Quiz 5 Properties of Materials CME 300
October 28, 2011

1) Sketch the phase diagram for Iron/Cementite showing the intermetallic phase at 6.70 wt. % carbon, the eutectic at 4.30 wt. % C (1147°C), the peritectic for $\delta + L \Rightarrow \gamma$ (1493°C), the eutectoid at 0.76 wt. % carbon (727°C), the ferrite miscibility limit at 0.022% and the austenite miscibility limit at 2.14%.

2) Use the phase diagram and sketches where necessary and explain what each of these are:

a) Pearlite
b) Spheroidite
c) Martensite
d) Tempered steel
e) Bainite

3) In a hypoeutectoid steel both eutectoid and proeutectoid ferrite exits. Explain the difference between them. What is the concentration of carbon in each (use your phase diagram)?

4) Explain the composition and heat treatment, microstructure and mechanical characteristics of gray cast iron.

ANSWERS: Quiz 5 Properties of Materials CME 300
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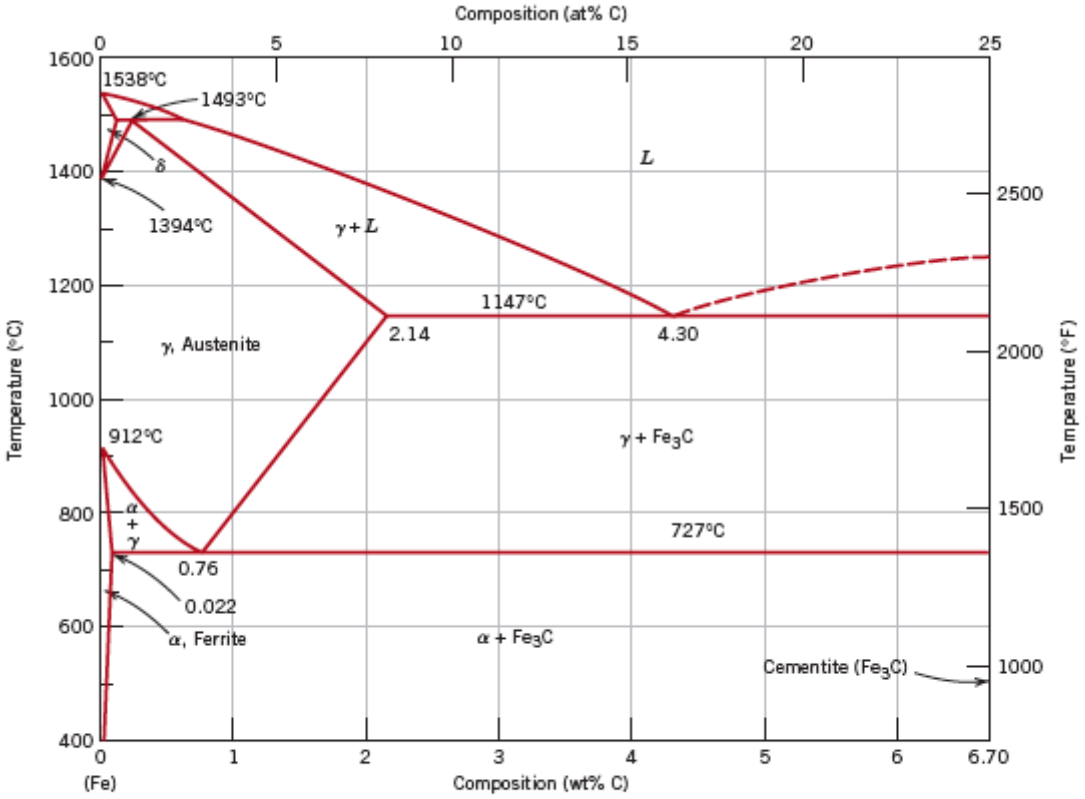
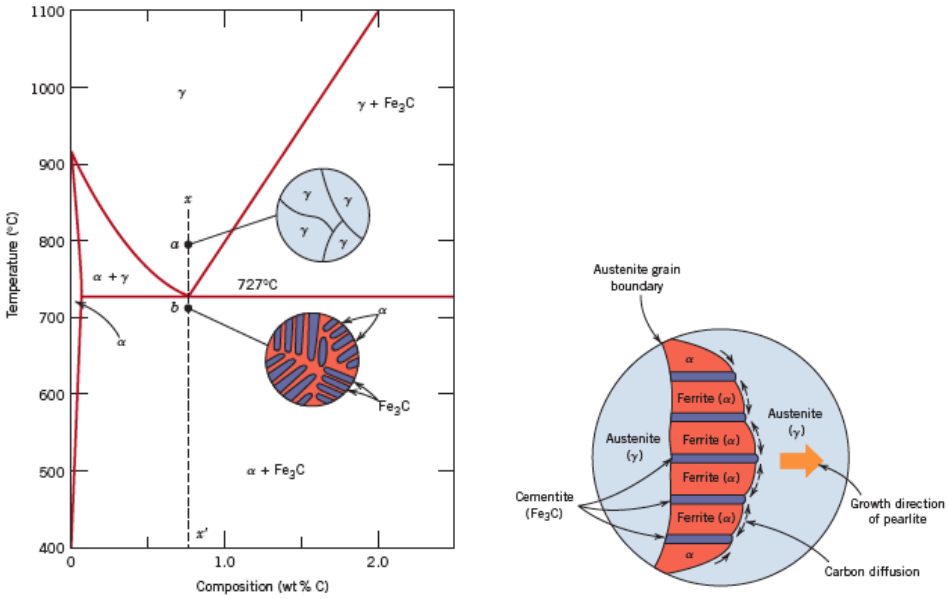
1) Sketch the phase diagram for Iron/Cementite showing the intermetallic phase at 6.70 wt. % carbon, the eutectic at 4.30 wt. % C (1147°C), the peritectic for δ + L => γ (1493°C), the eutectoid at 0.76 wt. % carbon (727°C), the ferrite miscibility limit at 0.022% and the austenite miscibility limit at 2.14%.



