A First Course on Kinetics and Reaction Engineering

Unit 24. Multiple Steady States in CSTRs

Definitions

stable steady state - a condition where none of the variables characterizing a reacting system vary with time and to which the system will return following a small, momentary perturbation of one of those variables

unstable steady state - a condition where none of the variables characterizing a reacting system vary with time but to which the system will not return following a small, momentary perturbation of one of those variables

bifurcation point - the location in parameter space where the solution to a set of equations changes from a single value to multiple values

Nomenclature

ΔH	heat of reaction
E	activation energy
$\hat{C}_{p,i}$	constant pressure specific molar heat capacity of species i
R	ideal gas constant
T	temperature; a superscripted 0 denotes the inlet temperature
V	reaction volume
$\dot{V}$	volumetric flow rate; a superscripted zero denotes the value at the reactor inlet
k_0	pre-exponential factor in the Arrhenius expression for the temperature dependence of a rate coefficient
$\dot{n}_i$	molar flow rate of species i; a superscripted zero denotes the value at the reactor inlet
r_j	the generalized rate of reaction j

Equations

$$\mathrm{A} \rightarrow \mathrm{R} \tag{24.1}$$

$$\dot{n}_A^0 - \dot{n}_A = \frac{k_0 V}{\dot{V}} \exp\left\{\frac{-E}{RT}\right\} \dot{n}_A \tag{24.2}$$

$$\dot{n}_R = \frac{k_0 V}{\dot{V}} \exp\left\{\frac{-E}{RT}\right\} \dot{n}_A \tag{24.3}$$

$$\dot{n}_{solvent}^0 \hat{C}_{p,solvent} \left(T - T^0\right) = -\frac{k_0 V}{\dot{V}} \exp\left\{\frac{-E}{RT}\right\} \dot{n}_A \Delta H\left(T\right) \tag{24.4}$$

$$\text{Heat absorbed} = \text{Heat released} \tag{24.5}$$