Ref. No.: Ex/ME(M2)/PC/B/T/413/2024

B.E. MECHANICAL ENGINEERING FOURTH YEAR FIRST SEMESTER EXAM 2024

SUBJECT: METAL CUTTING AND MACHINE TOOLS

Time: 3 Hours **Full Marks: 100**

Assume any relevant data, if necessary. Symbols in the Question Paper carry their usual meanings. Figures in the margin indicate full marks. All Parts of any one question must be answered together.

Answer five (5) Questions taking at least two (2) from each group.

GROUP - A

Q1. a) Draw a single point turning tool (SPTT) and show on it tool signature parameters in ASA.
b) Using the master line principle of tool geometry conversion, prove that,

$$\tan \gamma_o = \tan \gamma_x \sin \phi + \tan \gamma_y \cos \phi$$

where, γo is orthogonal rake angle, γ_x is side rake angle, γ_y is back rake angle and ϕ is principal cutting edge angle.
c) Determine the values of side clearance (α_x) and minimum clearance (α_m) angles of the single-point turning tool turning tool whose geometry is specified in ORS as -10°,10°,8°,6°,15°,75°,0 (mm). [7+7+6]

Q2. a) What are orthogonal and oblique cutting? Discuss about the different types of chips in metal cutting.
b) In orthogonal machining, prove that, $tan\phi = \frac{rCos\alpha}{1-rSin\alpha}$, where, ϕ =shear plane angle, α=Rake angle, r =Chip thickness ratio or cutting ratio.
c) Following data have been collected for an orthogonal cutting test: (i) depth of cut = 1.5 mm, (ii) width of cut = 5 mm, (iii) rake angle = 15°, (iv) cutting speed = 25 m/min, (v) chip thickness ratio = 0.4 and (vi) shear stress = 150 N/mm². Find (i) shear plane angle, (ii) friction angle, (iii) chip flow speed (iv) shear force and (v) power consumed. [(2+5)+(3+3)+7]

Q3. a) For minimum energy consumption during orthogonal cutting, establish the relationship between the shear angle (ϕ), friction angle (λ), and rake angle (α) as per Ernst Merchant Theory (Merchant's first solution).
b) During turning a steel round of 160 mm diameter at 560 rpm employing a feed of 0.32 mm/rev and depth of cut as 4 mm by a ceramic insert having rake angle of 0°, the following observation were made.
Cutting force = 1600 N, Thrust force = 828 N and chip thickness = 1mm
With/ without using merchant circle Diagram (MCD), compute the following:
(i) Friction force on tool rake face and corresponding normal reaction, (ii) Resultant force, (iii) Shear force and corresponding normal face, (iv) Co-efficient of friction between tool-chip inter faces, (v) Cutting power and specific cutting energy. [8+12]

Q4. a) What are the main characteristics that a cutting tool material should possess? Show schematically the pattern of growth of flank wear and crater wear with the progress of machining time.
b) Determine the actual machining time that will be required to remove, by shaping, a layer of 2 mm thickness from a cast iron plate of length 100 mm and width 60 mm at cutting velocity of 40 m/min and feed of 0.2 mm/stroke. Assume approach and overrun along width = 2 mm and along length = 5 mm. quick return ratio of the shaping machine is 2/3.

[Turn over

c) If in turning of a steel rod by a given cutting tool (material and geometry) at a given machining condition (feed and depth of cut) under a given environment (cutting fluid application), the tool life decreases from 80 min to 20 min due to an increase in cutting velocity from 60 m/min to 120 m/min, then at what cutting velocity the life of that tool under the same condition and environment will be 40 min?

[(3+3)+7+7]

GROUP - B

Q5. a) How do Generatrix (G) and directrix (D) help to produce a geometrical structure associated with tool-work motions? Explain Generatrix and Directrix with neat sketch for operations: i) Drilling ii) Turning.

b) State the advantages and disadvantages of hydraulic power drives in machine tools. If the frequency (f_r) is 50 and the number of effective pairs of magnetic poles (N_{PP}) is 2, then calculate the spindle speed.

c) Sketch and explain the Elementary Structure (E-22) and Compound Structure (K-23) of a Machine Tool. 5+(3+2)+(4+6)]

Q6. a) Why are the conventional machine tools provided a large number of spindle speeds (rpm)?

b) State why GP (geometric progression) is preferred to AP (arithmetic progression) for the layout of spindle speeds in machine tools. State the principle of fixation the value of the common ration (ϕ) during spindle speed layout in GP.

c) The speed gear box (SGB) has to be designed for a 12 speed centre lathe to be used for machining rods of diameter ranging from 60 to 250 mm at cutting velocity ranging from 40 to 300 m/min. Determine the values of all the spindle speeds for that lathe.

[2+(4+4)+10]

Q7. a) What are the basic characteristics of Ray diagram? Differentiate between unilateral or bilateral and open or cross type of Ray diagram of machine tool.

b) Design a 6 speed gear box for a drilling machine requiring speed variation between 140 and 450 rpm (Common ratio $\phi = 1.25$). The design of the gear box should include (i) drawing of gearing diagram, (ii) Ray diagram, (iii) number of teeth and outside diameter of all the gears (Take module of gears m=3).

[(3+3)+2+14]

Q8. a) Why CNC machining is necessary? Distinguish between NC and CNC machine tools.

b) How do linear encoder and recirculating ball screw functions in CNC machine tools?

c) Explain the use of cutter radius compensation (G40/G41/G42) and tool length compensation (G43/G44/G49) in CNC part programming.

[(3+3)+(3+3)+(4+4)]

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