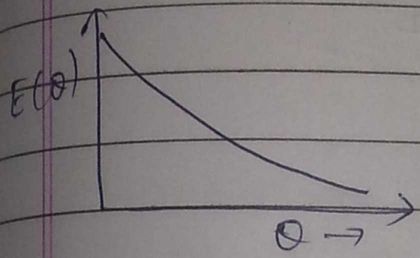
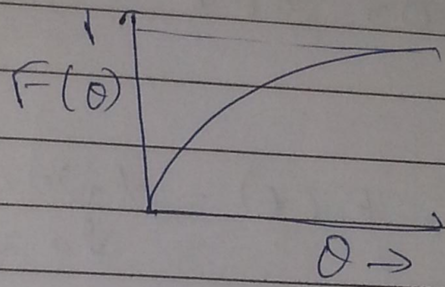
$$E(\theta) = \exp(-\theta) = \tau E(t)$$

$$F(\theta) = \int_0^{\infty} E(\theta)\,d\theta = 1 - \exp(-\theta)$$

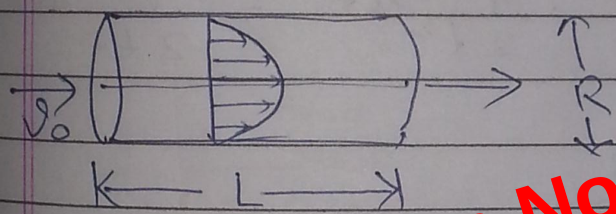




$t_m = \tau$,

$\sigma^2 = \tau^2 \Rightarrow \sigma = \tau$

Laminar flow reactor :→



$$u = 2u_{avg.}\left(1 - \frac{r^2}{R^2}\right) \qquad u_{avg.} = \frac{v_0}{\pi R^2}$$

Time that is spent by any fluid particle at 'r' →

$$t(r) = \frac{L}{u(r)} = L\left(\frac{\pi r^2}{v} \cdot \frac{1}{2(1 - r^2/R^2)}\right)$$

$$\Rightarrow t(r) = \frac{\tau}{2(1-(r/R)^2)} \quad \text{— (1)}$$

vol. flow rate b/w r and r+dr →

$$dv = u(r) \cdot 2\pi r\,dr$$

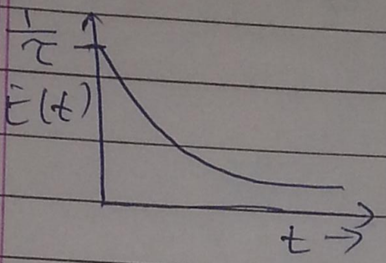
⇒ Fraction of total fluid through dr → $= E(t)\,dt$

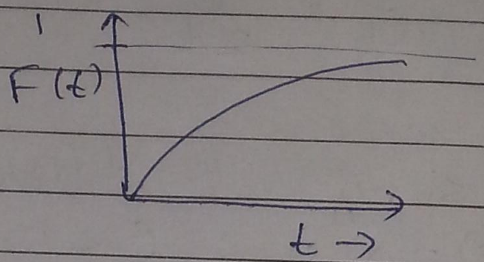
$$\frac{dv}{v_0} = \frac{u(r) \cdot 2\pi r\,dr}{v_0}$$

~~whose res.~~ fraction time is b/w t & t+dt.

Diff^n CSTR operations :→

a) Perfect (P) → ideal CSTR





If $\tau \uparrow\uparrow$, slope will decrease slowly.

b) Bypassing (BP) →

ν_b → bypass vol. flow rates

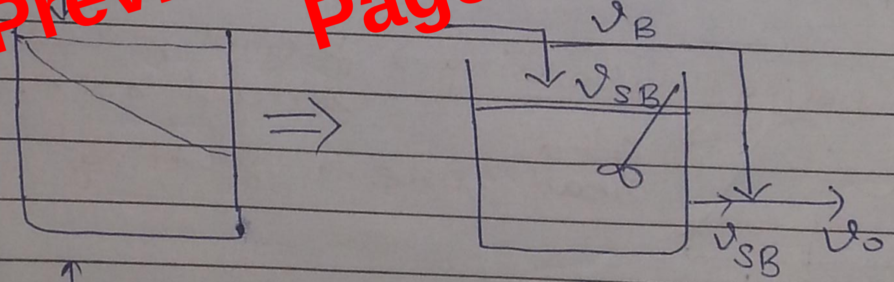
ν_{sb} → enters system vol.