2) Use the phase diagram and sketches where necessary and explain what each of these are:

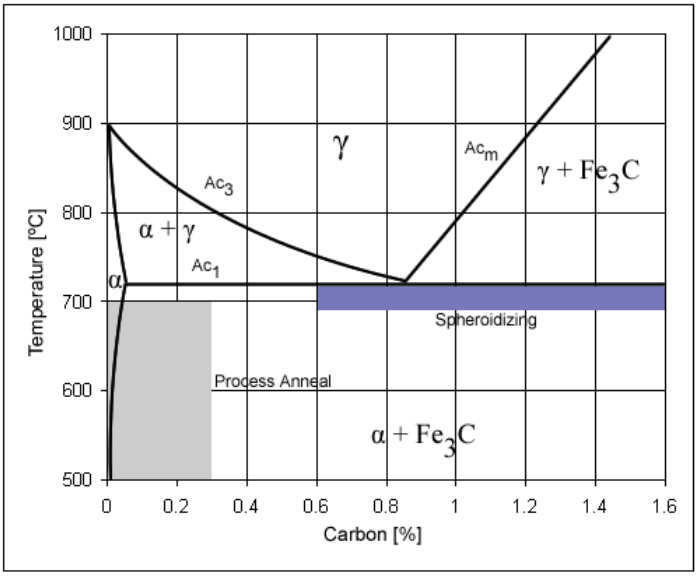
a) Pearlite

Pearlite is a eutectoid morphology formed as shown in the following phase diagram.



b) Spheroidite

Spheroidite forms when carbon steel is heated to approximately 700 °C for over 30 hours. Spheroidite can form at lower temperatures but the time needed drastically increases, as this is a diffusion-controlled process. The result is a structure of rods or spheres of cementite within primary structure (ferrite or pearlite, depending on which side of the eutectoid you are on). The purpose is to soften higher carbon steels and allow more formability. This is the softest and most ductile form of steel.



c) Martensite

Martensite is achieved by a rapid quench from austenite steel to temperatures below 500°C in a diffusionless process that converts the FCC structure of austenite to the BCT structure of martensite.

