Tutorial - 5

$$\text{MW of feed} = \frac{1}{\frac{0.3}{34} + \frac{0.7}{18}} = 22.02\ g$$

$$F = 5000\ kg/h = 227.05\ kmol/h.$$

$$x_D = \frac{\frac{0.88}{34}}{\frac{0.88}{34} + \frac{0.12}{18}} = 0.7416$$

$$x_B = \frac{\frac{0.04}{34}}{\frac{0.04}{34} + \frac{0.96}{18}} = 0.016$$

$$x_F = \frac{0.30/34}{0.3/34 + 0.7/18} = 0.1436$$

H_{V1} = enthalpy of vapour @ $x = x_D$ ("$x = x_D$ because complete/total condenser")

$\Rightarrow H_{V1} = 6865\ kJ/kmol$ (interpolation)

$H_f = 4290\ kJ/kmol$ (given)

H_{LO} = enthalpy of liquid @ $x = x_D$

$= 8840\ kJ/kmol$ (interpolation)

$$\frac{L}{D} = \frac{H_D' - H_{V1}}{H_D' - H_{LO}} \quad ; \text{Given } R = 1.$$

$$\Rightarrow H_D' - 2H_{V1} - H_{LO}$$

~~8839~~ ~~8822~~ kJ/kmol

$= 8822\ kJ/kmol$

In the enthalpy concentration diagram, if a line through (H_F, x_F), $(H_{D'}, x_D)$ passes through (H_B, x_B)

Using this property we get $H_{B'} = -13141$ kJ/kmol.

To obtain operating lines, we recognise that a line passing through D' cutting $H_L - xy$ curve at (x_L, y_L) & cutting $H_V - xy$ curve at (x_V, y_V) we means that the point (x_L, y_V) lies on the stripping section OL. Analogously using lines through B' we obtain the rectification operating line.

We then perform the stepping process to obtain

a) ∴ 10 total stages, 1 is a partial reboiler

⇒ 9 ideal trays are required.

b) H_D = enthalpy of liquid at $x = x_D$

= 8839.1 kJ/kmol $(= H_{L0})$

H_B = enthalpy of liquid at $x = x_B$

= 7361.9 kJ/kmol

$D = F \times \left(\frac{x_F - x_B}{x_D - x_B}\right) \simeq 39.93$ kmol/h

$B = F - D = 187.122$ kmol/h

Energy balance at condenser:

$$Q_C = D(H_D' - H_D)$$

$$= \boxed{3.19 \times 10^6 \text{ kJ/kmol}}$$

Energy balance at partial reboiler:

$$Q_B = BH_B + V_{m+1}H_{V_{m+1}} - L_m H_{L_m}$$

Or an easier way!

total energy balance:

$$Q_B + FH_f = Q_C + DH_D + BH_B$$

$$\Rightarrow Q_B = Q_C + DH_D + BH_B - FH_F$$

$$Q_B = 3.83 \times 10^6 \text{ kJ/kmol}$$

$$= \boxed{3.84 \times 10^6 \text{ kJ/kmol}}$$