<u>Tutorial Sheet - 4</u> 19/10/17

$$\frac{V}{F_{A0}} = \int_0^{0.96} \frac{dX_A}{-r_A}$$

$$-r_A = k C_A C_B = k C_{A0} (1 - X_A)(C_{B0} - C_{A0} X_A)$$

$$= k C_{A0}^2 (1 - X_A)\left(\frac{C_{B0}}{C_{A0}} - X_A\right)$$

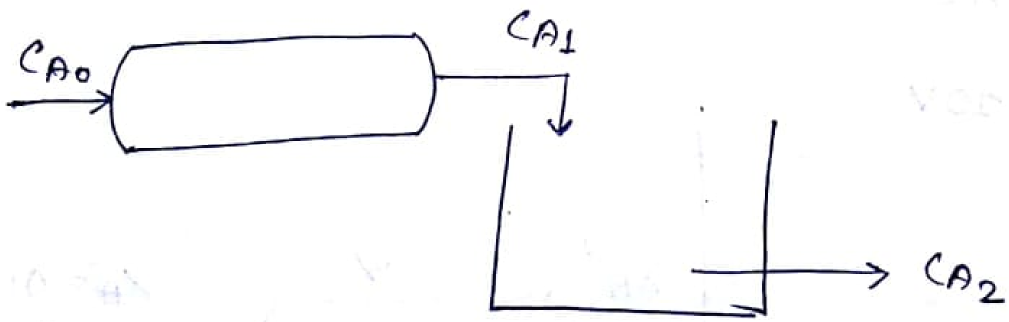
$$= k C_{A0}^2 (1 - X_A)^2$$

$$\frac{V}{F_{A0}} = \int_0^{0.96} \frac{dX_A}{k C_{A0}^2 (1 - X_A)^2}$$

$$\frac{V}{F_{A0}} = \left[\frac{1}{k C_{A0}^2}\left(\frac{1}{1 - X_A}\right)\right]_0^{0.96}$$

$$\frac{V k C_{A0}^2}{F_{A0}} = \frac{1}{0.04} - 1 = 24$$

<u>Option 1</u>



$$\frac{X_{A2}}{C_{A2}} = 0.96$$

$$\frac{V}{F_{A_1}} = \int_0^{X_A'} \frac{dX_A}{kC_{A_0}^2(1-X_A)^2} \quad \text{--- (1)}$$

$$\frac{VkC_{A_0}^2}{F_{A_1}} = \left(\frac{1}{1-X_A'} - 1\right)$$

$$\frac{10V}{F_{A_1}} = \frac{0.96 - X_A'}{kC_{A_0}^2(1-0.96)^2} \quad \text{--- (11)}$$

$$\frac{VkC_{A_0}^2}{F_{A_0}} = \frac{0.96 - X_A'}{(1-0.96)^2} = 60 - X_A'(62.5)$$

$$X_A' = (60 - 62.5 X_A')(1 - X_A')$$

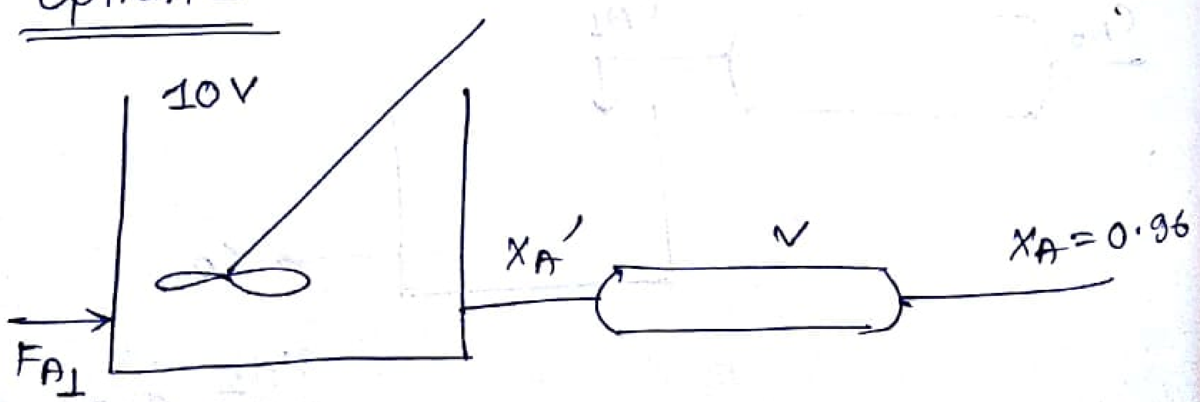
$X_A' = 0.86$ or $X_A' = 1.115$ Rejected)