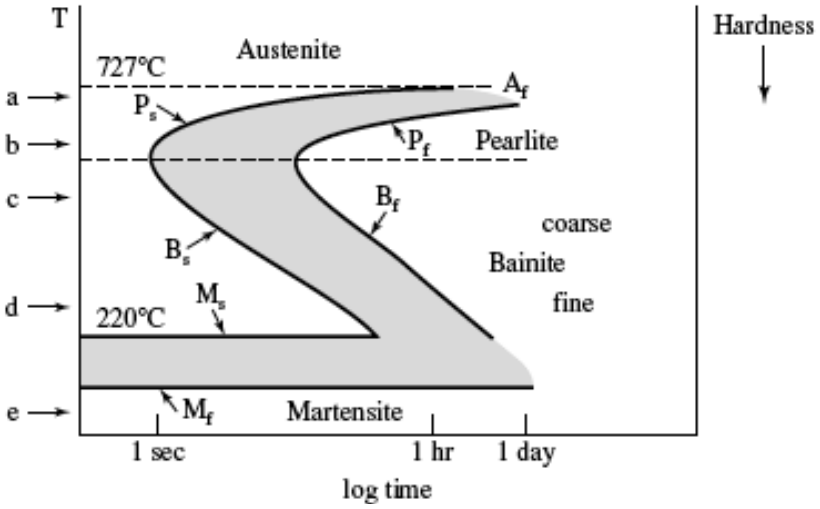


FIGURE 8.4. Schematic representation of a TTT diagram for eutectoid steel. The annealing temperatures (a) through (e) refer to specific cases as described in the text. Note that the hardness scale on the right points downward.

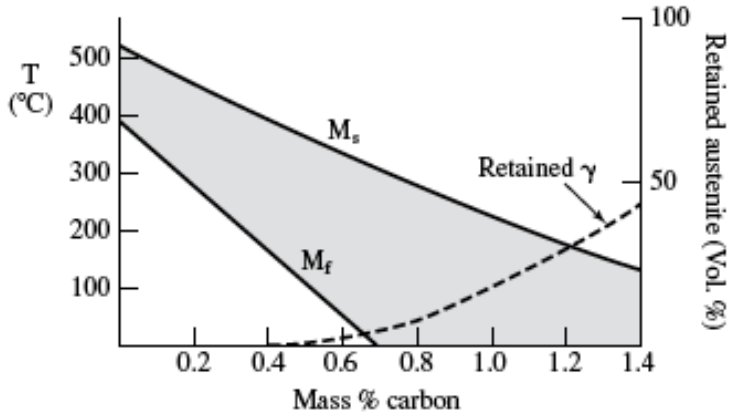


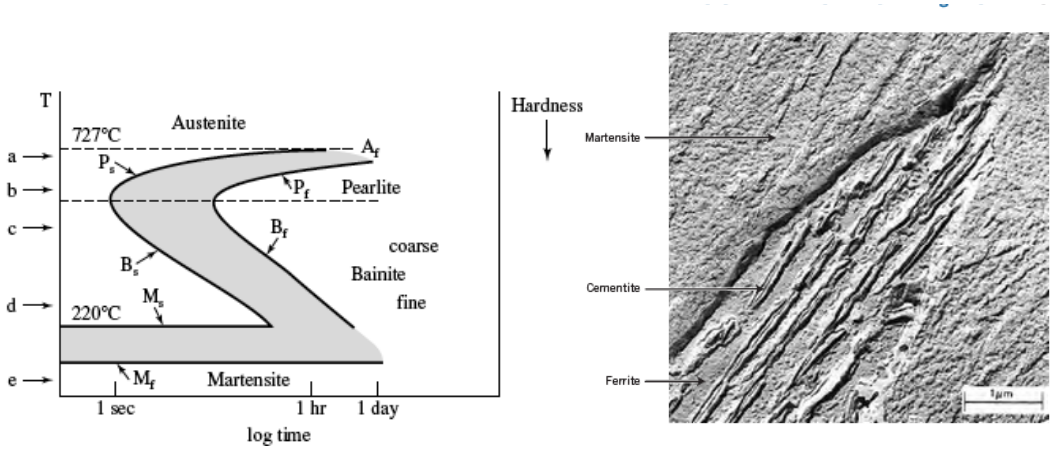
FIGURE 8.6. Schematic representation of the influence of carbon concentration on the M_s and M_f temperatures in steel and on the amount of retained austenite (given in volume percent).

