Exercise 7 - Autumn 2013

TMT4185 Materialteknologi

All exercise numbers are from *Materials Science and Engineering*, 7th edition.

10.2
a) Rewrite the expression for the total free energy change for nucleation (Equation 10.1) for the case of a cubic nucleus of edge length a (instead of a sphere of radius r). Now differentiate this expression with respect to a (per Equation 10.2) and solve for both the critical cube edge length, a*, and also ΔG^*.

b) Is ΔG^* greater for a cube or a sphere? Why?

10.20 Using the isothermal transformation diagram for a 1.13 wt% C steel alloy (Figure 10.39), determine the final microstructure (in terms of just the microconstituents present) of a small specimen that has been subjected to the following time–temperature treatments. In each case assume that the specimen begins at 920 °C and that it has been held at this temperature long enough to have achieved a complete and homogeneous austenitic structure.

a) Rapidly cool to 250 °C, hold for 10^3 s, then quench to room temperature.

b) Rapidly cool to 775 °C, hold for 500 s, then quench to room temperature.

c) Rapidly cool to 400 °C, hold for 500 s, then quench to room temperature.

d) Rapidly cool to 700 °C, hold for 10^5 s, then quench to room temperature.

e) Rapidly cool to 650 °C, hold at this temperature for 3 s, rapidly cool to 400 °C, hold for 25 s, then quench to room temperature.

f) Rapidly cool to 350 °C, hold for 300 s, then quench to room temperature.

g) Rapidly cool to 675 °C, hold for 7 s, then quench to room temperature.

h) Rapidly cool to 600 °C, hold at this temperature for 7 s, rapidly cool to 450 °C, hold for 4 s, then quench to room temperature.

10.27 Name the microstructural products of 4340 alloy steel specimens that are first completely transformed to austenite,then cooled to room temperature at the following rates:

a) 0.005 °C/s

b) 0.05 °C/s

c) 0.5 °C/s

d) 5 °C/s

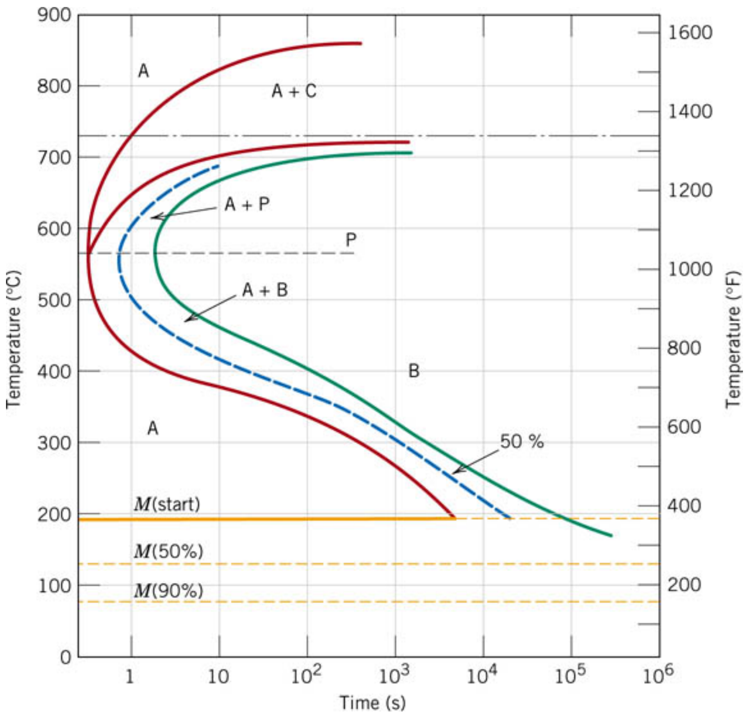

Figure 10.39: Isothermal transformation diagram for a 1.13 wt% C iron–carbon alloy: A, austenite; B, bainite; C, proeutectoid cementite; M, martensite; P, pearlite.

10.30 Briefly explain why fine pearlite is harder and stronger than coarse pearlite, which in turn is harder and stronger than spheroidite.