$$\frac{kC_{A_0}^2 V}{F_{A_0}} = 24, \qquad F_{A_1} = \frac{24}{6.14} F_{A_0}$$

$$X_A' = \frac{123.5 \pm \sqrt{(123.5)^2 - 4(60)(62.5)}}{2 \times 62.5}$$

3.9 times the production increases = $3.9 F_{A_0}$

Option 2



$$\frac{10V}{F_{A1}} = \frac{x_A'}{k C_{A0}^2 (1-x_A')^2}$$

$$\frac{V}{F_{A1}} = \int_{x_A}^{0.96} \frac{dx_A}{k C_{A0}^2 (1-x_A')^2} = \left[\frac{1}{k C_{A0}^2} - \frac{1}{1-x_A}\right]_{x_A'}^{0.96}$$

$$\frac{x_A'}{10(1-x_A')^2} = \frac{0.96-x_A'}{1-0.96}$$

$$10x_A'^2 - 19.64 x_A' + 9.6 = 0$$

$$x_A' = \underset{\text{Rejected.}}{1.05} \text{ or } 0.916$$

$$\frac{10 V k C_{A0}^2}{F_{A1}} = \frac{x_A'}{(1-x_A')^2} = 129.82$$

$$F_{A1} = F_{A0} \frac{24}{12.982} = 1.849 F_{A0}$$

First option is applicable

2)
$$C_{A0} x_A = C_{B0} x_B$$

$$-r_A = 5 C_{A0}(1-x_A)(C_{B0} - C_{A0} x_A)$$

$$= 5 C_{A0}^2 (1-x_A)(M - x_A)$$

$$M = \frac{C_{B0}}{C_{A0}}$$

sol^n // Problem 2 assignment 4 10/10/17

Basis: 1 hr. operation

$A + B \longrightarrow R + S$

Given $-r_A = 5 C_A C_B$ $M = \dfrac{C_{B_0}}{C_{A_0}}$

$$-r_A = 5 C_{A_0}^2 (1-x_A)(M-x_A)$$

$C_{A_0} = 0.1$ mole/L

Mole balance CSTR

$$\frac{V}{v_0} = \frac{C_{A_0} x_A}{-r_A} = \frac{C_{B_0} x_B}{-r_B} \Rightarrow \frac{V}{F_{B_0}} = \frac{x_B}{-r_B}$$

$$F_{B_0} = \frac{-r_B V}{x_B} = \frac{5 C_{A_0}^2 (1-x_A)(M-x_A) V C_{B_0}}{C_{A_0} x_A}$$

$$\boxed{\begin{aligned} C_{A_0} x_A &= C_{B_0} x_B \\ x_B &= \frac{C_{A_0} x_A}{C_{B_0}} \end{aligned}}$$

$$F_{B_0} = \frac{-r_B V}{x_B}$$

$C_T = F_{B_0} \times$ unit price + (Cap cost, Op cost etc.)

