CHFEN 3553: Chemical Reaction Engineering

Assignment 5: Due February 24, 2005

1. Draw the block diagram showing the recycle reactor and mark all the streams. Derive the following relationships, using the nomenclature used in class.

   $X_{A1} = \left(\frac{R}{R+1}\right) X_{Af}$ for the general case

   $C_{A1} = \frac{C_{A0} + RC_{A2}}{1+R}$, when ε=0 or $v_0 = v_f$

Derive the following integrated forms for the recycle reactor with no volume change.

$$\frac{k\tau}{R+1} = \ln\left[\frac{C_{A0} + RC_{Af}}{(R+1)C_{Af}}\right] \text{ First order}$$

$$\frac{k\tau C_{A0}}{R+1} = \frac{C_{A0}(C_{A0} - C_{Af})}{C_{Af}(C_{A0} + RC_{Af})} \text{ Second order}$$

Given:

$k = 1$ (in appropriate units, time in seconds)

$v = 1$ lit/s

$C_{A0} = 1$ mol/lit

Find values of the volume of a recycle reactor necessary to achieve a given conversion for recycle ratios of 0,1,5, 10, 50 and 100. Compare the volume at R=100 with that for a CSTR to achieve the same conversion. Perform the calculations for both the first and the second order reactions. Summarize your observations.

2. A gas-phase reaction $2A \rightarrow B$ is conducted with recycle and pure A is fed to the reactor at a rate of 2 mol/s. Find:
   a. Find the recycle size (some combination of rate constant, volume, pressure, temperature) as a function of recycle ratio for a conversion of 80%.
   b. If the reactor size is fixed at a value when 80% conversion is attained, how does conversion vary with recycle ratio?
3. Compare the performances of a PFR and a CSTR for an autocatalytic reaction
   $A + B \rightarrow 2B$

   $-r = kC_A C_B$

   The feed composition contains A and B in the ratio of 100:1.

   Plot the Damkohler number ($kC_{A0}\tau$) for the two reactors as a function of exit conversion. Draw a Levenspiel plot for this reaction and reconcile (justify) your answers.