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

\( \Delta H \) \hspace{1cm} \text{heat of reaction}
\( E \) \hspace{1cm} \text{activation energy}
\( \hat{C}_{p,i} \) \hspace{1cm} \text{constant pressure specific molar heat capacity of species } i
\( R \) \hspace{1cm} \text{ideal gas constant}
\( T \) \hspace{1cm} \text{temperature; a superscripted 0 denotes the inlet temperature}
\( V \) \hspace{1cm} \text{reaction volume}
\( \dot{V} \) \hspace{1cm} \text{volumetric flow rate; a superscripted zero denotes the value at the reactor inlet}
\( k_0 \) \hspace{1cm} \text{pre-exponential factor in the Arrhenius expression for the temperature dependence of a rate}
\text{coefficient}
\( \hat{n}_i \) \hspace{1cm} \text{molar flow rate of species } i; \text{ a superscripted zero denotes the value at the reactor inlet}
\( r_j \) \hspace{1cm} \text{the generalized rate of reaction } j

Equations

\[ A \rightarrow R \quad (24.1) \]
\[ \dot{n}_A^0 - \dot{n}_A = \frac{k_0 V}{V} \exp \left\{ -\frac{E}{RT} \right\} \dot{n}_A \quad (24.2) \]
\[ \dot{n}_R = \frac{k_0 V}{V} \exp \left\{ -\frac{E}{RT} \right\} \dot{n}_A \quad (24.3) \]
\[ \dot{n}_{\text{solute}} \hat{C}_{p,\text{solute}} \left( T - T^0 \right) = -\frac{k_0 V}{V} \exp \left\{ -\frac{E}{RT} \right\} \dot{n}_A \Delta H (T) \quad (24.4) \]
\[ \text{Heat absorbed} = \text{Heat released} \quad (24.5) \]