Q) A cylindrical test specimen 25mm in diameter and 200mm long is subjected to a tension test and fractured at 20000N. Percent reduction in cross-sectional area at fracture is 48. Assuming no volume change in the material during testing, calculate:

a) The final cross-sectional area ($A_i$),

b) The Engineering $\varepsilon_{Eng}$ and True $\varepsilon_{True}$ strains at fracture, and

c) The Engineering $\sigma_{Eng}$ and True $\sigma_{True}$ stresses at fracture,

Solution:

$D_0 = 25\text{mm}$, $l_0 = 200\text{mm}$, $P = 20000\text{N}$ (tension)

If there is no volume change: $A_0 \times l_0 = A_i \times l_i$

$$\frac{li}{lo} = \frac{Ao}{Ai}$$

a) \(\frac{\Delta A}{Ao} \times 100 = 48\) \(Ao = \frac{\pi D^2}{4} = 490.87\text{mm}^2\)

\(490.87 - Ai = 490.87 \times \frac{48}{100}\)

So $Ai = 255.25\text{mm}^2$

b) \(\varepsilon_{Eng} = \frac{\Delta l}{lo} = \frac{li - lo}{lo} = \frac{li}{lo} - 1 = \frac{Ao}{Ai} - 1\)

\(\varepsilon_{Eng} = \frac{255.25}{490.87} - 1 = 0.923\)

\(\varepsilon_{True} = \ln \left( \frac{li}{lo} \right) = \ln \left( \frac{Ao}{Ai} \right) = \ln \left( \frac{490.87}{255.25} \right) = 0.653\)

b) 1) \(\sigma_{Eng} = \frac{F}{Ao} = \frac{20000}{490.87} \approx 40.74\text{MPa}\)

2) \(\sigma_{Eng} = \frac{F}{Ai} = \frac{20000}{255.25} \approx 78.25\text{MPa}\)