$$\boxed{C_T = \frac{56.25 \times 5 C_{A_0} C_{B_0} (1-x_A)(M-x_A) V}{x_A} + 0.18 V} \quad \text{--- (1)}$$

$$F_{B_0} = \frac{-r_B V}{x_B} \Rightarrow F_R = F_{A_0} x_A \ , \ x_A = \frac{F_R}{F_{A_0}} = \frac{95}{1000}$$

$$= 0.95$$

$$\frac{V}{F_{A_0}} = \frac{x_A}{-r_A} \ , \quad M = \frac{C_{B_0}}{C_{A_0}} = 10\,C_{B_0}$$

$$V = \frac{100\,x_A}{K C_{A_0}^2 (1-x_A)(M-x_A)}$$

$$\boxed{V = \frac{38000}{10\,C_{B_0} - 0.95}} \quad \ldots (2)$$

$$C_T = 53437.5\,C_{B_0} + \frac{6840}{10\,C_{B_0} - 0.95}$$

$$\frac{dC_T}{dC_{B_0}} = 53437.5 - \frac{68400}{(10C_{B_0} - 0.95)^2} = 0$$

$$C_{B_0} = 0.208 \ \frac{mol}{L}$$

$$C_T = 17168 \ Rs.$$

$$\boxed{V = 33628.3 \ lit}$$

For PFR

$$C_T = 56.25\,F_{B_0} + 0.68\,V$$

$$V = F_{A_0} \int_0^{0.95} \frac{dx_A}{0.05\,(1-x_A)(M-x_A)}$$

$$V = \frac{2000}{(M-1)} \int_0^{0.95} \left[\frac{1}{1-x_A} - \frac{1}{M-x_A}\right] dx_A$$

$$V = \frac{2000}{(M-1)} \ln\left(\frac{M-0.95}{0.05M}\right)$$

$$C_T = 56.25\, M \times 100 + \frac{0.68 \times 2000}{(M-1)} \ln\left(\frac{M-0.95}{0.05M}\right)$$

$$\frac{dC_T}{dM} = 56.25 \times 100 \cancel{+} - \frac{0.68 \times 2000}{(M-1)^2} \ln\left(\frac{M-0.95}{0.05M}\right)$$

$$+ \frac{0.68 \times 2000}{(M-1)} \left[\frac{1}{\frac{M-0.95}{0.05M}} \times \frac{(M-0.95)(0.05)\ \cancel{0.05} - (0.05M)}{(0.05M)^2}\right]$$

$$5625(M-1)^2 + 1292\,\frac{(M-1)}{(M-0.95)M} = 1360 \ln\frac{M-0.95}{0.05M}$$

Assumed, M	LHS	RHS
2	6240.2	3197.87
1.5	2189.2	2709.7
1.6	2770.38	2849.12
1.61	2834.75	2861.42
1.615	2867.4	2867.46

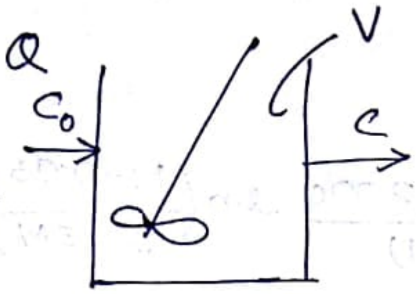
$M_{optimum} = 1.615 = \frac{F_{B0}}{F_{A0}}$

$V = 6856.5$ lit

$C_T = ₹13746.85$

Non ideal Reactor

CSTR/ step input



$$C_0 Q \Delta\theta - C Q \Delta\theta = V \Delta C$$

$$\frac{dC}{d\theta} = \frac{Q}{V}(C_0 - C)$$

$$\frac{dC}{d\theta} = \frac{1}{\bar{\theta}}(C_0 - C)$$

$$\int_0^C \frac{dC}{C_0 - C} = \int_0^\theta \frac{d\theta}{\bar{\theta}}$$

$$F = \left(\frac{C}{C_0}\right)_{step} = J(\theta) = 1 - e^{-\theta/\bar{\theta}}$$

$$F = 1 - e^{-\theta/\bar{\theta}}$$

$$E = J'(\theta) = \frac{1}{\bar{\theta}} e^{-\theta/\bar{\theta}}$$

again $C_{pulse} = \frac{M}{Q} J'(\theta)$

$$= \frac{M}{Q} \frac{1}{\bar{\theta}} e^{-\theta/\bar{\theta}}$$

$$C_{pulse} = \frac{C_0 \Delta t_0}{\bar{\theta}} e^{-\theta/\bar{\theta}}$$