Lecture 12

Sunday, April 27, 2008
9:02 PM

Ref: 1. G. Dieter, **Mechanical Metallurgy, 3rd Edition**, *McGraw-Hill*, 1986.
2. Reed-Hill, Abbaschian, **Physical Metallurgy Principles, 3rd Edition**, *PWS Publishing Company*, 1994.

Course Notes:

- Peter sent out an email which mentioned that there have been course schedule changes with the labs. Please note that next week will be your lab holiday and not the week after…this change was made to accommodate department equipment availability
- Remember that there is no homework due this week
- Your next exam will be Monday 5/19 (2 weeks from next Monday)

Review:

- Last time we finished our discussion talking about elasticity by discussing Poisson's ratio and a definition for Hooke's law for shear stress
- We then started discussing plastic deformation -- at least with respect to the stress strain curve
- We defined yield strength
- We defined ultimate tensile strength
- We discussed necking in tensile specimens
- We defined ductility
- We talked about Toughness -- and how it is the ability to absorb applied energy before fracturing
- We talked about the effect of temperature on toughness in steels (in particular)
- We talked about elastic strain recovery -- the fact that when the stress is removed after plastic deformation the elastic deformation is recovered
- We derived the relationships for true stress and true strain
- We talked about hardening -- and one of the common equations used to define plastic flow stress
- We finished off talking about the expected variability in properties

New:

- I want to add to this concept of property variability with some important terminology for all of you mechanical engineers
  - Nominal strength versus Minimum strength on orders

    Let's also clean something up:

- **Conservation of Volume or Volumetric Constraint:**

$$\frac{L}{L_o} = \frac{A_o}{A}$$ Constancy of volume

Break it down.

- We know we don't add matter when something plastically deforms.
- We have constant volume

$$V_i = V$$
$$A_o L_o = A L$$
$$\frac{L}{L_o} = \frac{A_o}{A}$$

Also means that

$$\ln \frac{L}{L_o} = \ln \frac{A_o}{A}$$

ε

- **Theoretical Shear Strength**

- Distance between atoms b
- Spacing between adjacent lattice planes a
- Shear stress causes a displacement x
- Value is 0 when planes are coincident
- Value is also 0 when the planes have moved 1 distance b
- Value is also 0 at midpoint

So:

$$\tau = \tau_m \sin \frac{2\pi x}{b} \quad (1)$$

τ_m — amplitude of sine wave; b — period

At small displacements Hooke's Law can be applied

$$\tau = G\gamma = \frac{Gx}{a} \quad (2)$$

For small values of $\frac{x}{b} \rightarrow \sin\frac{2\pi x}{b} = \frac{2\pi x}{b}$

$$\tau = \tau_m \frac{2\pi x}{b} \quad (3)$$

Combine (2) & (3)

$2\pi x$

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combine (2) & (3)

$$\frac{Gx}{a} = \tau_m \frac{2\pi x}{b}$$

$$\tau_m = \frac{G}{2\pi} \frac{b}{a}$$

$b \mp a$

max $\boxed{\tau_m = \frac{G}{2\pi}}$ (4)

For metals $G \sim$ 20 to 130 GPa

So (4) predicts

τ_m = 3 to 30 GPa

Actual single crystals

τ_m = 0.5 – 10 MPa

Theoretical is at least 100 × greater than observed strength

↳ therefore shearing planes not responsible for slip

↳ Concept of dislocations was proposed 1930's

Rest of Lecture is available in PowerPoint Presentation Paired with Lecture 12