Session 8a: Homework – Basic Plasticity

Mentor Guide Knowledge & Skills Question

1.11 Define what is meant by "plasticity" and describe a typical stress-strain curve for a metallic, elastic-plastic material, including defining the proof stress and the ultimate tensile strength. Explain the difference between engineering stress and strain and true stress and strain.

Numerical Questions

1) A material's stress –strain curve is given by the Ramberg-Osgood equation

$$\varepsilon = \frac{\sigma}{E} + \left(\frac{\sigma}{A}\right)^n \equiv \varepsilon_e + \varepsilon_p$$

with E = 160 GPa, A = 1 GPa, and n = 5. What is the material's 0.2% proof strength?

2) A sample of the material in (1) is strained to 1000 με in uniaxial tension. What is the stress?

3) An elastic calculation has suggested that the elastic stress at a notch is 900 MPa. Given Neuber's principle, namely that the product of stress and strain is the same before and after yielding, find the actual stress and total (elastic-plastic) strain, assuming the material as in (1).

Plant Example:-

4) The superheater tailpipes at ***** convey the steam from the main boilers to the s/h penetrations, where it egresses the reactor. They are familiar from the homeworks for sessions 1 and 3. The elastic calculation of the outer fibre bending stress in those homeworks gave 251 MPa, well beyond the yield strength of the material. Fortunately the load is applied as a fixed rotation (displacement controlled) so the tailpipe does not fail, but rather it deforms plastically.

The material is described by a Ramberg-Osgood fit with E = 160 GPa and n = 5. Find the value of A which reproduces the correct lower bound 0.2% proof strength of 125 MPa.

The behaviour of the structure after yielding is described by an "elastic follow-up factor", Z, which is the ratio of the plastic strain to the decrease in the elastic strain upon yielding, $Z = \varepsilon_p / |\Delta\varepsilon_e|$, where $|\Delta\varepsilon_e| = (\sigma_e - \sigma)/E$, and $\sigma_e = 251 MPa$ is the elastically calculated stress, and σ is the actual stress after yielding. Given that $Z = 3$ find the stress after yielding, and the elastic and plastic strains.