10D5 An alloy steel (4340) is to be used in an application requiring a minimum tensile strength of 1515 MPa (220,000 psi) and a minimum ductility of 40% RA. Oil quenching followed by tempering is to be used. Briefly describe the tempering heat treatment.

11.17 If it is assumed that, for steel alloys, the average cooling rate of the heat-affected zone in the vicinity of a weld is 10 °C/s, compare the microstructures and associated properties that will result for 1080 (eutectoid) and 4340 alloys in their HAZs.

11D15 A solution heat-treated 2014 aluminum alloy is to be precipitation hardened to have a minimum yield strength of 345 MPa (50,000 psi) and a ductility of at least 12%EL. Specify a practical precipitation heat treatment in terms of temperature and time that would give these mechanical characteristics. Justify your answer.

Hint: You need to use the graph from the 7th edition of the textbook for this problem (given on the next page).

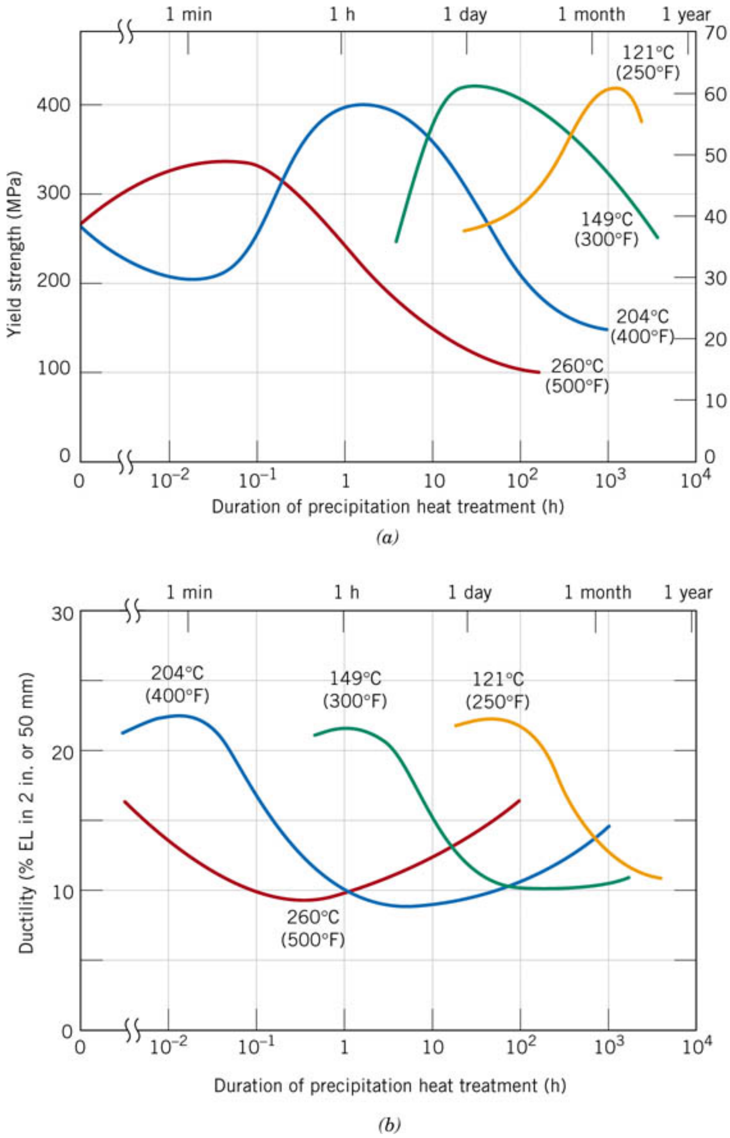

Figure 11.27: The precipitation hardening characteristics of a 2014 aluminum alloy (0.9 wt% Si, 4.4 wt% Cu, 0.8 wt% Mn, 0.5 wt% Mg) at four different aging temperatures: (a) yield strength, and (b) ductility (%EL).