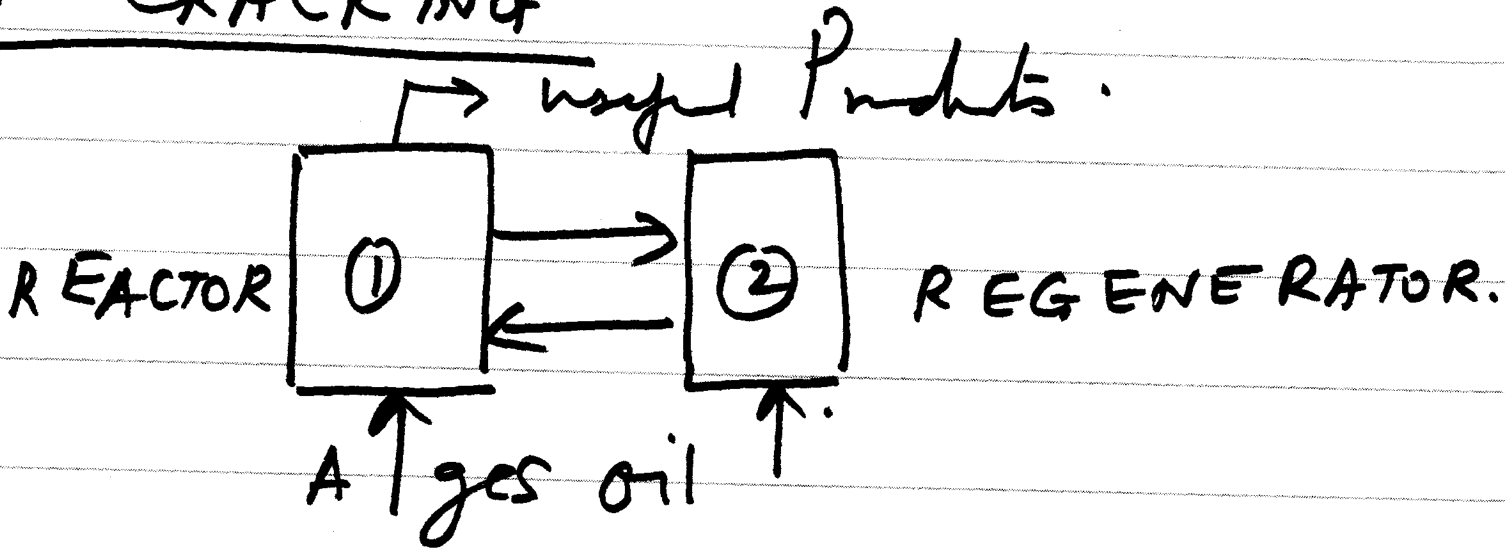
Prof. H. Shankar

CAT CRACKING



$$r_1 = -k_1 \bar{a} \checkmark \qquad \bar{a}_1$$

$$r_2 = k_2 (1 - \bar{a}) \checkmark \qquad \bar{a}_2$$

$$\boxed{-r_A = k_r C_A \bar{a}_1}$$

$$v_0 \bar{a}_2 - v_0 \bar{a}_1 - k_1 W_1 \bar{a}_1 = 0$$ REACTOR

$$v_0 \bar{a}_1 - v_0 \bar{a}_2 + k_2 W_2 (1-\bar{a}_2) = 0$$ REG.

$$\bar{t}_1 = \frac{\bar{a}_2 - \bar{a}_1}{k_1 \bar{a}_1}$$

$$\bar{t}_2 = \frac{\bar{a}_2 - \bar{a}_1}{k_2 (1-\bar{a}_2)}$$

$$\boxed{\bar{a}_2 - \bar{a}_1 = \Omega}$$

(3)

