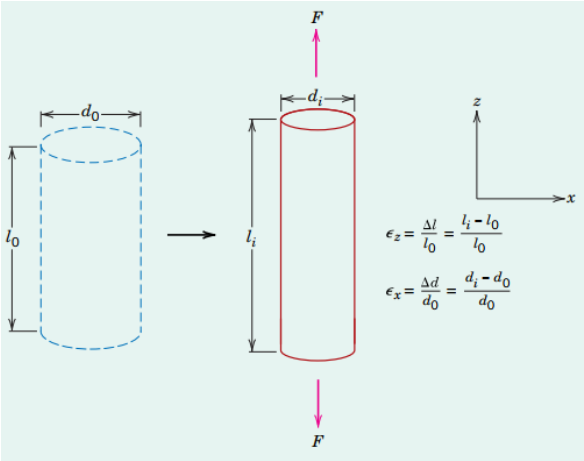
1. A tensile stress is to be applied along the long axis of a cylindrical brass rod that has a diameter of 10 mm. Determine the magnitude of the load required to produce a 2.5×10^{-3} mm change in diameter if the deformation is entirely elastic. Poisson's ratio for brass is 0.34, and the modulus of elasticity is 97 GPa.

Solution:



For the strain in the x direction,

$$\varepsilon_x = \frac{\Delta d}{d_0} = \frac{-2.5\times10^{-3}\,\text{mm}}{10\,\text{mm}} = -2.5\times10^{-4}$$

$$\varepsilon_z = -\frac{\varepsilon_x}{\nu} = -\frac{\left(-2.5\times10^{-4}\right)}{0.34} = 7.35\times10^{-4}$$

$$\sigma = \varepsilon_z E = 7.35\times10^{-4}\cdot 97\times10^{3}\,\text{MPa} = 71.3\,\text{MPa}$$

$$F = \sigma A_0 = \sigma\left(\frac{d_0}{2}\right)^2\pi = 71.3\times10^{6}\,\text{N/m}^2\times\left(\frac{10\times10^{-3}\,\text{m}}{2}\right)^2\pi = 5600\,\text{N}$$

2. For a brass alloy, the stress at which plastic deformation begins is 275 MPa, and the modulus of elasticity is 115 GPa.
(a) What is the maximum load that can be applied to a specimen with a cross-sectional area of 325 mm^2 without plastic deformation?
(b) If the original specimen length is 115 mm, what is the maximum length to which it can be stretched without causing plastic deformation?

Solution:

(a) $F_{max} = \sigma A_0 = 275\times10^6\,\mathrm{N/m^2}\times325\times10^{-6}\,\mathrm{m^2} = 89375\mathrm{N}$

(b) $E = \dfrac{\sigma}{\varepsilon} = \dfrac{\sigma}{\dfrac{l_i - l_0}{l_0}}$

$$l_i = l_0\left(1+\frac{\sigma}{E}\right) = 115\mathrm{mm}\cdot\left(1+\frac{275\mathrm{MPa}}{115\times10^3\,\mathrm{MPa}}\right) = 115.26\mathrm{mm}$$