A First Course on Kinetics and Reaction Engineering

Unit 31. Back-Mixing in a PFR via Recycle

Definitions

Recycle - split the effluent from a process and mix part of it into the feed to that process.

Nomenclature

C_i	molar concentration of species i
$\hat{C}_{p,i}$	constant pressure specific molar heat capacity of species i
R_R	recycle ratio
T	temperature; a subscript denotes the associated stream
$\dot{V}$	volumetric flow rate; a subscript denotes the associated stream
f_i	fractional conversion of species i, an additional subscript indicates whether it is defined for the overall process or for the reactor only
$\dot{n}_i$	molar flow rate of species i; an additional subscript denotes the associated stream

Equations

$$R_R = \frac{\dot{V}_r}{\dot{V}_d} = \frac{\dot{n}_{total,r}}{\dot{n}_{total,d}} = \frac{\dot{n}_{i,r}}{\dot{n}_{i,d}} \tag{31.1}$$

$$\dot{n}_{i,b} = \dot{n}_{i,a} + \dot{n}_{i,r} = \dot{n}_{i,a} + R_R \dot{n}_{i,d} \tag{31.2}$$

$$\dot{n}_{i,c} = \dot{n}_{i,d} + \dot{n}_{i,r} = \dot{n}_{i,d} + R_R \dot{n}_{i,d} = \left(1 + R_R\right)\dot{n}_{i,d} \tag{31.3}$$

$$\dot{n}_{i,d} = \frac{\dot{n}_{i,c}}{1 + R_R} \tag{31.4}$$

$$\dot{n}_{i,a} + \frac{R_R \dot{n}_{i,c}}{1 + R_R} - \dot{n}_{i,b} = 0 \tag{31.5}$$

$$\sum_{\substack{i=all \\ species}} \dot{n}_{i,a} \int_{T_a}^{T_b} \hat{C}_{p,i}\, dT + \sum_{\substack{i=all \\ species}} \dot{n}_{i,r} \int_{T_c(=T_r)}^{T_b} \hat{C}_{p,i}\, dT = 0 \tag{31.6}$$

$$f_{i,pass} = \frac{\dot{n}_{i,b} - \dot{n}_{i,c}}{\dot{n}_{i,b}} \tag{31.7}$$

$$f_{i,overall} = \frac{\dot{n}_{i,a} - \dot{n}_{i,d}}{\dot{n}_{i,a}} \tag{31.8}$$

$$C_i = \frac{\dot{n}_i}{\dot{V}} \tag{31.9}$$

$$C_i = \frac{\dot{n}_i}{\dot{V}_b} = \frac{\dot{n}_i}{\dot{V}_a + \dot{V}_r} = \frac{\dot{n}_i}{\dot{V}_a + R_R \dot{V}_d} = \frac{\dot{n}_i}{\dot{V}_a \left(1 + R_R\right)} \tag{31.10}$$