Example
Plastic Material Deformation

A cylindrical specimen of steel having an original diameter of 12.8 mm is tested in uniaxial tension to fracture. An engineering tensile fracture strength of 460 MPa and cross-sectional diameter of 10.7 mm is reported at fracture. In groups of 2-3, determine:

a) the true stress at fracture

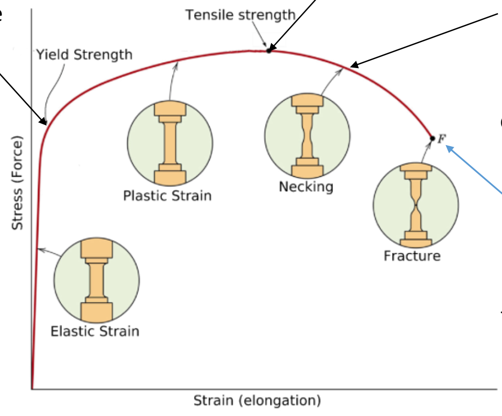
b) the true strain at fracture

Step 1: Schematic

Between yield and tensile strength, use True Engineering Stress-Strain relations because cross-sectional changes are significant

Use Engineering Stress-Strain up to yield because of negligible changes in cross-sectional area

Once necking has occurred, use measured cross-sections to calculate Stress and Strain



In our case, an Engineering tensile fracture strength of 460 MPa is given and we need to find the True Stress

Step 2: Calculate Force at Failure

- Definition of True Stress is

$$\sigma_T = \frac{F}{A_i}$$

Force. We need to find this.

Instantaneous area. We have measured this at failure (given).

- Force at failure using the Engineering equation
  - We were given Engineering tensile fracture strength

Area original diameter of 12.8 mm

$$F = \sigma_F A_o = \frac{460 \times 10^6 \,{}^{N}/_{m^2}\ (128.7\ mm^2)}{10^6\ {}^{mm^2}/_{m^2}}$$

$$= 59{,}200\ N$$

Step 3: Calculate True Stress

- Using the Force and the necked diameter at failure

$$\sigma_T = \frac{F}{A_i} = \frac{59{,}200\ N}{89.9\ mm^2}\ 10^6\ {}^{mm^2}/_{m^2}$$

$$= 660\ MPa$$

Area fractured diameter of 10.7 mm

- We can't use the True Stress equation $\sigma_T = \sigma(1+\varepsilon)$ because our material was tested beyond necking
- If the Engineering Tensile Strength was given instead of the Engineering Tensile <u>Fracture</u> Strength was given, we could have used the True Stress relationship $\sigma_T = \sigma(1+\varepsilon)$ before necking