Determination of Film ΔT –

Film ΔT is determined by equating heat removal rate from the catalyst to the rate of heat generation at steady state.

$$Q_{generation} = Q_{removal}$$

$$Q_{generation} = V_p(-r_A''')(-\Delta H_R)$$

$$Q_{removal} = h A_p (T_s - T_b)$$

$(T_s - T_b)$ → Film ΔT

At steady state,

$$T_s - T_b = \frac{V_p(-r_A''')(-\Delta H_R)}{h A_p}$$

Within particle ΔT can be determined by assuming tem and conc. profile are of similar nature within catalyst particle. Therefore heat conduction rate can be equated to diffusion flux multiplied by heat of reaction.

$$-K_{eff}\frac{dT}{dx} = D_e\frac{dC_A}{dx}(-\Delta H_r)$$

or, $$-K_{eff}\int_{T_s}^{T_c} dT = D_e(-\Delta H_r)\int_{C_{As}}^{C_c} dC_A$$

$$-K_{eff}(T_c - T_s) = D_e(-\Delta H_r)(C_c - C_{As})$$

C_c, T_c = Centre temp, conc.

$$K_{eff}(T_s - T_c) = D_e(-\Delta H_r)(C_c^{\,0} - C_{As})$$

C_{As}, T_s = Surface conc., temp

$$\Delta T = T_c - T_s = \frac{D_e}{K_{eff}}(-\Delta H_r)\,C_{As}$$

Performance Eq^n for Catalytic Reactor

For PFR

$$\frac{W}{F_{A0}} = \int_0^{X_A}\frac{dX_A}{(-r_A')} \rightarrow \text{Based on mass of catalyst}$$

$$-r_A' = -\frac{1}{W}\frac{dN_A}{dt}$$

Based on volume of catalyst —

$$\frac{V_p}{F_{A0}} = \int_0^{X_A}\frac{dX_A}{(-r_A''')}$$

For MFR

Based on weight of catalyst —

$$\frac{W}{F_{A0}} = \frac{X_{Aout} - X_{Ain}}{(-r_A')_{out}}$$

Based on volume of catalyst —

$$\frac{V_p}{F_{A0}} = \frac{X_{Aout} - X_{Ain}}{(-r_A''')_{out}}$$

Levenspiel — Example — 18.1 — 18.6

Exercise — 18.11, 18.12, 18.21, 18.23, 18.24, 18.25,

18.26, 18.7, 18.8

Space time $\tau = \frac{V}{v_0} = \frac{V C_{A0}}{F_{A0}}$

Weight time, $\tau' = \frac{W C_{A0}}{F_{A0}}$

Volume time, $\tau''' = \frac{V_p C_{A0}}{F_{A0}}$

Experimental Method for Finding Rate —

The experimental strategy in studying catalytic kinetics involves measuring conversion of fluid, passing in steady flow through a batch of solid. Any known contacting pattern can be used. Experimental devices for finding rates are —

i) **Differential Reactor** — In this reactor the rate is assumed to be const.

$$\frac{W}{F_{A0}} = \int_0^{X_A} \frac{dX_A}{(-r_A')} = \frac{X_A}{(-r_A')}$$

$$(-r_A') = \frac{X_A F_{A0}}{W}$$

ii) **Integral PFR** —

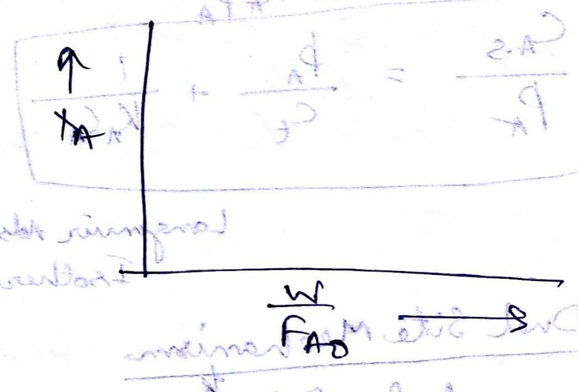
$$\frac{W}{F_{A0}} = \int_0^{X_A} \frac{dX_A}{(-r_A')}$$

We have to assume rate expression for $-r_A'$. ~~and~~

iii) **Differential PFR** —

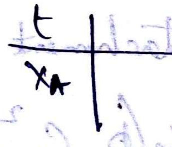
$$d\left(\frac{W}{F_{A0}}\right) = \frac{dX_A}{(-r_A)'}$$

$$\therefore (-r_A') = \frac{dX_A}{d\left(\frac{W}{F_{A0}}\right)}$$



iv) **Batch Reactor**

$$-r_A' = -\frac{1}{W}\frac{dN_A}{dt}$$



$$-r_A' = \frac{N_{A0}}{W}\frac{dX_A}{dt} = \frac{V C_{A0}}{W}\frac{dX_A}{dt}$$

Vol. of reactor

$$\int dt = \frac{V C_{A0}}{W}\int_0^{X_A} \frac{dX_A}{(-r_A')} = t$$