$$\frac{\bar{t}_1}{\bar{t}_2} = \frac{\bar{a}_1}{1-\bar{a}_2}$$

$\bar{a}_2 - \bar{a}_1 = 0.3$

$k_1 = 0.5/s$ at $C_A = 1.5\,g/L$

$k_2 = 0.4/s.$

$$\frac{\bar{t}_1}{\bar{t}_2} = \left(\frac{k_2}{k_1}\right)^{1/2}$$

$C_{A0} = g/L$

k_1 at $C_A = C_{A0}(1-x) \Rightarrow 5(1-0.6) = 2\,g/L$

$$\bar{t}_1 = \frac{0.3.}{(0.66)(0.307)} = 1.43\,s$$

$$\bar{t}_2 = \frac{0.3}{(0.4)(0.607)} = 1.235 \text{ s}$$

$$-r_A = k_r C_{A0} (1-x) \bar{a}_1$$

$$= (0.867) \text{ [illegible]}$$

$$k_r C_{A0} = 0.867$$

$$k_r C_A = \left(\frac{0.867}{5}\right)^2 = 0.346 \,/\text{s}$$

$$-r_A = k_r C_{A0}(1-x)\,\bar{a}_1$$

$$= (0.867)(1-0.6)\,0.307 = 0.106$$

REACTOR

$$F_{A0} - F_A + r_A W = 0$$

$$\underbrace{F_{A0} - F_A}\, - \underbrace{K_r C_{A0}(1-x)\,\bar{a}_1}\, W_1 = 0$$

$$(0.6)\,16\,kg/s - 0.106\,W_1 = 0$$

$$W_1 = \frac{(0.6)(16)}{0.106} = 91\ kg$$

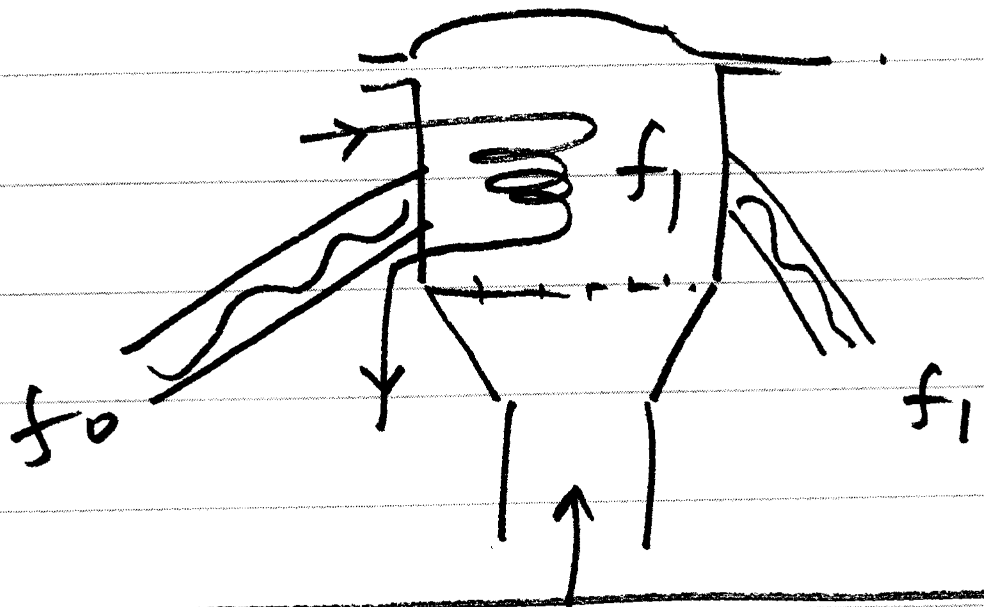
$$F_S = W_1 / \bar{t}_1 = \frac{91}{1.43} = 65\ kg/s$$

$$W_2 = (F_S)\ \bar{t}_2 = (65\ kg/s)\ 1.23 = 80\ kg$$

答

$F_{A0} = 16\ kg/s$
$F_S = 65\ kg/s$

Q7 PARTICLE SIZE DISTRIBUTION FLUID BED COMBUSTOR.



