T73S04 Session 36 Homework
Last Update 5/12/12

Mentor Guide Questions

1.51 Describe the metallurgical mechanisms underlying creep deformation and creep failure.

Numerical Questions

1) Suppose a material exhibits only secondary creep at a rate given by the Norton law $\dot{\bar{\varepsilon}} = A\bar{\sigma}^n$ (noting that this gives the Mises equivalent creep strain rate in terms of the Mises equivalent stress). Also suppose that it has been found that the time to rupture, under constant stress conditions, depends mostly on a function of maximum principal stress, $f(\sigma_1)$, but also shows a dependence upon Mises stress and hydrostatic stress so that the fitted rupture equation is,

$$t_{rup} = \bar{\sigma}^{-\alpha}\sigma_H^{-\beta} f(\sigma_1) \tag{1}$$

Show that the ratio of the multi-axial creep ductility to the uniaxial creep ductility when both have maximum principal stress σ_1 is,

$$\frac{\bar{\varepsilon}_{f,multi}}{\bar{\varepsilon}_{f,uni}} = \left(\frac{\bar{\sigma}}{\sigma_1}\right)^{n-\alpha}\left(\frac{3\sigma_H}{\sigma_1}\right)^{-\beta} \tag{2}$$

noting that the ductility is defined as the Mises equivalent creep strain at failure.

2) If $n = 4$, $\alpha = 2$ and $\beta = 1$, and if the three principal stresses are 200 MPa, 100 MPa and 60 MPa, find the ductility ratio.

3) If the material obeyed a primary creep law $\bar{\varepsilon}_c = A\bar{\sigma}^n t^m$ all the way to failure, derive the equivalent of (2) and find its numerical value for the example of Qu.(2) if $m = 0.5$.

4) Prove that the elastic follow-up factor for the plastic strain near a notch is,

$$Z = \frac{2-x}{1-x} \tag{3}$$

assuming Neuber applies. Here,

$$x = \frac{\sigma_{el} - \sigma_{ep}}{\sigma_{el}} \tag{4}$$

where σ_{el} is the stress which would occur at the point if the material remained elastic, and σ_{ep} is the actual, elastic-plastic, stress. In this context, the elastic follow-up factor is defined as,

$$Z = \frac{E\varepsilon_p}{\sigma_{el} - \sigma_{ep}} \tag{5}$$