Chapter 2

Properties of Engineering Materials

1- What is the stress in a wire whose diameter is 1 mm, which supports a load of 100 Newton

Solution:

$$\sigma = \frac{\text{load}}{\text{area}} = \frac{100}{\frac{\pi}{4}\left(\frac{1}{1000}\right)^2} = \frac{400}{\pi}(1000)^2 = 127 \quad \text{MPa}$$

$$= 127 \text{ N/mm}^2$$

2- Suppose that the wire in the above problem is cupper and is 30 m long. How much will it stretch? Repeat for a steel and aluminum wires

Solution:

Cu wire:

$$\varepsilon = \frac{\sigma}{E} = \frac{127000000}{10x10^{10}}$$

Total elongation for copper wire (Δl_{cu})

Since $\varepsilon = \frac{\Delta l}{l}$

$$\Delta l_{cu} = \varepsilon x l = \frac{127000000}{10x10^{10}} x30 = 0.038 \quad \text{m} \quad =38 \text{ mm}$$

Steel wire:

$$\varepsilon = \frac{\sigma}{E} = \frac{127000000}{21x10^{10}}$$

Total elongation for copper wire (Δl_{st})

Since $\varepsilon = \frac{\Delta l}{l}$

$$\Delta l_{st} = \varepsilon x l = \frac{127000000}{21x10^{10}} x30 = 0.018 \quad \text{m} \quad =18 \text{ mm}$$

Aluminum wire:

$$\varepsilon = \frac{\sigma}{E} = \frac{127000000}{7x10^{10}}$$

Total elongation for copper wire (Δl_{al})

Since $\varepsilon = \frac{\Delta l}{l}$

$$\Delta l_{al} = \varepsilon x l = \frac{127000000}{7x10^{10}} x30 = 0.054 \quad m \quad =54 \text{ mm}$$

Comment: Steel is stiffer than both cupper and aluminum. It is exactly 3 times more stiff than aluminum

3- Estimate the HB hardness of an alloy steel of ultimate tensile strength TS=1500 MPa using equation 2.9. Use the hardness conversion table to determine the HRC hardness.

Solution:

TS (MPa) = 3.5 HB

$$HB = \frac{1500}{3.5} = 428$$

Using the conversion table 2.3, the corresponding HRC of that alloy steel = 46

Referring to Figure 2.5 the hardness values are realized.

4- A constructional component made of Al-alloy can be represented as a bar of diameter 20 mm and length 400 mm is subjected to pure tension; calculate:

a- Extension of the bar if the imposed load= 8 kN

b-The load at which the bar suffers permanent deformation

c- Maximum load the bar can withstand fracture

Assume the following mechanical properties: E=70 GPa, YS=496 MPa, TS=560 MPa

Solution:

a- $$A_o = \frac{\pi x 20^2}{4} = 314 \quad mm^2$$

$$\text{Imposed tensile strength} = \frac{80000}{314} = 255 \quad N/mm^2$$

$$= 255 \quad MPa$$

It is thus less than the YS, which means that the deformation will be purly elastic.

b- $$YS = \sigma_{0.2} = 496 \quad N/mm^2$$

$$F_y = \sigma_{0.2} x A_o = 496 \text{ x } 314 = 156 \quad kN$$

c- $$F_{max} = TSxA_o = 560 \text{ x } 314 = 176 \quad kN$$