REACTION CONTROL

$$f_0 = \delta(s-1).$$

$$s = r/R = 1$$

$$f_0 - f_1 - \frac{d}{ds}(f_1 r_1 \bar{t}_1) = 0.$$

$$f_1 = g_1(s) + K_0\,\delta(s-0)$$

$$\boxed{1-\frac{r}{R} = t/\tau_R}$$

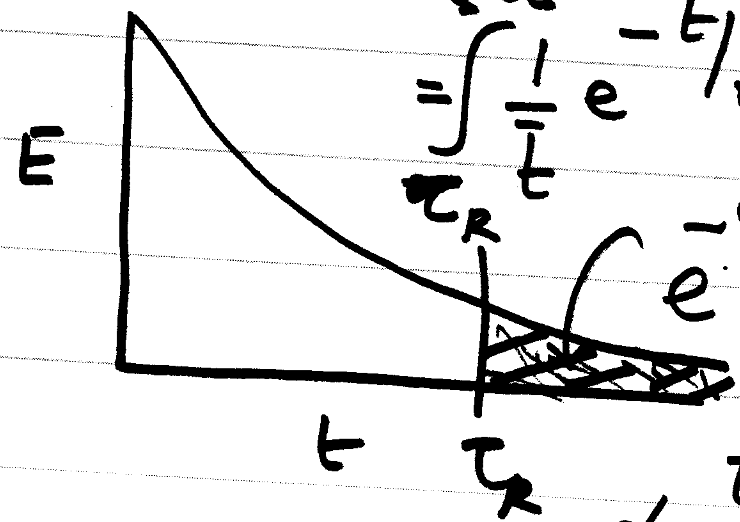
Reaction Control.

$$1-s = t/\tau_R$$

$$\lambda_1 = (ds/dt) = -1/\tau_R.$$

$$\int f_1\,ds = 1 = \int_0 g_1\,ds + K_0$$

$$\boxed{1-K_0 = \int g_1\,ds}$$



$$= \int_{\tau_R}^{\infty} \frac{1}{\bar{t}} e^{-t/\bar{t}}\,dt$$

$$e^{-\alpha}$$

$$\alpha = \frac{\tau_R}{\bar{t}}$$

$$f_0 - f_1 - \frac{d}{ds}\left(f_1 r_1 \bar{t}_1\right) = 0 \quad \times$$

$$r_1 = -\frac{1}{\tau_R}$$

$$g_1 + \frac{d}{ds}\left(g_1 r_1 \bar{t}_1\right) = 0 \quad \checkmark$$

$$\boxed{\ln\left(\frac{g_1 r_1 \bar{t}_1}{Q}\right) = \tau_R / \bar{t}} \quad \checkmark$$

$$\alpha = \frac{\tau_R}{\bar{t}_1}$$

$$\boxed{g_1 r_1 \bar{t}_1 = Q e^{\alpha s}}$$

B.C

Balance $(s - ds)$ & s.

Lt $s \to 0$ $\quad ds \to 0$

$I/p - O/p + Gen = 0$

Lt $\quad$ ~~$v_0 \delta(s-1) ds$~~ $\quad v_0 \left[\cancel{g_1} + K_0 \delta(s-0) \right] ds$

$s \to 0$

$ds \to 0$ $\quad + W_1 r_1 (s - \cancel{ds}) g_1(s - ds) - W_1 r_1 (s) g_1(s) = 0$

$$- v_0 K_0 - (W_1 r_1 g_1)_0 = 0$$

$$\boxed{\left(g_1 r_1 \bar{t}_1 \right)_0 = - K_0}$$

$$g_1(0) \neq \left[-\frac{1}{\tau_R} \bar{t}_1 \right] = -K_0$$

$$g_1(0) = \frac{\tau_R}{\bar{t}} K_0 =$$

$$g_1(0) = \alpha e^{-\alpha}$$

$$g_1 r_1 \bar{t}_1 = Q e^{\alpha s}.$$

$$g_1(0) = \alpha e^{-\alpha}$$

$$Q = -e^{-\alpha}.$$

$$\boxed{g_1(s) = \alpha e^{\alpha(s-1)}}$$

$$f_1 = \alpha e^{\alpha(s-1)} + K_0 \, \delta(s-0)$$

$$\boxed{f_1 = \alpha \, e^{\alpha(s-1)} + e^{-\alpha} \, \delta(s-0)}$$

Mean Conversion at the exit.

