CME 300 Properties of Materials

Homework 5 October 20, 2011

Callister:

4.5 For both FCC and BCC crystal structures, there are two different types of interstitial sites. In each case, one site is larger than the other, and is normally occupied by impurity atoms. For FCC, this larger one is located at the center of each edge of the unit cell; it is termed an octahedral interstitial site. On the other hand, with BCC the larger site type is found at $0\frac{1}{2}\frac{1}{4}$ positions—that is, lying on {100} faces, and situated midway between two unit cell edges on this face and one-quarter of the distance between the other two unit cell edges; it is termed a tetrahedral interstitial site. For both FCC and BCC crystal structures, compute the radius *r* of an impurity atom that will just fit into one of these sites in terms of the atomic radius *R* of the host atom.

9.47 **(a)** What is the distinction between hypoeutectoid and hypereutectoid steels?

(b) In a hypoeutectoid steel, both eutectoid and proeutectoid ferrite exist. Explain the difference between them. What will be the carbon concentration in each?

9.50 Consider 3.5 kg of austenite containing 0.95 wt% C, cooled to below 727°C (1341°F).

(a) What is the proeutectoid phase?

(b) How many kilograms each of total ferrite and cementite form?

(c) How many kilograms each of pearlite and the proeutectoid phase form?

(d) Schematically sketch and label the resulting microstructure.

9.54 The mass fractions of total ferrite and total cementite in an iron–carbon alloy are 0.91 and 0.09, respectively. Is this a hypoeutectoid or hypereutectoid alloy? Why?

9.63 For an iron–carbon alloy of composition 3 wt% C–97 wt% Fe, make schematic sketches of the microstructure that would be observed for conditions of very slow cooling at the following temperatures: 1250°C (2280°F), 1145°C (2095°F), and 700°C (1290°F). Label the phases and indicate their compositions (approximate).

9.66 A steel alloy is known to contain 93.65 wt% Fe, 6.0 wt% Mn, and 0.35 wt% C.

(a) What is the approximate eutectoid temperature of this alloy?

(b) What is the proeutectoid phase when this alloy is cooled to a temperature just below the eutectoid?

(c) Compute the relative amounts of the proeutectoid phase and pearlite. Assume that there are no alterations in the positions of other phase boundaries with the addition of Mn.

10.16 Briefly cite the differences between pearlite, bainite, and spheroidite relative to microstructure and mechanical properties.

10.18 Using the isothermal transformation diagram for an iron–carbon alloy of eutectoid composition (Figure 10.22), specify the nature of the final microstructure (in terms of microconstituents present and approximate percentages of each) of a small specimen that has been subjected to the following time–temperature treatments. In each case assume that the specimen begins at 760°C (1400°F) and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

(a) Cool rapidly to 350°C (660°F), hold for 10^3 s, then quench to room temperature.

(b) Rapidly cool to 625°C (1160°F), hold for 10 s, then quench to room temperature.

(c) Rapidly cool to 600°C (1110°F), hold for 4 s, rapidly cool to 450°C (840°F), hold for 10 s, then quench to room temperature.

(d) Reheat the specimen in part (c) to 700°C (1290°F) for 20 h.

(e) Rapidly cool to 300°C (570°F), hold for 20 s, then quench to room temperature in water. Reheat to 425°C (800°F) for 10^3 s and slowly cool to room temperature.

(f) Cool rapidly to 665°C (1230°F), hold for 10^3 s, then quench to room temperature.

(g) Rapidly cool to 575°C (1065°F), hold for 20 s, rapidly cool to 350°C (660°F), hold for 100 s, then quench to room temperature.

(h) Rapidly cool to 350°C (660°F), hold for 150 s, then quench to room temperature.

10.22 Make a copy of the isothermal transformation diagram for a 1.13 wt% C iron–carbon alloy (Figure 10.39), and then on this diagram sketch and label time–temperature paths to produce the following microstructures:

(a) 6.2% proeutectoid cementite and 93.8% coarse pearlite

(b) 50% fine pearlite and 50% bainite

(c) 100% martensite

(d) 100% tempered martensite

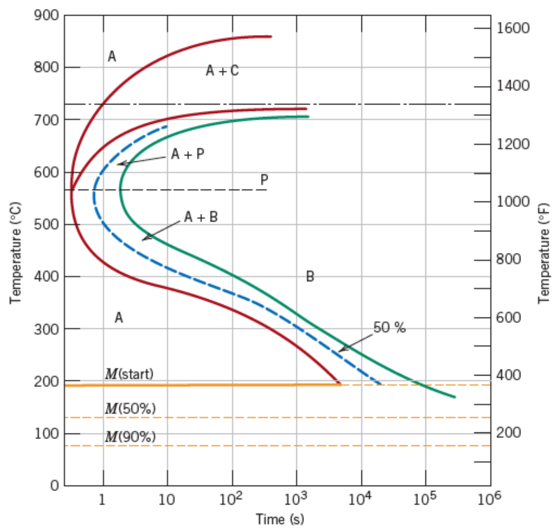

Figure 10.39 Isothermal transformation diagram for a 1.13 wt% C iron–carbon alloy: A, austenite; B, bainite; C, proeutectoid cementite; M, martensite; P, pearlite. [Adapted from H. Boyer (Editor), *Atlas of Isothermal Transformation and Cooling Transformation Diagrams,* American Society for Metals, 1977, p. 33.]

10.35 (a) Briefly describe the microstructural difference between spheroidite and tempered martensite.

(b) Explain why tempered martensite is much harder and stronger.

11.1 (a) List the four classifications of steels. **(b)** For each, briefly describe the properties and typical applications.

11.6 Compare gray and malleable cast irons with respect to **(a)** composition and heat treatment, **(b)** microstructure, and **(c)** mechanical characteristics.

11.7 Compare white and nodular cast irons with respect to **(a)** composition and heat treatment, **(b)** microstructure, and **(c)** mechanical characteristics.

11.10 Why must rivets of a 2017 aluminum alloy be refrigerated before they are used?