

Mat E 272-C
Fall 2001 – Homework Set # 9
Solutions and grading criteria
Total possible points for this assignment: 15

Due Thursday November 29, 2001

Graded problems:

11.5 What is the purpose of a spheroidizing heat treatment? On what classes of alloys is it normally used?

The purpose of a spheroidizing heat treatment is to produce a comparatively soft and ductile steel alloy having a spheroiditic microstructure. It is normally used on medium- and high-carbon steels, which, by virtue of carbon content, are relatively hard and strong.

Grading: 2 points for recognizing that the objective is to produce a more ductile steel by modifying the geometry of the cementite phase. 1 point for indicating that a spheroidizing heat treatment is usually applied to medium- and high-carbon steels.
Total for this problem: 3 points

11.6 Briefly explain the difference between hardness and hardenability.

Hardness is a measure of a material's resistance to localized surface deformation, whereas hardenability is a measure of the depth (or extent) to which a ferrous alloy may be hardened by the formation of martensite. Hardenability is determined from hardness tests

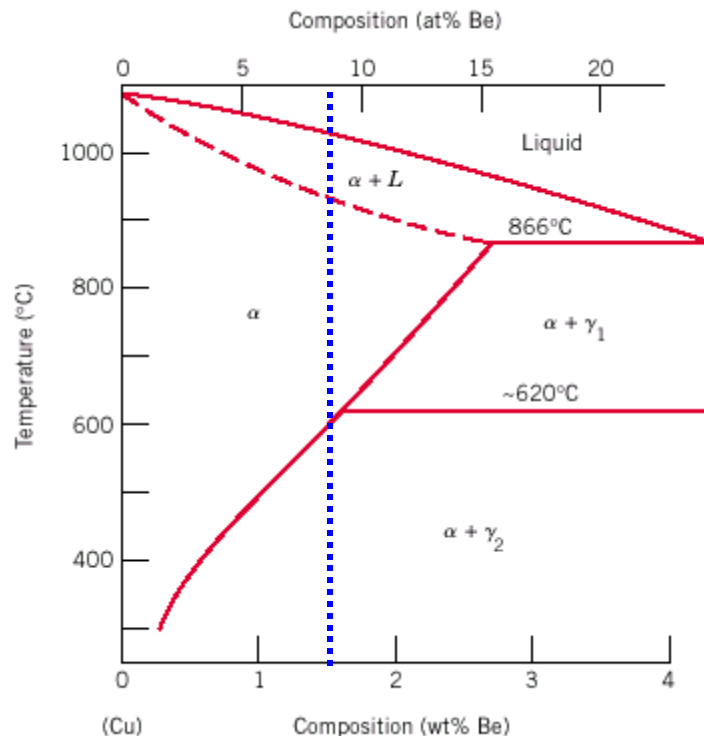
Grading: 1 point for correct interpretation of hardenability and 1 for correct interpretation of hardness. **Total for this problem: 2 points**

11.D8 Copper-rich copper–beryllium alloys are precipitation hardenable. After consulting the portion of the phase diagram (Figure 11.17), do the following:

(a) Specify the range of compositions over which these alloys may be precipitation hardened.

(b) Briefly describe the heat-treatment procedures (in terms of temperatures) that would be used to precipitation harden an alloy having a composition of 1.5 wt. % Be (this modification to part (b) was specified in the assignment)

The Cu-rich portion of the Cu-Be phase diagram is shown at right. The dashed line corresponds to a composition of 1.5 wt. % Be, as specified in the problem.



This problem is concerned with the precipitation-hardening of copper-rich Cu-Be alloys. The relevant portion of the Cu-Be phase diagram is shown above (Figure 11.17).