$$1 - X_B = \left(r/R\right)^3$$

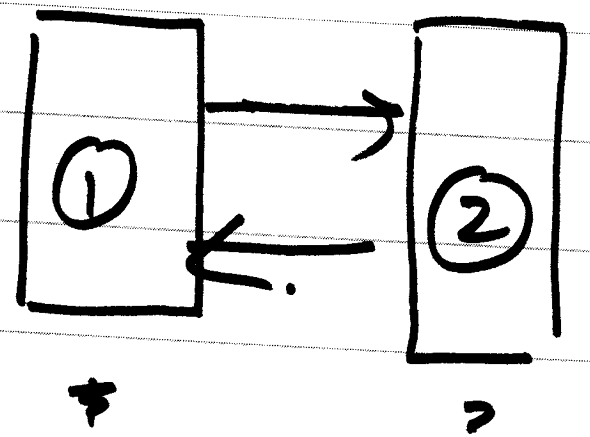
$$\overline{1 - X_B} = \int_0^R \frac{\frac{4}{3} \pi r^3 \, f(r) \, dr \, \rho_B}{\frac{4}{3} \pi R^3 \rho_B}.$$

$$\overline{1-X_B} = \int_0^1 s^3 f(s)\, ds$$

$$\overline{1-X_B} = \int_0^1 \left[s^3 \left\{ g_1(s) + K_0 \delta(s-0) \right] ds \right]$$

$$\overline{1-X_B} = \int_0^1 s^3 g_1(s)\, ds = \int_0^1 s^3 \left\{ \alpha e^{\alpha(s-1)} ds \right\}$$

$$\boxed{\overline{1-X_B} = 1 - \frac{3}{\alpha} + \frac{6}{\alpha^2} - \frac{6}{\alpha^3} + \frac{6e^{-\alpha}}{\alpha^3}}$$



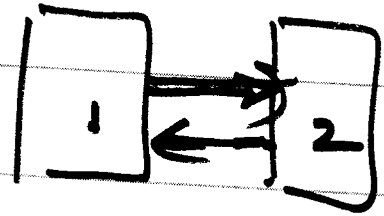
$$r_1 = -k_1 (s)$$

$$r_2 = k_2$$

Find f_1 and f_2

PBE

Reactor.



$$f_1 = g_1 + \cancel{K_0 \delta(s-0)} \quad (1)$$

$$f_2 = g_2 + K_1 \delta(s-1) \quad (2)$$

$$r_1 = -K_1 s$$

$$r_2 = +K_2$$

PBE:

Reactor

$$g_2 - g_1 - \frac{d}{ds}(g_1 r_1 \bar{t}_1) = 0$$

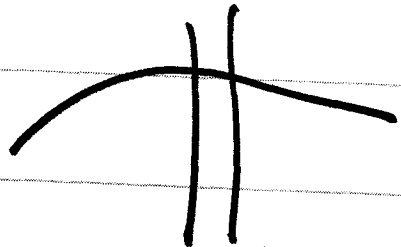
Reg

$$g_1 - g_2 - \frac{d}{ds}(g_2 r_2 \bar{t}_2) = 0$$

$$\frac{d}{ds}\left(g_1 r_1 \bar{t_1} + g_2 r_2 \bar{t_2}\right) = 0$$

$$g_1 r_1 \bar{t_1} + g_2 r_2 \bar{t_2} = \text{Constant.}$$

Reactor



$I/p - O/p + G = 0$

$$v_0\left[g_2\, ds + L_s\,\delta(s-1)\right] ds$$

$$- v_0\, g_1\, ds$$

$$+ W g_1(s - ds)\, r_1(s - ds)$$

$$- W g_1(s)\, r_1(s) = 0$$

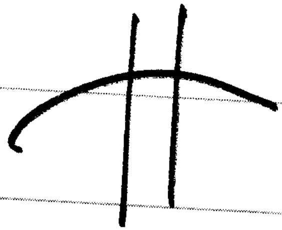
$$\left(g_1 r_1 \bar{t_1}\right)_0 = 0$$

