MAE 20 Homework 7 Solutions

12-2 Determine the constants c and n in Equation 12-2 that describe the rate of crystallization of polypropylene at 140°C. (See Figure 12-26).

Solution: $f = 1 - \exp(-ct^n)$ $T = 140°C = 413\ K$

We can rearrange the equation and eliminate the exponential by taking natural logarithms of both sides of the rearranged equation. We can then note that ln(1-f) versus t is a power equation; if these terms are plotted on a log-log plot, we should obtain a linear relationship, as the graph of the data below indicates. Note that in setting up the equation for plotting, we switch the minus sign from the right hand to the left hand side, since we don't have negative numbers on the log-log paper.

$$1 - f = \exp(-ct^n)$$

$$\ln(1-f) = -ct^n$$

$$\ln[-\ln(1-f)] = \ln(ct^n)$$

$$\ln[-\ln(1-f)] = \ln(c) + n\ln(t)$$

f	t (min)	-ln(1-f)
0.1	28	0.1
0.2	37	0.22
0.3	44	0.36
0.4	50	0.51
0.5	55	0.69
0.6	60	0.92
0.7	67	1.20
0.8	73	1.61
0.9	86	2.302

A log-log plot of "-ln(1-f)" versus "t" is shown. From the graph, we find that the slope n = 2.89 and the constant c can be found from one of the points from the curve:

if $f = 0.5$, $t = 55$. *Then*

$$1 - 0.5 = \exp[-c(55)^{2.89}]$$

$$c = 6.47 \times 10^{-6}$$

13-10 Describe the microstructure present in a 1050 steel after each step in the following heat treatments:

(a) Heat at 820°C, quench to 650°C and hold for 90 s, and quench to 25°C
(b) Heat at 820°C, quench to 450°C and hold for 90 s, and quench to 25°C
(c) Heat at 820°C and quench to 25°C
(d) Heat at 820°C, quench to 720°C and hold for 100 s, and quench to 25°C
(e) Heat at 820°C, quench to 720°C and hold for 100 s, quench to 400°C and hold for 500 s, and quench to 25°C
(f) Heat at 820°C, quench to 720°C and hold for 100 s, quench to 400°C and hold for 10 s, and quench to 25°C
(g) Heat at 820°C, quench to 25°C, heat to 500°C and hold for 10^3 s, and air cool to 25°C

Solution:

(a) *Austenite is present after heating to 820 °C; both ferrite and pearlite form during holding at 650°C; ferrite and pearlite remain after cooling to 25°C.*

(b) *Austenite is present after heating to 820°C; bainite forms after holding at 450°C; and bainite remains after cooling.*

(c) *Austenite is present after heating to 820°C; martensite forms due to the quench.*

(d) *Austenite is present after heating to 820°C; ferrite forms at 720°C, but some austenite still remains. During quenching, the remaining*

13-19 A part produced from a low alloy, 0.2% C steel (Figure 13-15) has a microstructure containing ferrite, pearlite, bainite, and martensite after quenching. What microstructure would be obtained if we had used a 1080 steel? What microstructure would be obtained if we had used a 4340 steel?

Solution: *To produce ferrite, pearlite, bainite, and martensite in the same microstructure during continuous cooling, the cooling rate must have been between 10 and 20°C/s. If the same cooling rates are used for the other steels, the microstructures are:*

1080 steel: fine pearlite
4340 steel: martensite

13.45

Based on the design conditions given,

>HRC 38 with Jominy distance=4/16

<HRC 32 with Jominy distance = 16/16

The material which satisfy both criteria is the steel 4320.