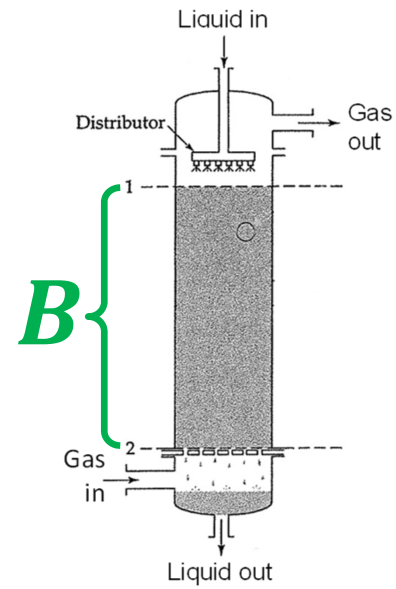
Mass Transfer in an Absorption Column:

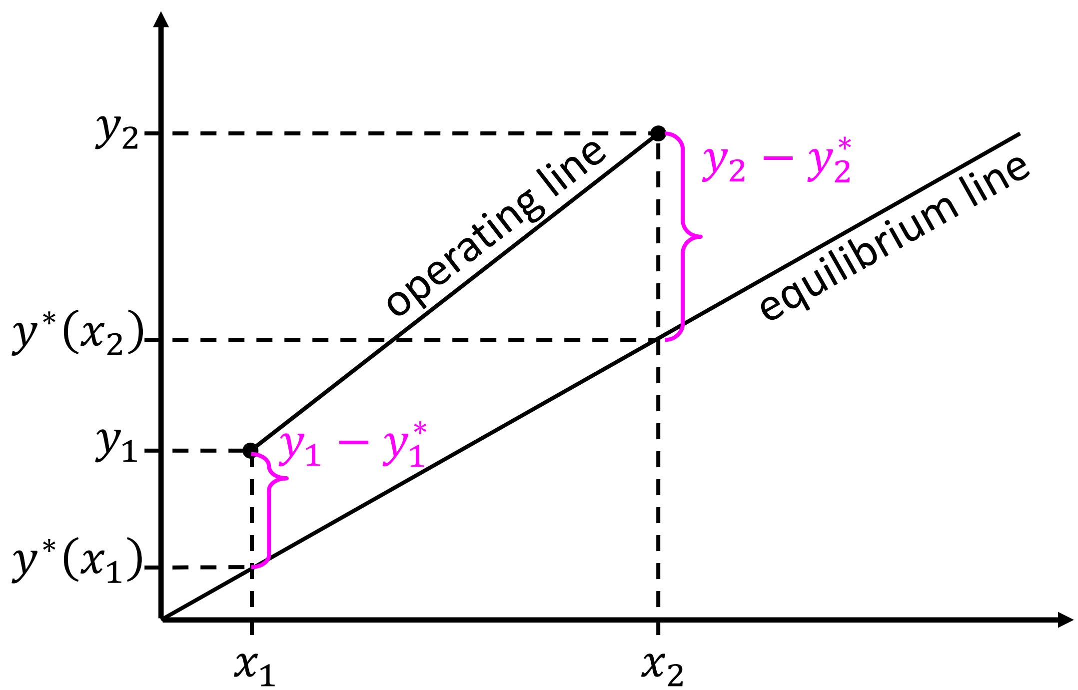


Species A from gas to liquid = Gas scrubbing

- operating line is above the equilibrium line

Species A from liquid to gas = Liquid stripping

- operating line is below the equilibrium line



$G [=] \frac{mol}{m^2 s}$

$L [=] \frac{mol}{m^2 s}$

$A_{xs} [=] m^2$

Column height, ***B*** (result)

$$\boldsymbol{B} = \frac{G}{K_y a} \left(\frac{1}{1 - \frac{G}{L} H} \right) \ln \left(\frac{y_2 - y_2^*}{y_1 - y_1^*} \right)$$

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Column Performance: HTU/NTU

Column height, $\boldsymbol{B}$

$$\boldsymbol{B} = \frac{G}{K_y a}\left(\frac{1}{1-\frac{G}{L}H}\right)\ln\left(\frac{y_2 - y_2^*}{y_1 - y_1^*}\right)$$

