Eksamen 2013 – Sep-tek

Forslag fasit MB Hägg

Oppgave 1 Membran-separasjon

25% vekt

a) Beregning av min reject.
Using given information and eq. 13.4-12

$$x_{oM} = \frac{x_f\left[1+(\alpha^*-1)\frac{p_l}{p_h}(1-x_f)\right]}{\alpha^*(1-x_f)+x_f}$$

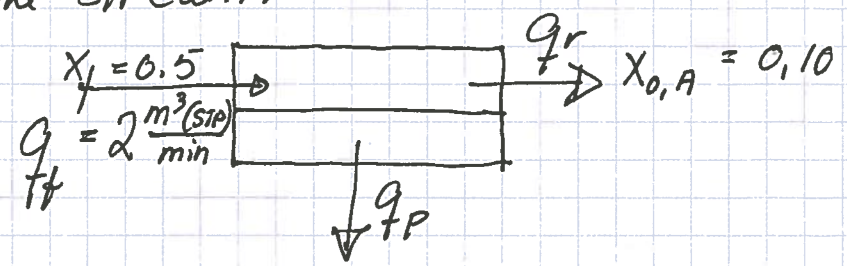
$$= \frac{0.5\left[1+(30-1)\frac{1}{10}(1-0.5)\right]}{30(1-0.5)+0.5}$$

$x_{oM,A} = 0.079 \simeq 0.08$ for gas A

$\Rightarrow$ Gass B is thus $x_{o,B} = 0.92$

b) assuming 20% higher $\Rightarrow x_{o,A} = 0.10$

$\Rightarrow$ using this value to calculate the stream:




$q_f = q_r + q_p \qquad q_f \cdot x_f = q_r \cdot x_o + q_p\, y_p$

b) $\theta = \frac{q_p}{q_f} = 0{,}53 \Rightarrow q_p = 0{,}53 \cdot 2 = 1.06 \frac{m^3(STP)}{min}$

Thus $q_r = 0.94$ "

Calculating composition $y_p$

using 13.4-8: $y_p = \frac{x_f - x_o(1-\theta)}{\theta}$

$= \frac{0{,}5 - 0.1(1-0{,}53)}{0{,}53}$

$= 0.855$ (Gas A)

How much of A are we loosing?

Gas A In : $2 \cdot 0{,}5 = 1\ m^3(STP)/min$

Hence, Gas B $= 1 \frac{m^3(STP)}{min}$

Gas B in permeate :

$1{,}06 \cdot 0{,}145 = 0.154 \frac{m^3(STP)}{min}$

which is $\frac{0.154}{1} \cdot 100\% = 15.4\%$ loss

1c) Calculating membrane area:

eq. 13.4-9:

$$A_m = \frac{\Theta q_f y_p}{(P'_A/t)(p_h x_o - p_l y_p)}$$

$$= \frac{0,53 \cdot 2 \frac{m^3}{min} \cdot 0,86}{\frac{400 \text{ Barrer}}{10^{-6} m} (10 \text{ bar} \cdot 0,\cancel{80} - 1 \text{ bar}\, 0,86)}$$

from given info ↑ $x_{o,A}$

må gjøre om: $1 - 0,86 = 0,14$ bar

$$= \frac{0,53 \cdot (2 \cdot 10^6 cm^3/60 s) \cdot 0,86}{\frac{400 \cdot 10^{-10}}{10^{-4}} \cdot \frac{cm^3 \cdot cm}{cm \cdot s \cdot cm^2 \cdot cmHg} \cdot 0,14 \cdot 76 \text{ cmHg}}$$

$$= \frac{0,53 \cdot 2 \cdot 0,86 \cdot 10^6}{60 \cdot 400 \cdot 10^{-6} \cdot 0,14 \cdot 76} \cdot cm^2$$

$$= \frac{0.9116 \cdot 10^6}{0.14 \cdot 76 \cdot 24 \cdot 10^{-3}} = 3{,}57 \cdot 10^6 cm^2$$

Membrane area $\Rightarrow$ = 357 $m^2$

d) Reduce the loss of B by:

- Make a cascade solution or two steps with reduced stage cut ($\Theta$)
- Change pressure ratio
- Try to increase selectivity (new material)

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25% weight

## Problem on Adsorption (4)

$H_T = 30\ cm \quad \rho_p = 712.8\ kg/m^3$

Calculating $c/c_0$ ⇒ Table x/ ~~...~~ 926

a)

| Time, h | $c/c_0$ | Time | $c/c_0$ |
|---|---|---|---|
| 0 | $0 \cdot 10^{-2}$ | 10.8 | 0.45 |
| 9 | $0.065 \cdot 10^{-2}$ | 11.25 | 0,68 |
| 9,2 | $0,129 \cdot 10^{-2}$ | 11.5 | 0,77 |
| | | 12.0 | 0,98 |
| $t_b$ → 9,6 | 0,027 | 12.8 | 1,00 |
| 10 | 0,098 | | |
| 10,4 | 0,25 | | |

⇒ curve can be drawn → see Textbook page 767

$$t_u = \int_0^{t_b} \left(1 - \frac{c}{c_0}\right) dt \Rightarrow \text{from graph or Table,}$$

b) Break point: $t_b = 9,58h$

$$H_{UNB} = \left(1 - \frac{t_u}{t_t}\right) H_T$$

$$= \left(1 - \frac{9,58}{12,8}\right) 0,30\ m$$

$$= 7,5\ cm \quad \text{unused bed}$$

c) The graph between $t = 9,58$ and $12,8h$ is $3,22\ h$.

$\Rightarrow$ additional bed in mass transfer zone is $\underline{1,61\ h}$

$\Rightarrow$ total capacity will be used after $9,58 + 1,61\ h = \underline{11,19\ h}$

which is fraction used up to $t_b$ / $\frac{t_u}{t_t} = \frac{9.58}{11.19} = 0,86 \Rightarrow \underline{86\%}$

d) Determine the saturation capacity of the column for water up-take untill break-point

after 12.8 h the column is fully saturated

$N_2$-flow rate: $4052\ kg N_2/m^2 \cdot h$

Total water adsorbed:

$$\frac{926 \cdot 10^{-6}\ kg\ H_2O}{kg\ N_2}$$

$$926 \cdot 10^{-6} \cdot 4052 \cdot 9,58 \quad \frac{kg\ H_2O}{m^2 \cdot 0,225 m}$$

$$= \frac{35.95}{0,225} \frac{kg\ H_2O}{m^3} \simeq \underline{160\ kg\ H_2O/m^3}$$

or: $\frac{160\ kg\ H_2O}{712.8\ kg\ particle} = 0.22 \frac{kg\ H_2O}{kg\ particles}$