Lecture 10

Tuesday, April 22, 2008
9:02 PM

Ref: G. Dieter, **Mechanical Metallurgy, 3rd Edition**, *McGraw-Hill*, 1986.

Course Notes:

1. Well, being new to UW I just learned about the Engineering College Open House on Friday
2. I know you are all going to be sad to hear this, but we are going to cancel class Friday in observance of the department tradition.
3. Your third Homework is still due.
4. We are just 1/3 of the way through the course.

Stress and Strain:

- OK up until now we have talked about atoms and how those atoms are arranged into crystalline solids
- We went through specific crystal structures
- Defects in crystals
- How we diffuse atoms from one location to another to change local composition
- We've been talking about really small things in particular detail

- Now we are going to change direction entirely
- We are going to approach the problem from the opposite side
- Instead of focusing on the trees, let's look at the forest

Let's play a thought experiment

- Lets say I take a round metal bar and I weld it to the wall here
- I then start applying force to it
- Well you might say what kind of force Bryan?
  - Am I pushing on it? Applying compression?
  - Am I pulling on it? Applying tension?
  - Am I bending it? Applying bending force?
  - Am I twisting it? Applying torsion

- I say …it doesn't really matter for the thought experiment….but lets say I'm pulling on it (applying a tensile force)
- So, let's say that I have unlimited strength and I can pull with any force level I want
- So I start pulling on the bar, slowly increasing the force that I pull with
- What will happen?
- Well…initially, not much -- I'm going to have to be stronger than the bar (and the weld)
- What happens when I start to pull really hard?

- What is really happening to the bar?
  - We know that the bar is composed of atoms.
  - That those atoms are bonded to one another.
  - We know that crystals are organized into some crystalline lattice
  - In fact we know there are many crystalline lattices which form polyhedral crystals.
  - We know that the bar has many crystals.
  - When we pull on the bar we will get a response from the crystals and we will get a response from the atoms themselves

- I will argue that only 3 things can happen:
  1. The bar can elastically deform -- it can change shape to accommodate the force that I was applying
     - What is happening? -- we are stretching the atomic bonds
     - If it is a truly elastic response, when I remove the applied force it will return to its original shape
  2. It can plastically deform -- the bar permanently deform and change its shape
     - What is happening then? -- the crystals are slipping and changing their shape
     - They are stretching

    - We are not creating bar…are we? We know that energy and matter cannot be created and destroyed -- merely converted from one form to another
    - So therefore we are moving atoms from one position within the crystals to another
3. The bar can crack and break (fracture)
    - The crystals can sever and break into two sections
    - We can create new surfaces and release the applied energy by doing so

- OK. So what factors were important in our bar experiment?
  - What would happen if the bar was made out of aluminum
  - What about titanium?
  - What about rubber?
  - What about ice cream?
- So clearly we have different responses for different materials

- OK. So what if the bar were 1 mm in diameter?
  - What if the bar was 10 feet in diameter?
  - What if the bar was square?
- So clearly the shape and size of the bar is important.

- OK. So what if I pulled faster?
  - What if I pulled really slowly?
  - What if I jerked on the bar?
  - What if the bar was pulled and released and then pulled again?
  - What if the bar was in an explosion?
  - Would it react the same?
- So, clearly the rate and type of force application is important too.

- What if it was really hot in here -- like approaching the melting temperature of the bar?
  - What if it was really cold in here?
  - What if the room was filled with water?
  - Would we get a different response?
- Maybe… environmental factors may play a role in our bar's response.

- So we perform a whole series of tests on our bar and we have this bar diagnosed.
  - We KNOW how this bar will respond to a variety of force applications and environments.
- Then somebody comes in the room and says can you make me another bar?
  - Well….I don't know. I mean I know how this bar works. But will another one be the same?
- What if he brings in another bar and asks if his bar is better?
- How are we going to compare bars?
- What if his bar is made of something else?
- What if we need 10,000 bars for to make a building?

- Clearly, if we want to make many bars that behave the same.
  - We are going to have to get some common terminology to describe behavior
  - We are going to have to be able to separate material behavior from geometrical behavior
  - We are going to need to diagnose on a very fine level what's going on.
  - We are going to have to develop some reproducible tests that show similar behavior for a specific type of material
  - So that we can compare bars and say whether one is good and another bad

What we are dealing with is **Mechanical Metallurgy**. It is the area of metallurgy that deals primarily with the response of metals to forces or applied loads.