Crystallization

15.27 In this problem we are asked to determine the values of the constants n and k (Equation 10.17) for the crystallization of polypropylene at 150°C (Figure 15.17). One way to solve this problem is to take two values of percent recrystallization (which is just 100y, Equation 10.17) and their corresponding time values, then set up two simultaneous equations, from which n and k may be determined. In order to expedite this process, we will rearrange and do some algebraic manipulation of Equation 10.17. First of all, we rearrange as follows:

$$1 - y = \exp\left(-kt^n\right)$$

Now taking natural logarithms

$$\ln (1 - y) = -kt^n$$

Or

$$-\ln (1 - y) = kt^n$$

which may also be expressed as

$$\ln\left(\frac{1}{1 - y}\right) = kt^n$$

Now taking natural logarithms again, leads to

$$\ln\left[\ln\left(\frac{1}{1 - y}\right)\right] = \ln k + n \ln t$$

which is the form of the equation that we will now use. From the 150°C curve of Figure 15.17, let us arbitrarily choose two percent crystallized values of 20% and 80% (i.e., $y_1 = 0.20$ and $y_2 = 0.80$). The corresponding time values are $t_1 = 220$ min and $t_2 = 460$ min (realizing that the time axis is scaled logarithmically). Thus, our two simultaneous equations become

$$\ln\left[\ln\left(\frac{1}{1 - 0.20}\right)\right] = \ln k + n \ln (220)$$

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$$\ln\left[\ln\left(\frac{1}{1-0.80}\right)\right] = \ln k + n \ln (460)$$

from which we obtain the values $n = 2.68$ and $k = 1.2 \times 10^{-7}$.

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