- The range of compositions over which these alloys may be precipitation hardened is between approximately 0.2 wt% Be (the maximum solubility of Be in Cu at about 300°C) and 2.7 wt% Be (the maximum solubility of Be in Cu at 866°C).
- The solution heat treatment must be carried out at a temperature within the α phase region, after which, the specimen is quenched to room temperature. Finally, the precipitation heat treatment is conducted at a temperature within the $\alpha + \gamma_2$ phase region.

For a 1.5 wt% Be-98.5 wt% Cu alloy as specified in the problem, the solution heat treating temperature must be between about 600°C (1110°F) and 900°C (1650°F), while the precipitation heat treatment would be below 600°C (1110°F), and probably above 300°C (570°F). Below 300°C, diffusion rates are low, and heat treatment times would be relatively long.

Grading: 3 points for correct identification of possible range over which precipitation hardening could be applied (0.2 wt% to 2.7 wt% Be) . 2 points for correctly identifying the temperature ranges within which a 1.5 wt. % Be composition would be solution heat treated (600°C to 900°C) and precipitation heat treated (300°C to < 600°C). Full credit is given for precipitation heat treatment temperatures below 300°C but the student should be cautioned about the relatively low diffusion rates. **Total for this problem: 5 points**

12.14 On the basis of microstructure, briefly explain why gray iron is brittle and weak in tension.

Gray iron is weak and brittle in tension because the tips of the graphite flakes act as points of stress concentration

Grading: 1 point for correctly identifying the problem associated with stress concentrators at the tips of the graphite flakes **Total for this problem: 1 point**

12.19 What is the principal difference between wrought and cast alloys?

The principal difference between wrought and cast alloys is as follows: wrought alloys are ductile enough so as to be hot or cold worked during fabrication, whereas cast alloys are brittle to the degree that shaping by deformation is not possible and they must be fabricated by casting.

Grading: 1 point for mentioning that wrought alloys tend to be ductile and 1 point for mentioning that cast alloys tend to be brittle **Total for this problem: 2 points**

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

Rivets of a 2017 aluminum alloy must be refrigerated before they are used because, after being solution heat treated, they precipitation harden at room

temperature. Once precipitation hardened, they are too strong and brittle to be driven.

Grading: 2 points for recognizing that this particular alloy precipitation-hardens at room temperature. **Total for this problem: 2 points**

Suggested problems:

11.3 Give the temperature range over which it is possible to austenitize each of the following iron–carbon alloys during a normalizing heat treatment: **(a)** 0.20 wt% C, **(b)** 0.76 wt% C, and **(c)** 0.95 wt% C.

This question asks that we cite the temperature range over which it is desirable to austenitize several iron-carbon alloys during a normalizing heat treatment.

(a) For 0.20 wt% C, heat to between 890 and 920°C (1635 and 1690°F) since the **A₃** temperature is 835°C (1535°F).

(b) For 0.76 wt% C, heat to between 782 and 812°C (1440 and 1494°F) since the **A₃** temperature is 727°C (1340°F).

(c) For 0.95 wt% C, heat to between 840 and 870°C (1545 and 1600°F) since **A_{cm}** is 785°C (1445°F).

12.4 Compare sand, die, investment, and continuous casting techniques.

This question asks us to compare sand, die, investment, and continuous casting techniques.

For **sand casting**, sand is the mold material, a two-piece mold is used, ordinarily the surface finish is not an important consideration, the sand may be reused (but the mold may not), casting rates are low, and large pieces are usually cast.

For **die casting**, a permanent mold is used, casting rates are high, the molten metal is forced into the mold under pressure, a two-piece mold is used, and small pieces are normally cast.

For **investment casting**, a single-piece mold is used, which is not reusable; it results in high dimensional accuracy, good reproduction of detail, fine surface finish; and casting rates are low.

For **continuous casting**, at the conclusion of the extraction process, the molten metal is cast into a continuous strand having either a rectangular or circular cross-section; these shapes are desirable for subsequent secondary metal-forming operations. The chemical composition and mechanical properties are relatively uniform throughout the cross-section.