**Practice Problems**

1. PFR with τp, X = 0.90, First Order Reaction. How large of an MFR do you need to get same X, assuming q and k are the same?

-r = kC

τm = C0-C/kC

C = C0(1-X)

τm = 1/k \* (X/1-X)

τp = ∫dC/-kC = -1/k lnC/C0 = 1/k ln(1/1-X)

τm/τp = [X/1-X]/[ln(1/1-X)]

X = 0.90

τm/τp = 3.909

1. Same problem, Second Order Reaction.

-r = kC2

τm = C0-C/kC2

C = C0(1-X)

τm = X/kC0(1-X)2

τp = ∫dC/-kC2 = -1/k(1/C-1/C0)= 1/kC0(1/1-X -1) = 1/kC0(X/1-X)

τm/τp = [X/kC0(1-X)2]/[kC0(1-X)/X] = 1/1-X

X = 0.90

τm/τp = 10

**Introduction to Non-Ideal Flow in Reactors**

Re < 2100 (laminar flow)

Re > ? (turbulent flow)

Residence Time Distribution

Flow in reactors deviates from ideal flow for various reasons:

* Channeling of fluid
* Recycling of fluid
* Stagnant regions (dead spaces) in vessels

Non-ideal flow is accounted for by the Residence Time Distribution

Exit Age Distribution

E, exit age distribution, is the normalized residence time distribution

The fraction of the flow exiting the reactor at a given time is described by the E(t) curve (from t to t+dt).

Normalized relationship is represented by: ∫0∞ **E**dt = 1

Note: the units of E are time-1



Food Application of RTD: Thermal Processing

* When a thermal process is designed, it is critical that the residence time distribution of the processing device be considered.
* For example, if orange juice is being pasteurized using a heat exchanger it is possible that some particles of the juice will spend a considerably longer period of time in the heat exchanger than others.

Medical Application of RDT: Hemodialyzer

* Hollow fiber modules. Each module contains multiple semi-permeable capillaries that have been grouped together.
* These devices are used as hemodialyzers for patients with renal disease.
* RTD is a critical factor that can be used to increase the efficiency of these devices.