Senami Hodonu HW#3 01/25/2023

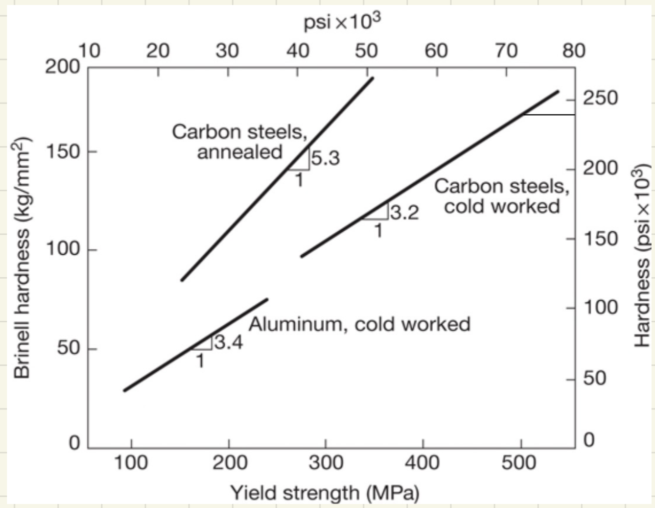
2.60 What is the modulus of resilience of a highly cold-worked piece of steel with a hardness of 280 HB? Of a piece of highly cold-worked copper with a hardness of 175 HB?

Given: i) Steel with hardness of 280 HB (398×10^3 psi)

ii) copper with hardness of 175 HB (245×10^3 psi)

find: Modulus of resilience of the given materials?

HB – Brinell hardness (kg/mm^2)



From eqn (2.31) $\quad$ Hardness $= c\,S_y$

where c = proportionality constant
S_y = yield Strength

and from eqn (2.5)

$$\text{Modulus of resilience} = \frac{S_y^2}{2E}$$

from eqn (2.31) $S_y = \dfrac{\text{Hardness}}{c}$

$$\text{so} \quad \text{Modulus of resilience} = \frac{\left(\frac{\text{Hardness}}{c}\right)^2}{2E}$$

for highly cold-worked steel,

$E = 200$ GPa

According to Eq (2.31) and c is approximately 3.2 (figure 2.22)

$$\text{modulus of resilience} = \left(\frac{280}{3.2}\,kg/mm^2 * \frac{9.806\,MPa}{1\,kg/mm^2} * \frac{10^6\,Pa}{MPa}\right)^2 \Big/ (2 * 200 * 10^9\,Pa)$$

$$= 1.84 * 10^6\ Nm/m^3$$

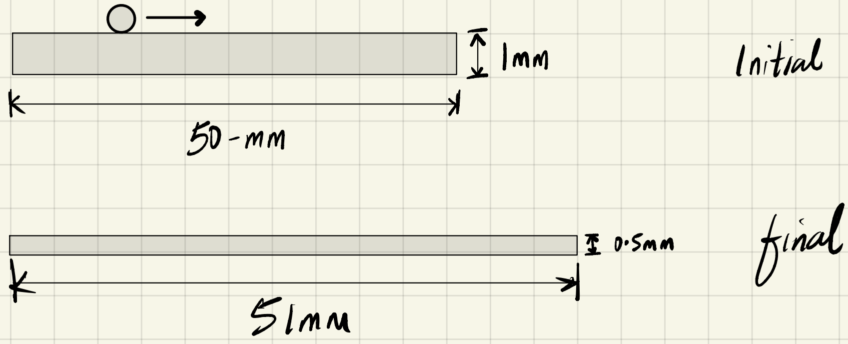
for highly cold-worked copper, c is approximately 3.3

$E = 124$ GPa

$$\text{modulus of resilience} = \frac{\left(\frac{175}{3.3} \times 9.806 \times 10^6\right)^2}{2(124 \times 10^9)} = 1.09 \times 10^6\ Nm/m^3$$

2.87 A 50-mm-wide, 1-mm-thick strip is rolled to a final thickness of 0.5 mm. It is noted that the strip has increased in width to 51 mm. What is the strain in the rolling direction?

Given:



find:

Strain in the rolling direction?

