Ref. No.: Ex/PG/ME/T/112I/2018

M.E. MECHANICAL ENGINEERING FIRST YEAR FIRST SEMESTER, 2018

THEORY OF METAL CUTTING

Time: **3 hour** Full Marks: **100**

Answer any ***five*** questions.

Assume suitable data if necessary.

1. a) Deduce an expression of kinetic coefficient of friction in the direction of chip flow in terms of forces that can be measured by dynamometer.
   b) Briefly explain the stagnant phenomena on rake surface during chip formation.
   c) Derive an expression of maximum normal stress at the cutting edge in orthogonal cutting. **8 + 4 + 8**

2. a) How does overall cutting temperature vary with cutting velocity? Derive an expression of overall cutting temperature rise in terms of cutting velocity, depth of uncut layer and physical properties of workpiece material.
   b) Estimate the magnitude of average shear plane temperature and power consumption during orthogonal turning of a ductile rod at cutting speed 2.5 m/s, feed rate, 0.20 mm/rev, and depth of cut, 3 mm, by a tool with orthogonal rake angle (-10^0). Use machining constant = 80^0, τ_0 = 400 MPa, chip velocity = 1 m/s, density = 7200 kg/m^3, and specific heat = 502J/kg.^{0}C. **10 + 10**

3. In a facing tool life test, the critical wear land of 1 mm was reached at 200 mm diameter at 250 rpm when the feed was 0.2 mm/rev. If the Taylor tool life exponent is 0.20, what is the value of constant C? Assume the cutting to start from the centre of the plate. Deduce the formula used. **20**

4. a) Derive an expression for optimum cutting speed for minimum cost of production in metal cutting operation. Show the variation of various cost with cutting speed.
   b) A Ø 30 X 300 long bar is to be turned on a lathe. The maximum allowable feed is 0.25 mm/rev. The cost of labour and overheads/min is Rs. 15 and each regrinding of the tool involves an expense of Rs. 120. The time required for every tool change is 1 min. Two alternative materials A and B can be used. Their cost and tool life equation (for a feed of 0.25 mm/rev) are given below:

Material	Cost/piece	Tool life equation
A	Rs. 150	$VT^{0.1} = 30$
B	Rs. 180	$VT^{0.16} = 76$

Determine which material should be used from the cost point of view. The setting and ideal time involved in each piece is 1 min. **10 + 10**

5. a) What is master line of rake surface? Derive a relationship for back rake angle and side rake angle with inclination angle and orthogonal rake angle of a single point turning tool.
   b) The tool geometry of single point turning tool is given as 0^0 - 10^0 - 6^0 - 6^0 - 8^0 -75^0 -1 mm (ORS). What are the back rake and side rake angles of the tool?
   c) Sketch the views of the above tool mentioned in (b) to show all the relevant features of it. **10 + 4 + 6**

6. a) What is orthogonal cutting? State the conditions for orthogonal cutting.
   b) Write the assumptions for developing Merchant's Circle Diagram.
   c) During orthogonal machining with an HSS tool, the rake angle was 5^0, the undeformed chip thickness was 0.25 mm and width of cut was 4 mm. Taking the shear strength of the work material to be 350 N/mm^2 and coefficient of friction between the chip and the tool to be 0.5, estimate the cutting force and the thrust force. Given that $2\beta + \eta + \gamma_0 = \pi/2$ (the notations carry usual meaning). **5 + 5 +10**

7. a) Discuss the mechanics of grinding. Derive the expression for force per single grit in terms of r_g, depth of cut and other terms.
   b) When turning a cylindrical workpiece, two different tools are used. In one tool no nose radius is provided, the side cutting and the end cutting edge being 30^0 and 7^0 respectively. In other tool a nose radius of 0.7 mm is provided. The feed used in both the cases is 0.15 mm/rev. Find out the maximum height of unevenness in the generated surfaces.
   c) Discuss about thermal aspects in grinding operation. **10 + 5 + 5**

8. a) Deduce an expression of chip length in cylindrical grinding operation.
   b) What are the essential properties of an ideal tool material? Explain.
   c) Discuss about cemented carbide, coated carbide and ceramic as tool material. **6 + 5 +9**