Assignment 4

4-7 PFR $A = B + 2C$ $\delta = 2$

$y_{A0} = 1$

(a) $k\tau = (1+\epsilon)\ln\frac{1}{1-X_A} - \epsilon X$ $\epsilon = 2$

$= 3 \ln \frac{1}{1-0.9} - 2 \cdot 0.9 = 5.107$

$C_{A0} = P_0/RT$ $F_{A0} = 2.5$ mol/min

$= \frac{10 \text{ atm}}{0.082 \cdot 427} = 0.3048$ mol/lit

$\tau = \frac{C_{A0} V}{F_{A0}} = 5.107$ $V = 946$ liters.

(b) CSTR : $k\tau = X\frac{(1+\epsilon X)}{1-X} = \frac{0.9 \cdot (1+1.8)}{0.1}$

$= 9 \cdot 2.8$

solve for, $V = 4667$ liters

(c) $F_{A0}\frac{dX}{dW} = -r_A$ $-r_A = kC_A$

$= kC_{A0}\frac{(1-X)}{(1+\epsilon X)} \cdot y$

$F_{A0}\frac{dX}{dV} = \frac{kC_{A0}(1-X)\,y}{(1+\epsilon X)}$ if $y = 1$

$\frac{(1+\epsilon X)}{(1-X)}\int dX = \frac{kC_{A0}}{F_{A0}} \cdot \int dV$ or $y = (1-\alpha V)^{1/2}$

$= \frac{kC_{A0}}{F_{A0}}\int_0^V (1-\alpha V)^{1/2}\, dV$

Numerical solution required

$$\frac{dx}{dV} = \frac{k\,C_{A0}}{F_{A0}} \frac{(1-x)}{(1+\epsilon x)} \cdot y$$

$$\frac{dy}{dV} = \alpha \frac{(1+\epsilon x)}{2y}$$

(4-12)

$$A \longrightarrow \tfrac{1}{2} B \qquad \delta = -\frac{1}{2}$$

$$\epsilon = y_{A0}\delta = -\frac{1}{4} = -0.25$$

$$V = F_{A0} \int_0^x \frac{dx}{-r_A}$$

$$-r_A = k C_A^2 = \frac{k C_{A0}^2 (1-x)^2}{(1+\epsilon x)^2}$$

$$\frac{k C_{A0}^2 V}{F_{A0}} = 2\epsilon(1+\epsilon)\ln(1-x) + \epsilon^2 x + (\epsilon+1)^2 \cdot \frac{x}{1-x}$$

$x = 0.8$

$\epsilon = -0.25$

$$\frac{k C_{A0}^2 V}{F_{A0}} = 2.9035 = \frac{k V P^2}{4 F_{A0} R^2 T^2} \qquad y_{A0} = 1/2$$

New conditions denoted by primes

$$\frac{k C_{A0}'^2 V}{F_{A0}'} = \frac{2 k V P^2}{9 F_{A0} R^2 T^2} = \frac{8}{9} \frac{k C_{A0}^2 V}{F_{A0}}$$

$$= 8/9 \cdot 2.9 = 2.58$$

Solve for x with this new value : $\boxed{x \cong 0.76}$

4-16 :

$$\tau_{PFR} = \frac{X_e}{k} \ln\left(\frac{X_e}{X_e - X_1}\right)$$

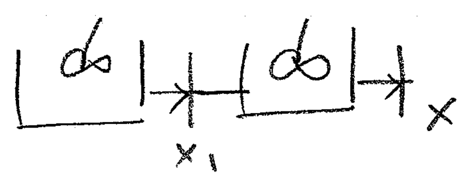
solved in class :

$$\tau_{CSTR} = \frac{X}{k}\left(\frac{X_e}{X_e - X}\right)$$

$$\frac{V_{PFR}}{V_{CSTR}} = \frac{(X_e - X)\ln\left(\frac{X_e}{X_e - X}\right)}{X}$$

Reversible reaction : CSTRs in series

$$\frac{1}{K_e} + 1 = \frac{1}{X_e}$$



$$\tau_1 = \frac{\cancel{C_0} X_1}{k \cancel{C_0}\left(1 - \frac{X_1}{X_e}\right)} = \tau_2 = \frac{\cancel{C_0}(X - X_1)}{k \cancel{C_0}\left(1 - \frac{X}{X_e}\right)}$$

$$\tau_1 = \frac{X_1}{\cancel{k}\left(1 - \frac{X_1}{X_e}\right)} = \tau_2 = \frac{X - X_1}{\cancel{k}\left(1 - \frac{X}{X_e}\right)}$$

$$X_1 - \cancel{\frac{X X_1}{X_e}} = X - \cancel{\frac{X X_1}{X_e}} - X_1 + \frac{X_1^2}{X_e}$$

$$\frac{X_1^2}{X_e} = 2X_1 - X \qquad \frac{X_1^2}{X_e} - 2X_1 + X = 0$$

1. solve for X_1 in terms of X
2. X is known in terms of τ_{PFR} which
3. you can then find $(\tau_1 + \tau_2)$ and obtain volume efficiency.

(4-18) CSTR - fluidized

$$W = \frac{F_{A0} X}{-r_A} \qquad -r_A = k\,p_A \qquad C_{0A} = \frac{P_0}{RT}$$

$$= \frac{F_{A0} X}{k RT\, C_A} = \frac{F_{A0} X}{k RT C_{A0}(1-X)} \qquad C_{A0} = \frac{y_{A0} P_0}{RT}$$

$$p_{A_0} = C_{A_0} RT$$

$$= \frac{F_{A0} X}{k\, y_{A0} P_0 (1-X)}$$

$$\frac{W}{F_{A0}} \cdot k P_0 = \frac{X}{1-X} = \frac{0.5}{0.5} = 1$$

$$\Rightarrow \frac{k P_0}{F_{A0}} = \frac{1}{W_{CSTR}} = \frac{1}{50}$$

PBR first

$$\frac{dX}{dW} = \frac{-r_A}{F_{A0}} \qquad \begin{aligned} -r_A &= k\,p_A \\ &= k RT C_{A0}(1-X) \cdot y \\ &= k P_0 (1-X)\cdot y \\ y &= (1-\alpha W)^{1/2} \end{aligned}$$

$$\frac{dX}{dW} = \frac{k P_0 (1-X)\cdot y}{F_{A0}}$$

$$\int_0^X \frac{dX}{1-X} = \frac{k P_0}{F_{A0}} \int_0^W (1-\alpha W)^{1/2}\, dW$$

$$\ln \frac{1}{1-X} = \frac{1}{50} \cdot \left(\frac{2}{3\alpha} \left[1 - (1-\alpha W)^{3/2} \right] \right) \qquad \begin{aligned} \alpha &= 0.018 \text{ kg}^{-1} \\ W &= 50 \text{ kg} \end{aligned}$$

$$X = 0.512$$

CSTR second:

$$W = \frac{F_{A0}(X_2 - X_1)}{-r_A} = \frac{F_{A0}(X_2 - X_1)}{k RT C_{A0}(1-X_2)}$$

$$\frac{W \cdot k P_0}{F_{A0}} = \frac{X_2 - X_1}{1 - X_2} = 1 \qquad X_1 = 0.512$$

$$X_2 - X_1 = 1 - X_2 \qquad 2X_2 = 1 + X_1$$

$$X_2 = 0.76$$