In the plastic range, where $\nu = 0.5$, the volume change is zero. Thus, in plastic working of metals,

(2.49) $$\epsilon_1 + \epsilon_2 + \epsilon_3 = 0$$

true strain, $\epsilon = \ln\left(\frac{l}{l_0}\right)$ eqn (2.9)

$$\epsilon_1 = \ln\left(\frac{51}{50}\right) = 0.0198$$

$$\epsilon_2 = \ln\left(\frac{0.5}{1}\right) = -0.6931$$

from eqn (2.49)

$$0.0198 + (-0.6931) + \epsilon_3 = 0$$

$$\epsilon_3 = -0.6733$$

2.88 An aluminum alloy yields at a stress of 50 MPa in uniaxial tension. If this material is subjected to the stresses $\sigma_1 = 25$ MPa, $\sigma_2 = 15$ MPa, and $\sigma_3 = -26$ MPa, will it yield? Explain.

Given: Aluminum alloy, $S_y = 50 MPa$ in uniaxial tension

material is subjected to $\sigma_1 = 25 MPa$, $\sigma_2 = 15 MPa$ and $\sigma_3 = -26 MPa$

Using the distortion-energy criterion eq (2.53)

the effective stress, $\bar{\sigma} = \frac{1}{\sqrt{2}}\left[(\sigma_1-\sigma_2)^2+(\sigma_2-\sigma_3)^2+(\sigma_3-\sigma_1)^2\right]^{1/2}$

$$\bar{\sigma} = \frac{1}{\sqrt{2}}\left[(25-15)^2+(15-(-26))^2+(-26-25)^2\right]^{1/2}$$

$$\bar{\sigma} = 46.8081 MPa$$

Since $\bar{\sigma}$ is less that the unixial yield stress, $S_y = 50 MPa$, the calculation suggests that, the material will not yield.

Also, according to the maximum-shear-stress-criterion,

$$\sigma_{max} - \sigma_{min} = S_y \qquad eqn (2.38)$$

$\sigma_{max} = 25 MPa$

$\sigma_{min} = -26 MPa$

Therefore, $25MPa - (-26MPa) = 51 MPa$

This result suggests that the material will fail since $51MPa > 50MPa$.

Verdict: It will be hard to tell and other tests should be carried out for confirmation since the maximum-shear-stress criterion and the distortion energy criterion produce conflicting results.

2.100 Estimate the depth of penetration in a Brinell hardness test using 500 kg as the load when the sample is a cold-worked aluminum with a yield strength of 150 MPa.

Given: 500 kg load

$S_y = 150 MPa$

Find: Estimate the depth of penetration

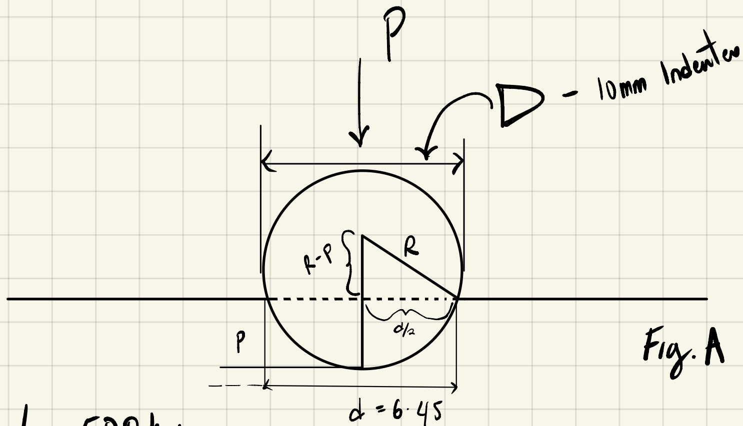


Fig. A

Load = 500 kg

Force acting on the Indenter would be

$P = 500kg * 9.81 m/s$

$P = 4905 N$

Using eqn (2.8) $\sigma = \frac{P}{A}$

$$150 MPa = \frac{4905 N}{\pi \frac{d^2}{4}}$$

$$1.5 \times 10^8 N/m^2 = \frac{4905 N * 4}{\pi d^2}$$

$$d^2 = \left(\frac{4905 N * 4}{(1.5 \times 10^8)\pi}\right)^{1/2}$$

$$d = 0.0065 m = 6.5 mm$$

Using a 10mm steel Indenter (ie D = 10mm)

in Figure A above.

$D = 10mm$, $R = 10mm/2 = 5mm$

$d = 6.5mm$

using pythagoras theorem, we can solve for $R-p$

$$5^2 = (R-p)^2 + (6.5/2)^2$$

$$R-p = \left(5^2 - \left(\frac{6.5}{2}\right)^2\right)^{1/2}$$

$$R-p = 3.7997$$

$$p = R - 3.7997$$

$$p = 5 - 3.7997 = 1.2\,mm \quad *$$