MT253:Analysis of neck initiation

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Let us assume that the material follows the following constitutive equation.

$$\sigma = C' \epsilon^n \dot{\epsilon}^m$$

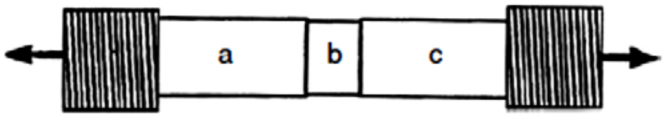

Figure 1: Stepped Tensile Specimen

Following the same procedure as we have done in class, we get,

$$\begin{aligned} \sigma_a A_a &= \sigma_b A_b \\ C' \epsilon_a^n \dot{\epsilon_a}^m A_{o,a} \exp(-\epsilon_a) &= C' \epsilon_b^n \dot{\epsilon_b}^m A_{o,b} \exp(-\epsilon_b) \\ \left(\frac{\dot{\epsilon_a}}{\dot{\epsilon_b}}\right)^m &= \underbrace{\frac{A_{o,b}}{A_{o,a}}}_{f} \times \exp(\epsilon_a - \epsilon_b) \times \left(\frac{\epsilon_a}{\epsilon_b}\right)^n \end{aligned}$$

For simplifying, we consider

$$\frac{\dot{\epsilon_a}}{\dot{\epsilon_b}} = \frac{d\epsilon_a}{d\epsilon_b}$$

And thus we have solve the differential equation

$$\frac{d\epsilon_a}{d\epsilon_b} = f^{1/m} \times \exp(\frac{\epsilon_a - \epsilon_b}{m}) \times \left(\frac{\epsilon_a}{\epsilon_b}\right)^{n/m}$$

with the initial condition $\epsilon_b = \epsilon_a \to 0$ as we cant put the condition $\epsilon_a = 0$ which comes in the denominator. Solving the above equation in matlab, we get the following the plots.

- From figure 2, we see that higher the m, higher the strain to failure.

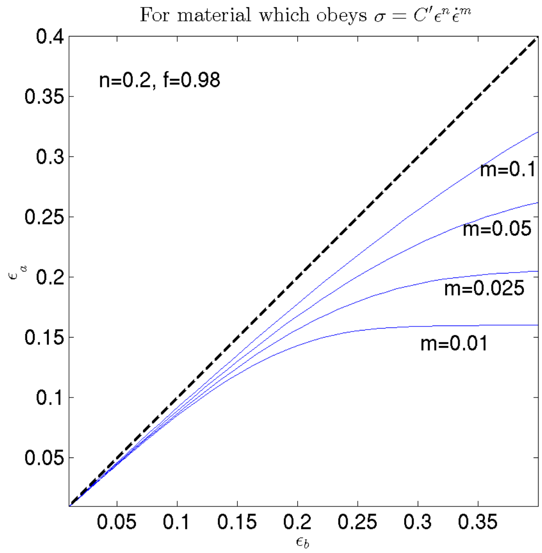

Figure 2: Effect of m

- From figure 3, we see that higher the n, higher the strain to failure.
- From figure 4, we see that higher the f (close to 1), higher the strain to failure.
- It should be noted that , the saturation region represents that , at constant applied stress, the material undergoes failure. Hence the beginning of the saturation region is the failure strain.
- From the figures, it can be seen that the failure occur strain more than, what is predicted from consider'e criterion $\epsilon = n$. (particularly in figure 3)

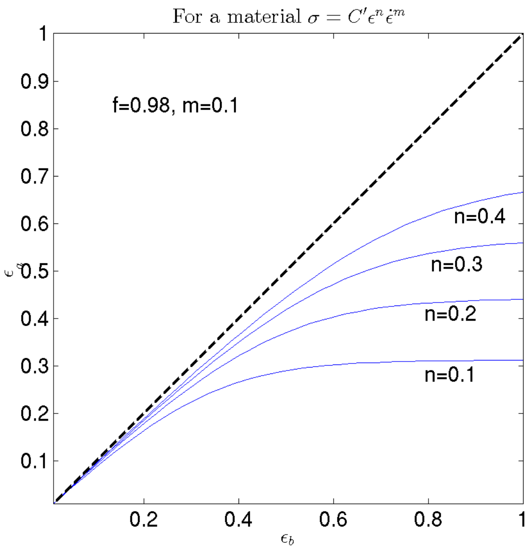

Figure 3: Effect of n

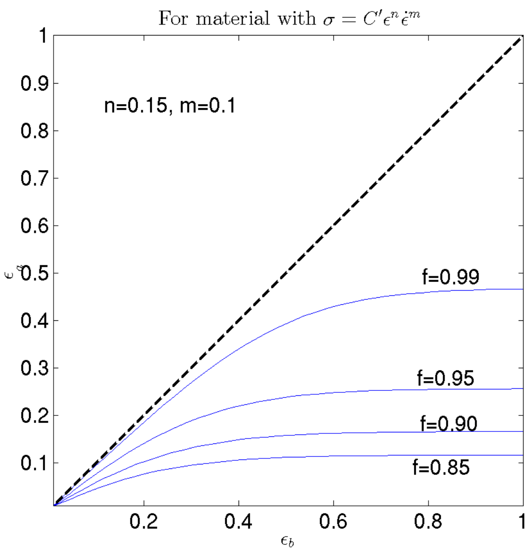

Figure 4: Effect of f