"rate" equation (gas-side, species A mass balance)

$$\frac{dy}{dz} = \frac{K_y a}{G}(y - Hx) \qquad y^* = y^*(x) = Hx$$

$$\frac{dy}{dz} = \frac{K_y a}{G}(y - y^*)$$

$$\int_{y_1}^{y^2} \frac{dy}{(y - y^*)} = \int_0^B \frac{K_y a}{G} dz$$

$$B = \frac{G}{K_y a}\int_{y_1}^{y^2} \frac{dy}{(y - y^*)}$$

$$B = \left(\frac{G}{K_y a}\right)\left(\int_{y_1}^{y^2} \frac{dy}{(y - y^*)}\right)$$

$$B = \boldsymbol{HTU} \cdot \boldsymbol{NTU}$$

HTU = height of a transfer unit

A measure of the efficiency of the equipment

NTU = number of transfer units

A measure of difficulty of separation

$G [=] \frac{mol}{m^2 s}$

$L [=] \frac{mol}{m^2 s}$

$A_{xs} [=] m^2$

Cussler p318

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- As the gap between the operating line and the equilibrium line narrows, NTU increases ($B \propto$ integral of 1/gap)

$$B = \left(\frac{G}{K_y a}\right)\left(\int_{y_1}^{y^2} \frac{dy}{(y-y^*)}\right)$$

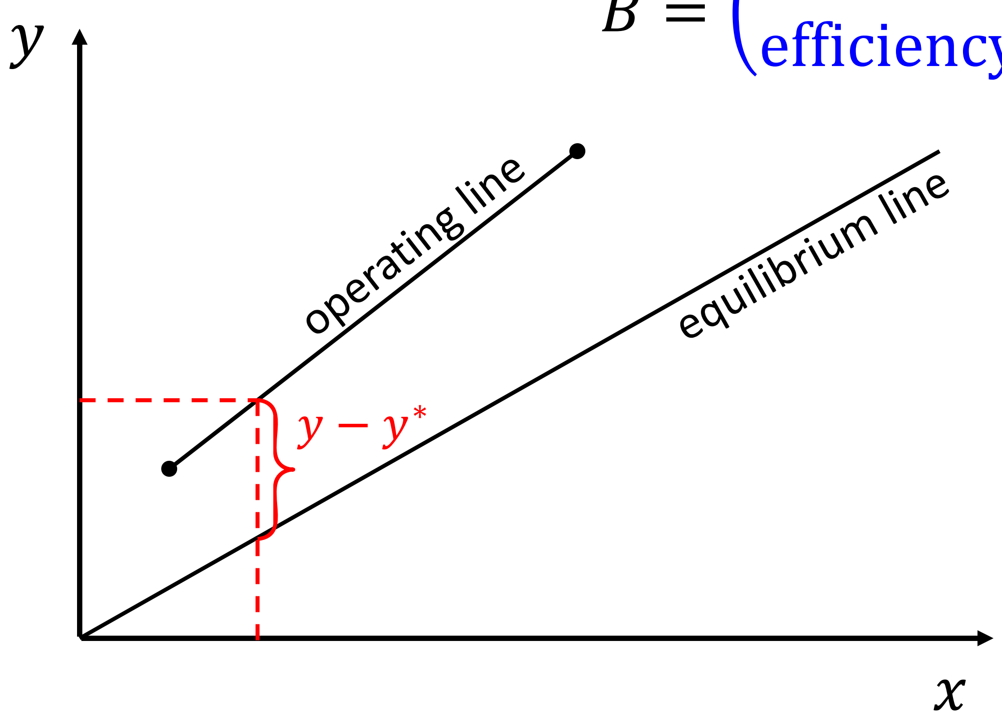
$$B = \boldsymbol{HTU} \cdot \boldsymbol{NTU}$$

$$B = \left(\begin{matrix}\text{column}\\ \text{efficiency}\end{matrix}\right)\left(\begin{matrix}\text{difficulty}\\ \text{of separation}\end{matrix}\right)$$

$G[=]\dfrac{mol}{m^2 s}$

$L[=]\dfrac{mol}{m^2 s}$

$A_{xs}[=]\, m^2$



HW 4.17

- Both operating and equilibrium lines are straight for dilute systems; When not dilute, both lines may be curved; integration then is done numerically (Excel)

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