B.E. PRODUCTION ENGINEERING
THIRD YEAR SECOND SEMESTER EXAM 2025

METAL FORMING

Time: 3 hours | Full Marks: 100

Answer any FIVE questions

All parts of a question (a, b, etc.) should be answered a one place.

GROUP – A

1. (a) State Von Mises' maximum distortion energy criterion and show that

$$(\sigma_1 - \sigma_2)^2 + (\sigma_2 - \sigma_3)^2 + (\sigma_3 - \sigma_1)^2 = 2\sigma_{y.p.}^2$$

where σ_1, σ_2, and σ_3 are the principal stresses and $\sigma_{y.p}$ is the tensile yield stress.

(b) Show that at the point of necking,

$$\frac{d\sigma}{d\varepsilon} = \sigma \quad \text{and} \quad \frac{d\sigma}{d\phi} = S$$

where σ = true stress, ε = true strain
and S = engg. stress, φ = engg. strain.

10+10

2. (a) Derive the following expression for cylindrical wire or rod drawing, clearly stating the different assumptions

$$\frac{\sigma_d}{\bar{\sigma}_{yp}} = \frac{1+B}{B}\left[1-(1-r)^B\right] \quad \text{Where } B = \mu \cot a$$

σ_d = drawing stress
$\bar{\sigma}_{yp}$ = average yield stress
μ = coefficient of friction
r = fractional reduction of area
α = semi-die angle

(b) A bar of material has a stress-strain curve given by $\sigma = 50\varepsilon^{0.5}$, where σ is in tons per sq. inch. Such a bar, which has already received an engineering tensile strain of 0.25, is to be pulled in tension until it begins to neck. What further engineering strain may be expected?

(c) What is the flow rule? Write down the expression for flow stress and flow strain.

10+6+4

3. (a) Describe the variation of extrusion force with respect to punch displacement in the case of forward and inverted extrusion.

(b) Discuss various extrusion defects.

(c)The following equation expresses the pressure for the extrusion of an aluminum bar:

$$p = \sigma_0(0.47 + 1.2\ln R)e^{4\mu L/D}$$

Billets 200 mm in diameter and 400mm long are extruded into 19mm diameter bars. In order to increase the length of the product by 3m, would it be more economical in terms of pressure to increase the billet length or the diameter? (Assume μ =0.1)

5+5+10

4. (a) Describe three high rolling mill and discuss its advantages.

(c) Determine the roll pressure for strip rolling, indicating the assumptions used in the method of roll pressure evaluation.

(d) Sketch a roll pressure versus angular coordinate curve. Why does the peak pressure at the neutral point decrease with an increase in back and front tension? Explain why the neutral point shifts towards the entry end with an increase in front and back tension.

3+12+5

5. (a) Derive expressions for pressure distribution in the forging of a strip, considering both sliding and sticking friction.

(b) A 20 mm x 20 mm x 160 mm copper plate is forged between two flat dies to a final size of 10 mm x 40 mm x 160 mm. The coefficient of friction is 0.2, and the tensile yield stress of copper can be taken as 70 N/mm^2. Determine the peak forging force

(i) Assuming no strain hardening.

(ii) Assuming the strain hardening characteristics for copper as

$\sigma_y = 70 + 30\varepsilon^{0.33}$ N/mm^2

10+10

6 (a) Derive an expression for the deep drawing force. Indicate the assumptions.

(b) A cold-rolled steel cup with an inside radius of 30 mm and a thickness of 3 mm is to be drawn from a blank of radius 40 mm. The shear yield stress and

the maximum allowable stress of the material can be taken as 210 N/mm^2 and 600 N/mm^2, respectively.

i) Determine the drawing force, assuming that the coefficient of friction μ = 0.1 and β = 0.05.

ii) Determine the minimum possible radius of the cup that can be drawn from the given blank without causing a fracture.

10+10

7. (a) Derive expressions for pressure distribution in the forging of a cylindrical disc, considering both sliding and sticking friction.

(b) A circular disc of lead of radius 150 mm and thickness 50 mm is reduced to a thickness of 25 mm by open die forging. If the coefficient of friction between the job and the die is 0.25, determine the maximum forging force. The average shear yield stress of lead can be taken as 4 N/mm2.

10+10

8. (a) What are the main features of High Energy Rate Forming (H.E.R.F.)? Describe electrohydraulic forming.

(b) What is strain hardening? Write down the reasons for strain hardening.

(c) What is recrystallization temperature?

(d) Discuss the adverse and beneficial effects of friction.

(e) Discuss how center bursting may occur in the bar drawing operation.

6+3+3+5+3