R2.1 Levenspiel Plots in Terms of Conversion

For reactions in which the rate depends only on the concentration of one species [i.e., $-r_A = f(C_A)$], it is usually convenient to report $-r_A$ as a function of concentration rather than conversion. We can rewrite the design equation for a plug-flow reactor [Equation (R2-16)] in terms of the concentration, C_A, rather than in terms of conversion for the special case when $\upsilon = \upsilon_0$.

$$V = F_{A0} \int_0^X \frac{dX}{-r_A} \tag{2-16}$$

$$F_{A0} = \upsilon_0 C_{A0} \tag{R2.1-1}$$

Rearranging Equation (2-10) gives us

$$X = \frac{F_{A0} - F_A}{F_{A0}} \tag{R2.1-2}$$

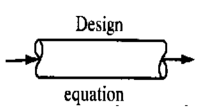
For the *special case* when $\upsilon = \upsilon_0$,

$$X = \frac{F_{A0} - F_A}{F_{A0}} = \frac{C_{A0}\upsilon_0 - C_A\upsilon}{C_{A0}\upsilon_0} = \frac{C_{A0} - C_A}{C_{A0}}$$

when $X = 0$, $C_A = C_{A0}$

when $X = X$, $C_A = C_A$

Differentiating yields



$$dX = \frac{-dC_A}{C_{A0}}$$

$$V = \upsilon_0 \int_{C_A}^{C_{A0}} \frac{dC_A}{-r_A} \tag{R2.1-3}$$

Valid only if $\upsilon = \upsilon_0$

$$\boxed{\tau = \int_{C_A}^{C_{A0}} \frac{dC_A}{-r_A}} \tag{R2.1-4}$$

Equation (R2.1-4) is a form of the design equation for constant volumetric flow rate υ_0 that may prove more useful in determining the space time or reactor volume for reaction rates that depend only on the concentration of one species.

Figure R2.1-1 shows a typical curve of the reciprocal reaction rate as a function of concentration for an isothermal reaction carried out at constant volume. For reaction orders greater than zero, the rate decreases as concentration decreases. The area under the curve gives the space time necessary to reduce the concentration of A from C_{A0} to C_{A1}.

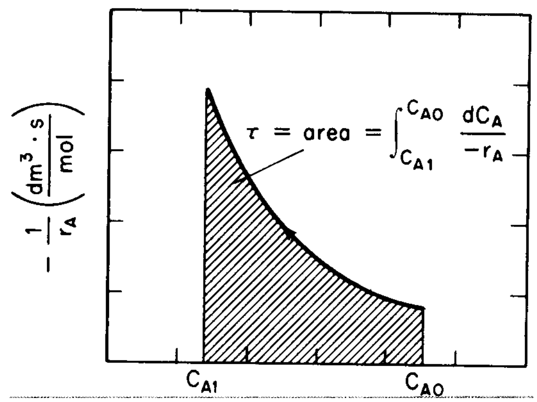


Figure R2.1-1 Determining the space time, τ.