Time: 2PM – 4 PM   Max Marks:90

Instructions:
- Closed book/note/slides examination.
- Invigilators can award zero if any unfair means are resorted.
- Write your answers on blank A4 sheets/papers. Submit a single pdf file with your rough work papers in last. The file name of your pdf should be your roll no.
- Make suitable assumptions.

Que 1: Ultrasonic machining is performed to make square hole in the tungsten carbide material which has flow strength of σ_w. Size of square hole is 'm' and thickness of the workpiece is 'n'. The diamond abrasives slurry is used in machining with concentration 'c'. The diamond abrasive particles are assumed to be sharp rigid octahedrons of the same size. Every four adjacent triangles have a common vertex, forming a pyramid, as shown in Fig. 1(a). Only vertex side of pyramid of each octahedral particle takes part in cutting. The semi-angle (β) between two opposite edges of an abrasive particle is **45°** and the lengths of its 12 edges are same and can be expressed as 's'. The volume of the pyramid with square base with edge length 's' and height 'h_1' is $\dfrac{s^2 h_1}{3}$. Density of abrasive particles is ρ_p . Assume the removal of material using brittle fracture and in hemi spherical shape. View of abrasive particle and material is shown in Fig 1(b). **Value of 'p' shown in Fig. 1(b) is {p= h* 0.1*(last digit of your roll number)}. Those students have zero (0) last digit can take p=h.**
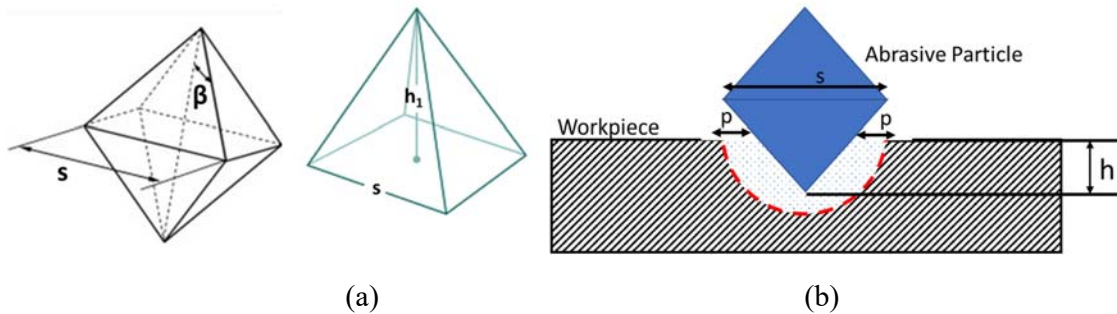

Fig. 1. (a) Abrasive particle shaped in octahedron (b) Material removal mechanism.

Tool is vibrating at frequency F with an amplitude of a. Material of the tool is copper with flow strength of σ_t.

(a) Assume monolayer of abrasive particles, determine the formula for number of active abrasive particles.   [5]
(b) Derive the formula for depth of penetration h and material removal rate for particle throwing model   [10]
(c) Derive the formula for depth of penetration h and material removal rate for particle hammering model. Assume force acting on the particles is $f = \left(\dfrac{f_m a}{h_h}\right)$ where h_h is sum of penetration in tool and workpiece and f_m is the mean force.   [10]

Que 2: In Abrasive water jet machining of titanium with specific energy of u=**4.1 J/mm³**, a hydraulic pump delivers the hydraulic oil to the intensifier at pressure of P_h =**60 bar**. The ratio of cross section of piston cylinder and plunger cylinders of intensifier is **50**. Water jet is coming out of the nozzle orifice of diameter d_0 =**500** micron without any loss in momentum and energy to mixing chamber where mixing with abrasive particles will take place. Abrasives added in the mixing chamber at mass flow rate of m_{ab}. During mixing, it has been found that there was a **10%** loss of momentum/energy. (**1 bar =0.1N/mm²**)

(a) Determine the value of mass flow rate m_{ab} of abrasive particles for maximum machining rate or production. [15]

(b) Determine the material removal rate of titanium in abrasive water jet machining if mass flow rate m_{ab} of abrasive particles reduces to **x percent of maximum value** obtained in previous part. Will if increase or decrease? **(x=10*last digit of your roll number)**. **Those students have zero (0) last digit can take x=50.** [5]

(c) What will be the depth of penetration if traverse speed of head is **2 mm/sec** and diameter of focusing tube is **1 mm**? [5]

Que 3: In abrasive jet machining, abrasive particles of octahedral shape of edge length 's' as shown in Que.1 (Fig 1a and 1b) with mass flow rate of m_{ab} are used to remove the material from workpiece with flow strength of σ_w. Velocity of abrasive particles is V. The density of abrasive particle is ρ_p. Derive the formula for material removal rate if workpiece material is a ductile material. Use information from Ques 1 if required. [15]

Que 4: Chemical machining is used to make a slot of width **40 mm** and depth of **15 mm** on one surface of steel workpiece size of **60mmx60mm** and thickness of **30mm** using etchant $FeCl_3$.

(a) Draw a schematic diagram to represent the etch factor. [5]

(b) What is the width of maskant removed or scribed from the coated surface before etching process if etch factor is equal to **0.01*(last two digit of your roll number)?** [5]

Que 5: (a) Explain the working principle of abrasive flow finishing process (2-3 sentences) by drawing a schematic of two-way abrasive flow finish setup. [7.5]

(b) During slotting operation of titanium using abrasive water jet machining, what will the effect of traverse speed (feed rate) on surface quality of cut/kerf. Write in 2-3 sentences and show the schematic diagrams of the surfaces for low and high traverse speeds. [7.5]