Lt $s \to 0$

$ds \to 0$

Lt $s \to 1$ $ds \to 0$

Reactor



I/p − O/p + Gen = 0

$v_0 \left[g_2 \, ds + L_1 \, \delta(s-1) \, ds \right]$

$- v_0 \, g_1 \, ds$

$+ W r_1(s) g_1(s) - W r_1(s+ds) g_1(s+ds)$

$= 0$

Lt $s \to 1$, $ds \to 0$

$(g_1 r_1 \bar{t}_1)_1 = -L_1$

Rejemdi

$$[s-ds,\ s]$$

Lt $s \to 0$ $ds \to 0$

$$v_0 \, g_1 \, ds - v_0 \left[g_2 + L_1 \delta(s-1) \right] ds$$

$$+ W_2 g_2 (s - ds) \, r_2 (s - ds)$$

$$- W_2 g_2 (s - d) \, r_2 (s) = 0$$

$$\left(g_2 r_2 \bar{t}_2 \right)_0 = 0$$

$$\left(g_2 r_2 \bar{t}_2 \right)_1 = L_1$$

$$(g_1 r_1 t_1)_0 = 0 \quad (g_2 r_2 \bar{t}_2)_0$$

So Coeff of Intg = 0.

$$g_1 r_1 \bar{t}_1 + g_2 r_2 \bar{t}_2 = 0$$

$$g_2 = \frac{- g_1 r_1 \bar{t}_1}{r_2 \bar{t}_2}$$

Reactn

$$-\frac{g_1 r_1 \bar{t}_1}{r_2 \bar{t}_2} - g_1 - \frac{d}{ds} g_1 r_1 \bar{t}_1 = 0$$

$$\frac{d}{ds} g_1 r_1 \bar{t}_1 = - g_1 r_1 \bar{t}_1 \left[\frac{1}{r_1 \bar{t}_1} + \frac{1}{r_2 \bar{t}_2} \right].$$

$$r_1 = -k_1 s$$

$$r_2 = +k_2$$

$$\ln\left[\frac{g_1 r_1 \bar{t}_1}{Q}\right] - \alpha \ln S = -\beta S$$

$$\ln \frac{g_1 r_1 \bar{t}_1}{Q} - \ln S^{\alpha} = -\beta S$$

$$g_1 r_1 \bar{t}_1 = Q S^{\alpha} \exp(-\beta S)$$

$$g_1 = -Q \alpha S^{\alpha - 1} \exp(-\beta S)$$

$$g_2 = -Q \beta S^{\alpha} \exp(-\beta S).$$

$$t = \tau_R \left(1 - r_c/R\right) + \tau_D \left[1 - 3\frac{r_c^2}{R^2} + 2\frac{r_c^3}{R^3}\right].$$

$$\frac{\tau_{R1}\,(4\,MM)}{\tau_{R2}\,(12\,MM)} = \frac{4}{12} = \frac{1}{3}$$

$$\frac{\tau_{D1}\,(4\,MM)}{\tau_{D2}\,(12\,MM)} = \left(\frac{4^2}{12^2}\right) = \frac{16}{144} = \frac{1}{9}$$

$$1 - X_B = \underline{\underline{0.5}}$$

$$0.5 = 1 - X_B = \left(\frac{r_c}{R}\right)^3$$

$$\left(r_c/R\right) = \left(1 - 0.5\right)^{1/3} = 0.79$$

GAS SOLIDS REACTIONS

Data

	Neglect Film Diff Contrl.	
dp	4 MM	12 MM
T	550	590
Time for 50% CONV	15 MIN	2 Hrs

Time for 98% CONVERSION OF 3 MM particle

4 MM Partile

(550 C) $0.25 = \tau_{R1}(1-0.8) + \tau_{D1}\left(1-3(0.8)^2+2(0.8)^3\right)$.

12 MM Partile

(590 C)

$2 = \tau_{R2}(1-0.8) + \tau_{D2}\left[1-3(0.8^2)+2(.8)^3\right]$

$\tau_{D1} =$ ~~0.35 hrs~~ 2.25

$\tau_{D2} =$ ~~2.25 hrs~~ ~~2.2 hrs~~ 18

$\tau_{R1} =$ ~~0.35 hr~~ 0.208 hr

$\tau_{R2} =$ 0.624 hrs.