



MACHAKOS UNIVERSITY

University Examinations for 2020/2021 Academic Year

SCHOOL OF ENGINEERING AND TECHNOLOGY

DEPARTMENT OF MECHANICAL AND MANUFACTURING ENGINEERING

FIFTH YEAR SPECIAL/SUPPLEMENTARY EXAMINATION FOR

BACHELOR OF SCIENCE (MECHANICAL ENGINEERING)

EMM 504: THEORY OF PRODUCTION PROCESSES

DATE: 26/3/2021

TIME: 2.00-4.00 PM

INSTRUCTIONS

- This paper contains FIVE questions
- Question ONE is compulsory and carries 30 Marks while the rest (Questions TWO – FIVE) carries 20 Marks each

QUESTIONS ONE (30 MARKS)

- Using relevant diagrams and equations, explain the difference between engineering stress and true stress in a tensile test. (4 marks)
- Describe the three basic forms of stress–strain relationship that describe the behavior of nearly all types of solid materials (6 marks)
- A shaft is subjected to a maximum bending torque of 10 KNm and a maximum bending moment of 7.5 KNm at a particular section, if the allowable equivalent stress in simple tension is 160 MPa, determine the diameter of the shaft according to von-mises yield criterion and compare the answer with that obtained using Tresca's yield criterion. (10 marks)
- Give four reasons why friction is generally undesirable in metal forming operations (4 marks)
- Indicate the mathematical equation for the flow curve (1 mark)
 - How does increasing temperature affect the parameters in the flow curve equation? (1 mark)
- Indicate some of the advantages of cold working relative to warm and hot working (4 marks)

QUESTION TWO (20 MARKS)

- a) An element in plane stress is subjected to stresses $\sigma_x = 84 \text{ Mpa}$, $\sigma_y = -30 \text{ Mpa}$ and $\tau_{xy} = -32 \text{ Mpa}$.
- (i) determine the principal stresses and show them on a sketch of a properly oriented element (5 marks)
 - (ii) determine the maximum shear stresses and show them on a sketch of a properly oriented element. (3 marks)
- b) A single-pass rolling operation reduces a 20 mm thick plate to 18 mm. The starting plate is 200 mm wide. Roll radius = 250 mm and rotational speed = 12 rev/min. The work material has a strength coefficient = 600 MPa and a strength coefficient = 0.22. Determine:
- i. roll force, (3 marks)
 - ii. roll torque, and (3 marks)
 - iii. power required for this operation. (2 marks)
- c) Name any two products that are produced by extrusion. (2 marks)
- d) What are the two basic types of forging equipment? (2 marks)

QUESTIONS THREE (20 MARKS)

- a) What are the reasons why the bulk deformation processes are important commercially and technologically? (3 marks)
- b) A 40 mm thick plate is to be reduced to 30 mm in one pass in a rolling operation. Entrance speed = 16 m/min. Roll radius = 300 mm, and rotational speed = 18.5 rev/min. Determine:
- i. the minimum required coefficient of friction that would make this rolling operation possible, (2 marks)
 - ii. exit velocity under the assumption that the plate widens by 2% during the operation, and (2 marks)
 - iii. forward slip. (1 marks)
- c) Distinguish between direct and indirect extrusion. (6 marks)
- d) A hot upset forging operation is performed in an open die. The initial size of the workpart is: $D_o = 25 \text{ mm}$, and $h_o = 50 \text{ mm}$. The part is upset to a diameter = 50 mm. The work metal at this elevated temperature yields at 85 MPa ($n = 0$). Coefficient of friction at the die -work interface = 0.40. Determine:
- i. final height of the part, and (3 marks)
 - ii. maximum force in the operation. (3 marks)

QUESTIONS FOUR (20 MARKS)

- a) A cylindrical billet that is 100 mm long and 40 mm in diameter is reduced by indirect (backward) extrusion to a 15 mm diameter. Die angle = 90° . If the Johnson equation has $a = 0.8$ and $b = 1.5$, and the flow curve for the work metal has $K = 750$ MPa and $n = 0.15$, determine: (a) extrusion ratio, (b) true strain (homogeneous deformation), (c) extrusion strain, (d) ram pressure, and (e) ram force. (6 marks)
- b) Wire of starting diameter = 3.0 mm is drawn to 2.5 mm in a die with entrance angle = 15° degrees. Coefficient of friction at the work-die interface = 0.07. For the work metal, $K = 500$ MPa and $n = 0.30$. Determine:
- area reduction, (1½ marks)
 - draw stress, and (3 marks)
 - draw force required for the operation. (1½ marks)
- c) What is spring-back in sheet metal bending? (2 marks)
- d) A cylindrical workpiece 125 mm in diameter and 900 mm long is to be turned in an engine lathe. Cutting conditions are: $v = 2.5$ m/s, $f = 0.3$ mm/rev, and $d = 2.0$ mm. Determine:
- Cutting time (2 marks)
 - Metal removal rate. (2 marks)
- e) What are some of the possible defects in drawn sheet metal parts? (2 marks)

QUESTION FIVE (20 MARKS)

- a) What are some of the simple measures used to assess the feasibility of a proposed cup drawing operation? (3 marks)
- b) A sheet-metal blank is to be bent as shown in Figure Q5b. The metal has a modulus of elasticity = $205 (10^3)$ MPa, yield strength = 275 MPa, and tensile strength = 450 MPa. Determine;
- the starting blank size and (3 marks)
 - the bending force if a V-die is used with a dieopening dimension = 25 mm. (2 marks)

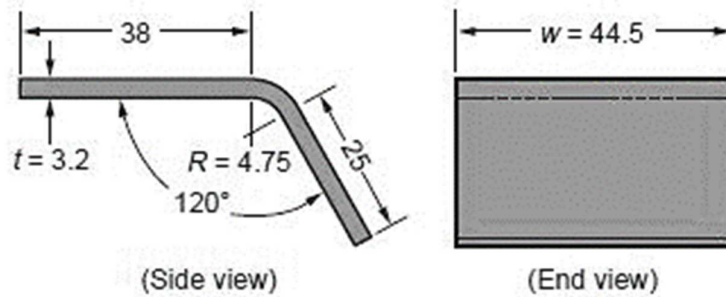


Figure Q5b

- c) Turning is performed on a work material with shear strength of 250 MPa. The cutting tool has a rake angle of 7° in the direction of chip flow. The width(w) of the orthogonal cutting operation is 3mm and the chip thickness before the cut is 0.2mm. The resulting chip ratio = 0.5. Using the orthogonal model as an approximation of turning, determine:
- the shear plane angle; (1½ marks)
 - the shear force; (1½ marks)
 - cutting force and feed force. (3 marks)
- d) Tool life tests in turning yield the following data: (1) $v = 100$ m/min, $T = 10$ min; (2) $v = 75$ m/min, $T = 30$ min.
- Determine the n and C values in the Taylor tool life equation. (2 marks)
- Based on your equation, compute
- the tool life for a speed of 90 m/min (2 marks)
 - the speed corresponding to a tool life of 20 min. (2 marks)