d) Tempered steel

Since martensite is a brittle material it is desirable to controllably revert the martensitic structure into ferrite and cementite phases by annealing the steel just below the eutectoid temperture. This process is called tempering and the resulting steel is tempered steel.

e) Bainite

Moderate quenches lead to a needle like cementite in a ferrite matrix dispersed in austenite or martensite structure called bainite.



3) In a hypoeutectoid steel both eutectoid and proeutectoid ferrite exits. Explain the difference between them. What is the concentration of carbon in each (use your phase diagram)?

Proeutectoid ferrite forms above the eutectoid temperature and has a final equilibrium composition of 0.022 % C. Eutectoid ferrite has a slightly lower concentration of carbon since it forms below the eutectoid temperature and exists in the pearlite structure.

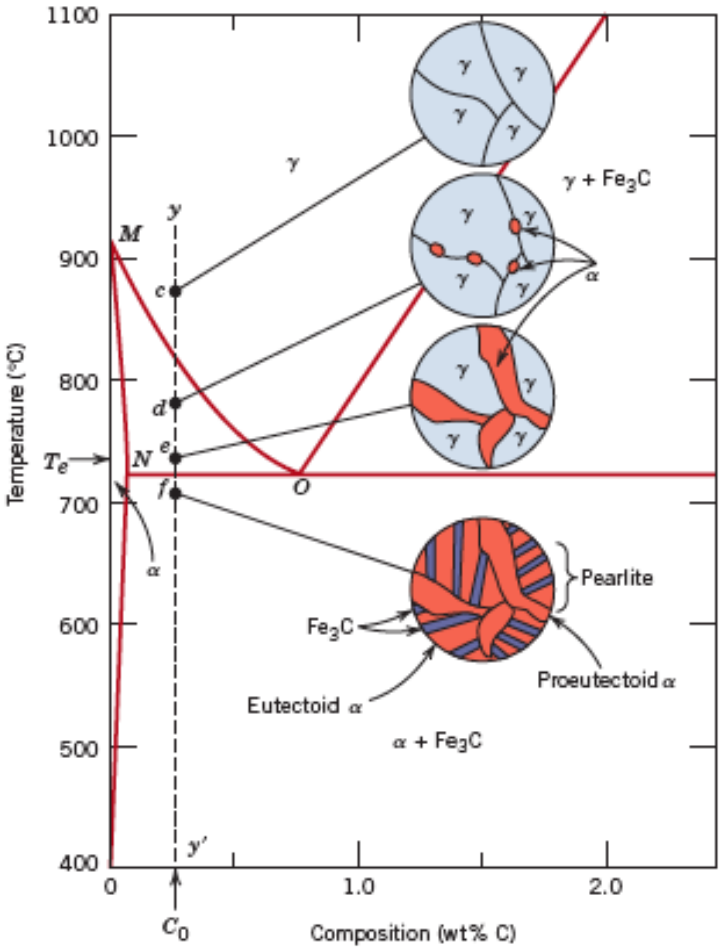


Figure 9.29 Schematic representations of the microstructures for an iron–carbon alloy of hypoeutectoid composition C_0 (containing less than 0.76 wt% C) as it is cooled from within the austenite phase region to below the eutectoid temperature.

4) Explain the composition and heat treatment, microstructure and mechanical characteristics of gray cast iron.

Grey cast iron is 2.5 to 4 wt. % carbon and 1 to 3 % silicon. Microstructure includes flakes of graphite surrounded by ferrite or pearlite matrix. Grey cast iron is weak and brittle under tension but is strong under compression. Good damping for vibrations, easily cast, low cost.