Muddy Card Responses Lecture M16 3/02/2004

Synopsis. Reviewed prototypical stress-strain response of a material undergoing plastic deformation. Introduced concept of Hardness, related to yield strength. Analyzed necking in term of true-stress, true strain. Introduced concept of the ideal strength of a material resulting from the strength of the interatomic bonds. Introduced concept of dislocations, lattice defects that can move under the influence of shear stresses.

Knowing this that we can increase the plasticity by shear these interatomic bonds what advantage does that provide us with? Not quite sure what the question is asking, but I think that its is asking what the point of the next lecture is – i.e. to examine how we can improve the strength of a metal alloy by increasing the resistance to dislocation motion.

Can't access lecture notes on the web. My apologies. There does seem to be a problem. We will try to get it fixed.

If dislocation "slips" to a surface does it make it easier than to "open up" I would think if enough dislocations go then yes… (also a diagram) Yes, in fact this is one of the important ways in which cracks initiate in fatigue. See chapter 15 in Ashby and Jones.

How did you arrive at $\sigma_{ideal} \approx \frac{E}{10}$. See Ashby and Jones Chapter 9, beginning. Basically by making a scaling argument, that the shape of the bond force-displacement curve will scale with the peak force. This implies that the peak force is proportional to the stiffness of the bond. Putting in typical numbers for the force-displacement relationships give us $\sigma_{ideal} \approx \frac{E}{10}$. You should be aware of the idea of the ideal strength as an ultimate limit on the strength of materials, but I am not expecting a greater depth of knowledge here.

Didn't understand the hardness test. Doesn't A depend on the customed (?) and doesn't P depend on the test force? Then how is P/A dependent on the material. See A&J chapter 9 and chapter 11 for more on this. P is the test force and is chosen by the person doing the test. It turns out that for a given applied force and a given indenter shape the projected area of the indent has a unique relationship for the force applied, that is in turn linked to the yield stress. Hardness is therefore a material property (although it is not independent of the yield stress).

I'm a little confused by what the difference is between stiffness and strength. Stiffness is the constant of proportionality between a force and a displacement (at the structural level) or a stress and a strain (at the material level). A strength is the maximum load that a structure can carry or the maximum stress than a material can carry (without yielding (yield strength) or failing (ultimate tensile strength).

When compressing the clay you said that increasing friction makes it harder to compress, how can there be friction if the motion of the metal on the clay is perpendicular? Good question. The transverse force due to the friction resists the transverse deformation of the material that arises due to the conservation of volume under plastic deformation. This is similar to the problem set question you did last term when you looked at a thin adhesive layer between two stiff blocks. The Poisson contraction was suppressed, which led to a higher value of the axial strain than would have otherwise been the case.

For the hardness test is the indent area enclosed by the other rectangle or the area of the indented surface. Important point. It is usually defined as the projected area of the indent. This is true for the commonly used Vickers diamond indenter.

When discussing how to achieve some of the highest strengths you mentioned carbon nano-tubes and how they are coming the closest to reaching the upper predictions. Carbon nano-tubes are a matter of atomic packing and crystal structure, so doesn't this show the classes indecision between 1 and 5 on the PRS is very much justified. Since they both become important in achieving the upper strengths that are suggested by the strengths of the bonds. Fair enough. I would maintain that the packing is secondary to the strength of the bonds. In the case of a nanotube, the requirement for a particular crystal structure can lead to a defect free lattice, which allows the bond strength to be fully utilized. It is certainly true that defects in the crystal lattice (such as dislocations) are the main reason why materials do not have strengths approaching their ideal strength.

Muddy points: If you apply a shear stresss to a crystalline structure with 1 dislocation such that only 1 bond is broken or "flipped" between atoms, does that mean that the crystalline structure no longer undergoes a shear stress? (diagram also drawn). I did not intend to apply this. I drew the second diagram with the dislocation moved one atom spacing to the right, without any shear stress applied, to indicate that the deformation due to the dislocation is permanent, i.e. a permanent shear strain results. If the shear stress continues to be applied then the shear strain will continue to accumulate until something else happens.

Since melting point basically defines how much energy is needed to break a bond, and the forces applied can translate to energy add (?) (in the form of work instead of heat) why is melting point not a good judging criteria? Or does it just not say enough about the behavior. Your logic is good. Higher strength and stiffness materials typically have high melting temperatures for exactly this reason. In the context of the concept question I think that the bond strength is more directly related to the ideal strength than the melting temperature. Please remember that the concept questions are really intended to get you to think, rather than necessarily to come up with a particular answer, so I am very pleased to see that you have thought quite deeply about your response.

On the PRS, does the temperature (being a measure of how much energy a bond can absorb (right?) also affect the strength? Or because temperature is associated with random motion is it unrelated. You are absolutely right. See response above.

1 muddy card noted that class was too early. – but I am glad that you were there!

There were 8 muddy cards with no mud, or positive responses. Thank you