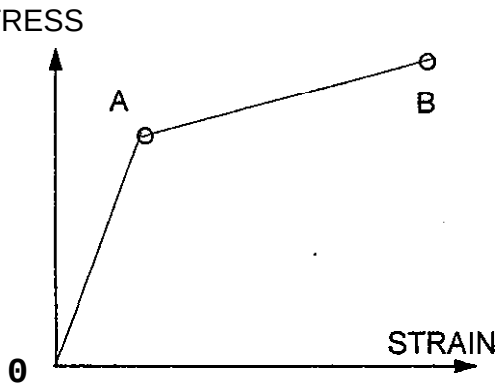
22.314/1.56/2.084/13.14 Fall 2006
Problem Set V

Due 10/19/06

This problem illustrates some "plastic strain" concepts and some calculation methods for treating plasticity.

Uniaxial Stress-Strain Information: Consider a material that has the uniaxial stress-strain curve (actually two straight lines) shown below. The first portion of the curve, a line from the origin to point A, has no plastic deformation. The second portion, a line from point A to point B, has both elastic and plastic deformation.



The elastic stress-strain behavior is characterized by a Young's Modulus of 195 GPa and a Poisson's ratio of 0.3.

Additional information about the uniaxial curve includes the stress at point A (150 MPa) and the (stress, strain) at point B (260 MPa, 0.54%).

Derived Properties: Using the above uniaxial stress-strain information, what is the 0.2% offset yield stress for this material? What is the plastic stress (σ_p) as a function of equivalent (strain-hardening) strain (ε_e)?

Loadina Sequences and Questions:

A three dimensional stress is applied in a proportional manner to a solid made of the above material until the following stress state (σa_{ij}) is reached (note that this state is 2.5 multiplied by the σa tensor of problem set #1):

$$\sigma a_{ij} = \begin{pmatrix} 137.5 & -12.5 & 75 \\ -12.5 & 137.5 & 75 \\ 75 & 75 & 50 \end{pmatrix}$$

where the stresses are given in MPa.

1) What is the deviatoric stress (Sa_{ij}) that corresponds to (σa_{ij})? What is the equivalent stress (σa_e) as evaluated by the following equation:

$$\sigma a_e = \sqrt{\frac{3}{2} Sa_{ij} Sa_{ij}} \ .$$

Show that this equivalent stress is equal to the previously defined "von Mises stress."

2) What strain tensors (elastic, mechanical, and total) exist when aa is reached?

The stress on the same solid is next proportionally reduced until zero stress remains.

3) What strain tensors (elastic, mechanical, and total) exist when zero stress is reached?

The same solid is subjected to a different proportional loading to reach the stress state (σb_{ij}), where:

$$\sigma b_{ij} = \begin{pmatrix} 260 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix} ;$$

where the stress is given in MPa.

4) What strain tensors (elastic, mechanical, and total) exist when σb is reached?

The stress is next proportionally reduced until zero stress remains.

5) What strain tensors (elastic, mechanical, and total) exist when zero stress is reached?