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CH3030 AMT TUTORIAL - 6

① Given data:

$z_F = 0.1$, $x_B = 0.01$, $x_D = 0.8$

Feed is bubble-point liquid.

$\Rightarrow q = 1$

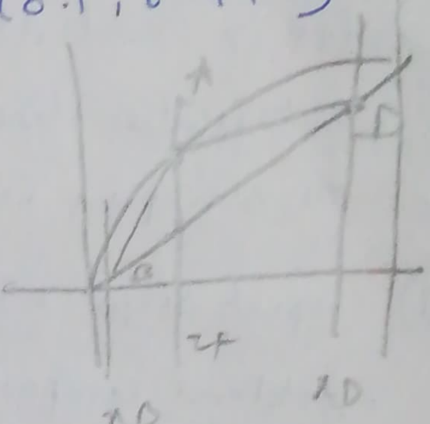
$\Rightarrow$ the q-line is simply a vertical line passing through (z_F, z_F)

Step i): Finding R_{min}.

→ Find the intersection between q-line ($x = 0.1$) and the eqbm curve

→ Intersection is found to be: $A(0.1, 0.4426)$.

→ The line joining $D(x_D, x_D)$ to A has slope $= \frac{R_{min}}{R_{min}+1}$



$\Rightarrow R_{min} = \frac{m_{min}}{1 - m_{min}}$

$= \underline{1.043}$.

Step ii) Finding R and doing the stepping by constructing operating lines.

→ $R = 1.5\,R_{min} = \underline{1.5645}$

→ ~~Stripping~~ Rectification section operating line: slope $= \frac{R}{R+1}$ and passes through (x_D, x_D)

~~⇒ eqn is~~

$\Rightarrow$ eqn is $(y - x_D) = \left(\frac{R}{R+1}\right)(x - x_D)$

$\Rightarrow y = 0.6101x + 0.3119$

→ Join point B(x_B, x_B) and the intersection of the q-line. This is the stripping operating line.
$\boxed{y = 4.03x - 0.303.}$

→ ~~8~~ the lines are plotted in MATLAB and the figure is attached

→ Stepping is done in ~~matlab~~. MATLAB

Procedure :

a) Start from $y = x_D$, $x = x_D$.

b) fix ~~x~~ y and move left to the ~~corresponding~~ point on the equilibrium curve.

c) fix x and drop to the point on ~~stripping~~ Rectification line if $x > z_F$ or to the point on stripping line if $x < z_F$.

d) Repeat steps b to c till the ~~x~~ desired bottoms composition ($x_B = 0.01$) is achieved ~~(i.e. y x Repeat till.~~

(i.e. stop only when $y <= 0.01$)

a) We find that there are 14 theoritical stages in rectification
13 theoritical stages in stripping

⇒ 17 theoritical stages.

But the last stage in stripping section is PARTIAL REBOILER

∴ Totally $\boxed{13 \text{ above} + 2 \text{ below}}$ = 15 theoritical plates
= $\boxed{15 \text{ plates reqd.}}$

1 b) Since H is given in terms of overall Mass Transfer Coefficient, $N_{OG} = \int_{y_1}^{y_2} \frac{dy}{y^* - y}$.

For obtaining y^*, we just fix the x coordinate of a point on the operating line and find the corresponding y-coordinate in the eqbm curve.

Thus we can find multiple such points and then integrate numerically

Intersection of the operating lines $\equiv (0.1, 0.373)$

Limits of Integral

i) Rectification section: $y_1 = 0.373$,

$y_2 = 0.8$ $(= x_D)$

ii) Stripping section: $y_1 = 0.098$ (this is the purity at which vapour from the partial reboiler enters)

$y_2 = 0.373$.

~~y_1, stripping is found ~~

y_1, stripping = y_{eqbm} at $x = x_B = 0.01$

Note that to generate points with (y, y^*) it is easier to know the x-coordinates and find y using operating line equation and y^* using eqbm curve

So these eqns are numerically integrated in MATLAB using (y, y^*) generated for a set of x-coordinates.

One small manipulation is needed only in x_1, stripping (otherwise $x_2 = y_2$ & $x_1 = y_1$)

In that case I use the stripping line equation to get x_1 from y_1

Upon integration with 30 points for each section),

NTU, above = 14.152 ~~≈ 14.15 units~~

NTU, below = 2.230 ~~or 3 units~~.

b) NTU above = 14.15 ~ 15

Subsracting one for feed,

NTU above = 15 − 1 = 14 units

NTU below = 2.23 ~ 3.

Subtracting one for feed,

NTU below = 2 units

∴ Total number of transfer units (including feed) = 14 + 2 = $\boxed{16 \text{ units}}$

c) We obtained 16 ~~theroiti~~ theoritical plates including the feed in part (a).

Efficiency = 0.8.

$$\Rightarrow \frac{\text{No. of theoritical plates}}{\text{No. of actual plates}} = 0.8.$$

$$\Rightarrow \text{No. of actual plates} = \frac{\text{No. of theoritical plates}}{0.8}$$

$\Rightarrow$ Number of actual plates $= \dfrac{16}{0.8} = 20$ plates.

$\therefore$ Height of plated section $= (20-1) \times 18$ m

(if we have n plates, we have (n−1) gaps b/w plates)

$= 342$ inches.

$= \boxed{8.839 \text{ m}}$

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c) We have totally $14 + 3 + 1 = 18$ transfer units

Height of bed $=$ NTU $\times$ HTU

$= 18 \times 1.2$ feet

$= 21.6$ feet

$= 6.584$ m.

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d) We have totally $14 + 2 + 1 = 17$ transfer units

(feed)

$\Rightarrow$ Height of bed $=$ NTU $\times$ HTU

$= 17 \times 1.2$

$= \boxed{20.4 \text{ feet}}$

$= 6.218$ m

(here I have rounded off the NTU to nearest integer ; since it is height if we can simply use the Integral value. In that case we get a less conservative value of $16.38 \times 1.2 = 19.66$ feet ~ 5.99m)