Plug Flow Reactors in Series

Three connected in series

Reactor volumes are additive

First order

𝜏 = ∫dC/-kC

Second order

𝜏 = ∫dC/-kC2

In Series: 𝜏 = ⅀𝜏i

q = 1 + ⅀𝜏i

Plug Flow Reactors in Parallel

Mixed Flow Reactors

𝜏i = (Ci-1 - Ci) / -r = (Ci-1 - Ci) / kCi (first order)

If all reactions are first order reactions: Simplify

Ci-1/Ci = 1 + k𝜏i

C0/Cn = Πi=1i=n (1+k𝜏i)

What happens in second order reactions?

𝜏i = (Ci-1 - Ci) / -r = (Ci-1 - Ci) / kCi2 (first order)

K𝜏1C12 = C0 - C1

C1 = [-1 +sqrt(1+4k𝜏1C0)]/2k𝜏1

Plug in, keep going until get final C

X = C0 - Cn/C0

Increasing number of MFRs... how does this affect final conversion, compared to PFR?

Number of MFreactors increases, concentration closer to PFR, more efficient in converting reactors to products.

Mathematical proof:

C0/Cn = (1 + k𝜏1)n

𝜏1= 1/k [(C0/Cn)1/n - 1]

Overall: (assuming equal volume MFRs)

N𝜏1 = n/k [(C0/Cn)1/n - 1]

= n/k [(1/1-X)1/n - 1]

As n --> infinity, n [(C0/Cn)1/n - 1] --> ln(C0/Cn)

𝜏overall = 1/k ln(C0/C) --> PFR.

Most significant change is from n=1 to n=2 for first order reactions

To Use graphs: (Only if tau values are equal among all reactors)

1. Reaction order
2. Number of units
3. Space time for each reactor
4. Determine value of ktau for each reactor
5. Multiply by number of units.
6. Find dashed line (Nktau)
7. Find where it intersects number of units
8. 1-X = x value of intersection point