Reaction Engineering

Assignment-1

1. The gas phase reaction A + 2B $\rightarrow$ 2D is to be carried out in an isothermal plug-flow reactor at 5.0 atm. The feed contains 20 mole% of A, 50 mole% of B and rest inerts.

(a) What is the steady-state volumetric flow rate at any point in the reactor if the pressure drop due to fluid friction can be ignored?

(b) How large must the plug-flow reactor be to achieve a conversion (based on A) of 0.70 if the feed temperature in the reactor is uniform(55^{o}C), the volumetric feed rate is 50 dm^3/min and the rate equation at 55^{o}C is

$-r_A = 2.5\ C_A^{1/2} C_B$ kmol/m^3. min

(c) Plot the concentrations, volumetric flow rate, and conversion as a functions of reactor length. The reactor diameter is 8.0 cm.

(d) How large would a CSTR have to be to take the effluent from the PFR in part (b) and achieve a conversion of 0.85 (based on the feed of A to the PFR) if the temperature of the CSTR is 55^{o}C?

2. (a) For the reaction of Problem 1, what size of mixed flow reactor is needed for 75%conversion of a feed stream of 1000 mol A/ hr at C_{Ao}=1.2 mol/liter ?

(b) Repeat part **(a)** with the modification that the feed rate is doubled ,thus 2000 mol A/hr at C_{Ao}=1.2 mol/liter are to be treated.

(c) Repeat part (a) with the modification that C_{Ao}=2.4 mol/liter; however, 1000mol A/hr are still to be treated down to C_{Af} = 0.3 mol/liter.

3. Substance A reacts according to a second-order kinetics and conversion is 95% from a single plug-flow reactor. We buy a second unit identical to the first. For the same conversion, by how much is the capacity changed by operating these two units in parallel or in series?

4. At present conversion is 2/3 for our elementary second-order liquid reaction

2A $\rightarrow$2R when operating in an isothermal plug flow reactor with a recycle ratio of unity. What will be the conversion if the recycle stream is shut off ?

5. Data from the following table were obtained for the gas phase decomposition of reactant A in a constant volume batch reactor at 100°C fed with pure A. The stoichiometry of the reaction is 2A $\rightarrow$R + S. Calculate the size of the plug flow reactor, operating at 100°C and 1 atm, capable of treating 100 moles/h of a feeding that contains 20% inerts to obtain a 95% conversion of A.

t , s	0	20	40	60	80	100	140	200	260	330	420
PA,atm	1.0	0.8	0.68	0.56	0.45	0.37	0.25	0.14	0.08	0.04	0.02

6. A tubular reactor is going to be designed to treat 1000 m3/h of a gaseous mixture consisting of 80% acetylene and 20% inerts, measured at 550°C and 20 atm. The tubular reactor will consist of a combination of tubes in series. Each tube has a length of 3.5 m and an inner diameter of 20 cm. The reaction temperature will be 550°C and under these conditions acetylene is polymerized as

$$4C_2H_2 \rightarrow (C_2H_2)_2 \quad -\mathrm{r}_{\mathrm{acetylene}} = \mathrm{k}\,\mathrm{C}^2_{\mathrm{Actylene}}\,, \mathrm{k} = 0.6\ \mathrm{L}/(\mathrm{mol.\,s})$$

If pressure drop through the tubes is neglected, calculate the number of tubes required for a 60% conversion of acetylene to tetramer complex. The pressure at the inlet of the first tube is 20 atm.