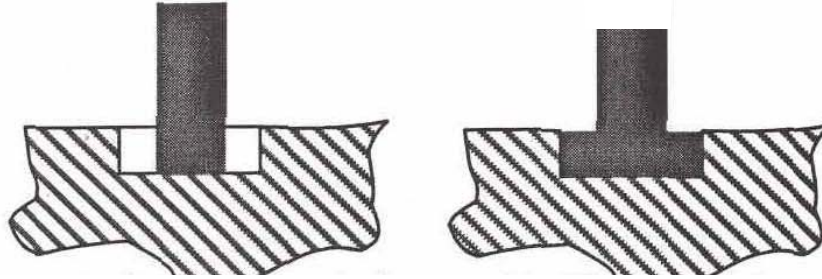


Question 1:

Consider the heading operation shown below. An aluminum rod of 0.3 inch diameter is deformed to 0.375 inch diameter. The final height of the head is 0.25 inch. Assume a coefficient of friction at the die of 0.4. The material stress-strain relationship is:

$$\sigma = 5000 + 20000 \varepsilon^{0.2} \text{ psi}$$



- i- Determine the force applied when the head diameter is 0.375 inch.
- ii- What is the work required to complete this operation?

Question 2:

- (a) Briefly explain why HCP metals are typically more brittle than FCC and BCC metals.
- (b) Does plastic deformation of polycrystalline materials occur at stresses that are equal to the theoretical strength of their perfect crystals? Why?

Question 3:

A 0.5 m wide sheet of 5052-O aluminum ($K = 210 \text{ MPa}$ and $n = 0.13$) is reduced in thickness from 6 mm to 4 mm in two passes through a rolling mill. The thickness is reduced 1.0 mm during each pass. The roll diameter is 250 mm. The initial sheet is 1 m long. Assuming the friction is insignificant,

- (a) estimate the rolling force on the first pass.
- (b) estimate the rolling force on the second pass.
- (c) estimate the length of the 4 mm thick sheet.

Question 4:

i- An AISI 1015 steel slab of $h_o = 300 \text{ mm}$ thickness and $w_o = 1000 \text{ mm}$ width is hot rolled at 1000°C on a mill with rolls of diameter 600 mm. The presence of scale reduces friction to $\mu = 0.3$. A reduction of 27 mm is taken. Roll speed is 1.2 m/s. Calculate roll force and power requirement.

ii- After hot rolling the material is cold rolled on a mill of roll diameter 400 mm at speed of 700 m/min. Calculate the force and power requirement for rolling from 1.0 mm to 0.6 mm, if a lubricant reduces the coefficient of friction to 0.05.

(Hint: for AISI 1015 steel $C = 120$ MPa, $m = 0.1$, $K = 620$ MPa and $n = 0.18$)

Question 5:

A metal is deformed in a tension test into its plastic region. The starting specimen had a gage length = 2.0 in and an area = 0.50 in². At one point in the tensile test, the gage length = 2.5 in and the corresponding engineering stress = 24,000 lb/in²; and at another point in the test prior to necking, the gage length = 3.2 in and the corresponding engineering stress = 28,000 lb/in². Determine the strength coefficient and the strain hardening exponent for this metal.

Question 6:

With appropriate sketches, explain the rolling defects.