A First Course on Kinetics and Reaction Engineering

Activity 31.1

Problem Purpose

This problem will allow you to practice the general approach for analyzing a recycle PFR.

Problem Statement

In liquid phase reaction (1) the chiral molecule, B, is produced autocatalytically according to the rate expression given in equation (2). The heat of reaction is -14 kcal mol^{-1}, independent of temperature. The pre-exponential factor is equal to 4.2 x 10^{15} cm^{3} mol^{-1} min^{-1} and the activation energy is 18 kcal mol^{-1}. A solvent is used, and the heat capacity of the reacting solution can be taken to equal that of the solvent, 1.3 cal cm^{-3} K^{-1}. The density of the liquid may be assumed to be constant. The concentrations of A and B in the feed to the process are 2 M and 0 M, respectively, and the flow rate is 500 cm^{3} min^{-1} at 300K. An adiabatic recycle PFR with a recycle ratio of 1.3 is used. The reactor diameter is 5 cm and it is 50 cm long. What are the outlet concentrations of A and B and the outlet temperature from the process?

$$A + B \rightarrow 2\,B \qquad (1)$$

$$r_1 = k_1 C_A C_B \qquad (2)$$

Worksheet

1. Make a sketch of the system, labeling each flow stream.

2. Read through the problem statement. Each time you encounter a quantity, write it down and equate it to the appropriate variable. When you have completed doing so, if there are any additional constant quantities that you know will be needed and that can be calculated from the values you found, write the equations needed for doing so.

3. Generate the design equations needed to model the PFR by simplification of the general PFR design equations found in Unit 17 or on the AFCoKaRE Exam Handout.

4. Identify the specific set of equations that needs to be solved and within those equations identify the independent and dependent variables, if appropriate, and the unknown quantities to be found by solving the equations.

5. Assuming that the PFR design equations will be solved numerically, specify the information that must be provided and show how to calculate any unknown values.

6. Write mole and energy balances for the mixing point.

7. Identify the specific set of equations that needs to be solved and within those equations identify the independent and dependent variables, if appropriate, and the unknown quantities to be found by solving the equations.

8. Assuming that the mixing point design equations will be solved numerically, specify the information that must be provided and show how to calculate any unknown values.

9. Solve the design equations and use the results to answer the questions asked.