

CHAPTER 7

DISLOCATIONS AND STRENGTHENING MECHANISMS

PROBLEM SOLUTIONS

Basic Concepts of Dislocations**Characteristics of Dislocations**

7.1 The dislocation density is just the total dislocation length per unit volume of material (in this case per cubic millimeters). Thus, the total length in 1000 mm^3 of material having a density of 10^5 mm^{-2} is just

$$(10^5 \text{ mm}^{-2})(1000 \text{ mm}^3) = 10^8 \text{ mm} = 10^5 \text{ m} = 62 \text{ mi}$$

Similarly, for a dislocation density of 10^9 mm^{-2} , the total length is

$$(10^9 \text{ mm}^{-2})(1000 \text{ mm}^3) = 10^{12} \text{ mm} = 10^9 \text{ m} = 6.2 \times 10^5 \text{ mi}$$

7.4 For the various dislocation types, the relationships between the direction of the applied shear stress and the direction of dislocation line motion are as follows:

edge dislocation--parallel

screw dislocation--perpendicular

mixed dislocation--neither parallel nor perpendicular

Slip Systems

7.5 (a) A slip system is a crystallographic plane, and, within that plane, a direction along which dislocation motion (or slip) occurs.

(b) All metals do not have the same slip system. The reason for this is that for most metals, the slip system will consist of the most densely packed crystallographic plane, and within that plane the most closely packed direction. This plane and direction will vary from crystal structure to crystal structure.

7.22 These three strengthening mechanisms are described in Sections 7.8, 7.9, and 7.10.

7.28 In order for these two cylindrical specimens to have the same deformed hardness, they must be deformed to the same percent cold work. For the first specimen

$$\begin{aligned} \%CW &= \frac{A_0 - A_d}{A_0} \times 100 = \frac{\pi r_0^2 - \pi r_d^2}{\pi r_0^2} \times 100 \\ &= \frac{\pi (15 \text{ mm})^2 - \pi (12 \text{ mm})^2}{\pi (15 \text{ mm})^2} \times 100 = 36\%CW \end{aligned}$$

For the second specimen, the deformed radius is computed using the above equation and solving for r_d as

$$\begin{aligned} r_d &= r_0 \sqrt{1 - \frac{\%CW}{100}} \\ &= (11 \text{ mm}) \sqrt{1 - \frac{36\%CW}{100}} = 8.80 \text{ mm} \end{aligned}$$

Recovery
Recrystallization
Grain Growth

7.33 For recovery, there is some relief of internal strain energy by dislocation motion; however, there are virtually no changes in either the grain structure or mechanical characteristics. During recrystallization, on the other hand, a new set of strain-free grains forms, and the material becomes softer and more ductile.

7.35 During cold-working, the grain structure of the metal has been distorted to accommodate the deformation. Recrystallization produces grains that are equiaxed and smaller than the parent grains.