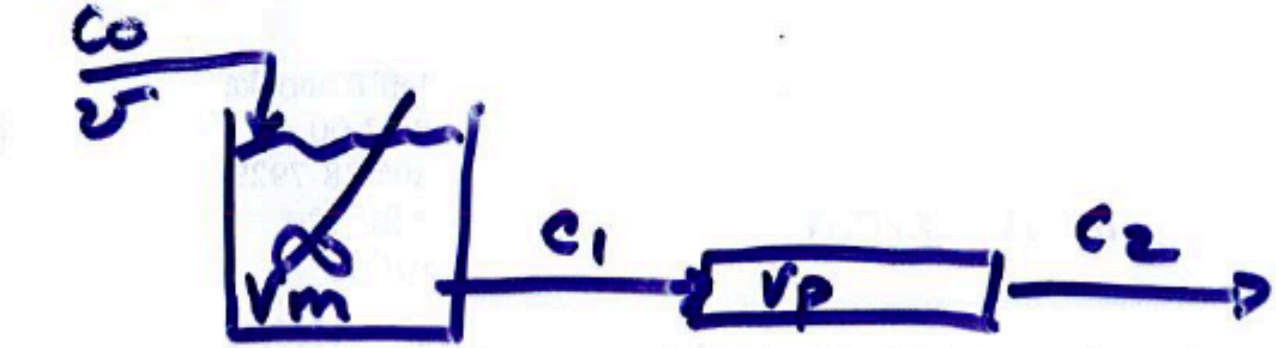
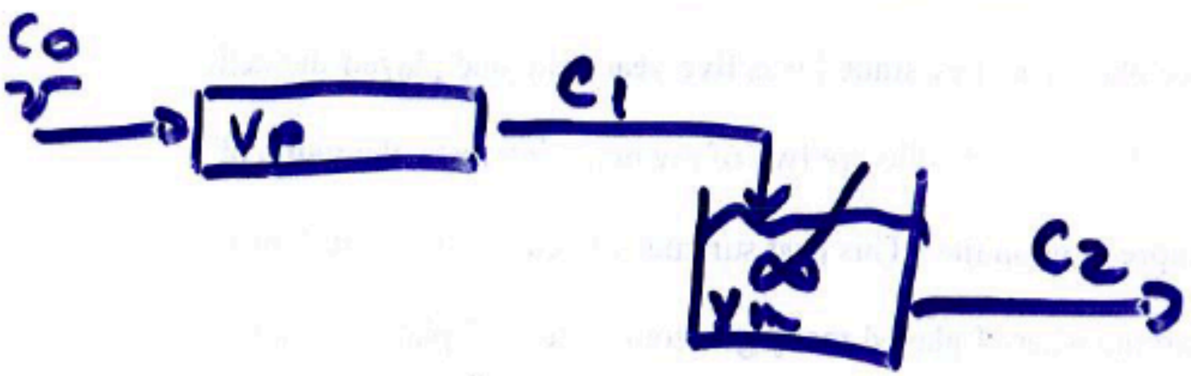
MFR + PFR in series



config. A



config. B

for zero, 1st, 2nd order rxn,
which configuration has better conversion?

MFR $\tau_m = \dfrac{C_0 - C}{r}$

PFR $\tau_p = \int \dfrac{dC}{r}$

Zero order

$\tau_m = \dfrac{C_0 - C}{K}$

$C = C_0 - K\tau_m$

$\tau_p = \dfrac{C_0 - C}{K}$

$C = C_0 - K\tau_p$

Config A   MFR→PFR

Zero order $C_1 = C_0 - K\tau_m$

$C_2 = C_1 - K\tau_p$

$= C_0 - K\tau_m - K\tau_p$

Config B   PFR → MFR

$C_1 = C_0 - K\tau_p$

$C_2 = C_1 - K\tau_m$

$= C_0 - K\tau_p - K\tau_m$

∴ no difference

1st order

$$\tau_m = \frac{C_0 - C}{kC}$$

$$C = \frac{C_0}{1 + k\tau_m}$$

$$\tau_p = \int \frac{dC}{kC} = \frac{1}{k}\ln\left(C_0/C\right)$$

$$C = C_0 e^{-k\tau_p}$$

1st order MFR→PFR

Config A.
$$C_1 = \frac{C_0}{1+k\tau_m}$$

$$C_2 = C_1 e^{-k\tau_p}$$

$$= \frac{C_0 e^{-k\tau_p}}{1+k\tau_m}$$

Config B PFR→MFR

$$C_1 = C_0 e^{-k\tau_p}$$

$$C_2 = \frac{C_1}{1+k\tau_m} = \frac{C_0 e^{-k\tau_p}}{1+k\tau_m}$$

∴ No difference

2nd order

MFR

$$C = \frac{-1 + \sqrt{1 + 4k\tau_m C_0}}{2k\tau_m}$$

PFR

$$C = C_0\left(1 - \frac{k\tau_p C_0}{1 + k\tau_p C_0}\right)$$

MFR→PFR

$$C_1 = \frac{-1+\sqrt{1+4k\tau_m C_0}}{2k\tau_m}$$

$$C_2 = C_1\left(1 - \frac{k\tau_p C_1}{1+k\tau_p C_1}\right)$$

$$= \frac{-1+\sqrt{1+4k\tau_m C_0}}{2k\tau_m}\left(1 - \; ? \;\right)$$

PFR→MFR

$$C_1 = C_0\left(1 - \frac{k\tau_p C_0}{1+k\tau_p C_0}\right)$$

$$C_2 = \frac{-1+\sqrt{1+4k\tau_m C_1}}{2k\tau_m}$$

$$= \frac{-1+\sqrt{1+4k\tau_m C_0(1-\sim)}}{2k\tau_m}$$

Performance eqns

	MFR	PFR
zero	$k\tau = C_0 - C$	$k\tau = C_0 - C$
1st	$k\tau = \frac{C_0 - C}{C}$	$k\tau = \ln \frac{C_0}{C}$
2nd	$k\tau = \frac{C_0 - C}{C^2}$	$k\tau = \frac{C_0 - C}{C_0 C} = \frac{1}{C} - \frac{1}{C_0}$

If 2 different sized ideal mixed flow reactors are placed in series, will the configuration affect the overall conversion?