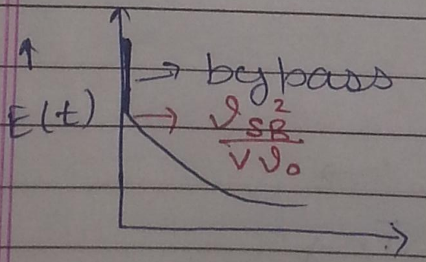
$\nu_0 = \nu_b + \nu_{sb}$.

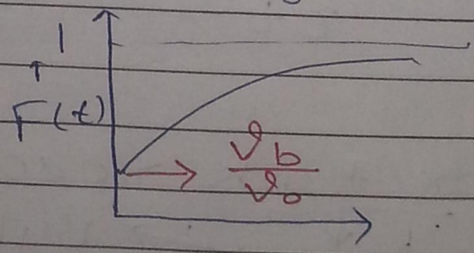
⇒ since, $\nu_{SB} < \nu_0 \Rightarrow \tau_{SB} > \tau$

⇒ C(t) or E(t) decays slowly

$$E(t) = \frac{\nu_b}{\nu_0}\delta(t-0) + \frac{\nu_{SB}^2}{V\nu_0}\left(\exp\left(-\frac{t}{\tau_{SB}}\right)\right)$$







c) Dead volume (DV) → decays faster.

→ No bypassing ↑

V_D → dead volume ($\tau_{SD} < \tau$)

ν_{SD} → enters system vol.

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$$\Rightarrow \boxed{\frac{dC_A(\lambda)}{d\lambda} = -r_A + (C_A - C_{A0}) \frac{E(\lambda)}{1-F(\lambda)}}$$

or

$$\boxed{\frac{dX}{d\lambda} = \frac{r_A}{C_{A0}} + \frac{E(\lambda)}{1-F(\lambda)} \cdot X}$$

To calculate X for max. mixedness model, integrate by starting from large λ & move backward till $\lambda = 0$.

→ For $n > 1$, max. mixedness model gives lower bound on conversion.

Multiple Reactions :→ A+B → reactant

Segregation Model

Each globule → diff^n conc^n of A & B

$$\bar{C}_A = \int_0^\infty C_A(t) \cdot E(t)\, dt$$

$$\bar{C}_B = \int_0^\infty C_B(t) \cdot E(t)\, dt$$

→ batch reactor.

q → rxns occ. simultaneously

$$\frac{dC_A}{dt} = r_A = \sum_{i=1}^{q} r_{iA} , \quad \frac{dC_B}{dt} = r_B = \sum_{i=1}^{q} r_{iB}$$

Maximum mixedness model :→

$$\frac{dC_A}{d\lambda} = -\sum_{i=1}^{q} r_{iA} + (C_A - C_{A0}) \frac{E(\lambda)}{1-F(\lambda)}$$

$$\frac{dC_B}{d\lambda} = -\sum_{i=1}^{q} r_{iB} + (C_B - C_{B0}) \frac{E(\lambda)}{1-F(\lambda)}$$

If r_{iA} is known, we can calculate C_{A}, C_{B}

→ Above model was zero-dimensional model, which give range of conversion for given E curve.

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$$\Rightarrow \boxed{\frac{dC_A(\lambda)}{d\lambda} = -r_A + (C_A - C_{A0})\frac{E(\lambda)}{1-F(\lambda)}}$$

or $$\boxed{\frac{dX}{d\lambda} = \frac{r_A}{C_{A0}} + \frac{E(\lambda)}{1-F(\lambda)} \cdot X}$$

To calculate X for max. mixedness model, integrate by starting from large λ & move backward till $\lambda = 0$.

→ For $n>1$, max. mixedness model gives lower bound on conversion.

Multiple Reactions :→ A+B → reactant (product)

Segregation Model.

Each globule → diff. conc^n of A & B

$$\bar{C}_A = \int_0^\infty C_A(t) E(t)\, dt$$

→ Batch reactor.

$$\bar{C}_B = \int_0^\infty C_B(t) E(t)\, dt$$

q → rxns occ. simultaneously

$$\frac{dC_A}{dt} = r_A = \sum_{i=1}^{q} r_{iA}, \quad \frac{dC_B}{dt} = r_B = \sum_{i=1}^{q} r_{iB}$$

Maximum mixedness model :→

$$\frac{dC_A}{d\lambda} = -\sum_{i=1}^{q} r_{iA} + (C_A - C_{A0})\frac{E(\lambda)}{1-F(\lambda)}$$

$$\frac{dC_B}{d\lambda} = -\sum_{i=1}^{q} r_{iB} + (C_B - C_{B0})\frac{E(\lambda)}{1-F(\lambda)}$$

If r_{iA} is known, we can calculate C_A, C_B

→ Above model was zero-dimensional model, which give range of conversion for given E curve

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