PhD Qualifying Exam – 2015

Manufacturing Processes-II

- Full marks 100
- No books and notes are allowed but two A4 sheets of handwritten formulae are allowed
- Please make any suitable assumption if required

1. Following data refers to the cutting tests carried out on a material during orthogonal machining and Surface Grinding operations.

Orthogonal Machining		**Surface Grinding**	
Depth of cut	2 mm	Wheel width	25 mm
Width of cut	4 mm	Infeed (Depth of cut)	10 microns
Cutting Speed	1 m/s	Table Speed (Linear)	2 m/min
Cutting Force	400 N	Grinding speed	30 m/s
Thrust Force	250 N		

Specific cutting energy during grinding can be taken as 6 times of that during the orthogonal machining process for the material. Estimate the tangential cutting force during the surface grinding operation.

Why is the specific cutting energy in grinding more than in orthogonal machining despite very small depth of cut? [15]

2.
    a. Holes of diameter 10.00 +/- 0.010 mm are produced in a batch of components. The holes are subsequently electroplated. Plating thickness is 1.0 +/- 0.005 mm. Considering worst case (extreme limit) basis of tolerances, calculate the size (diameter) range of plated holes produced. Calculate the sizes of the GO and NO-GO gages to inspect the plated holes for the batch. [14]

    b. An orthogonal cutting tool with rake and clearance angles of 5 and 10 degrees respectively is used for turning a 50 mm diameter shaft on a lathe. During the machine set up, the operator mounted the tool tip 1 mm below the job center. Calculate the effective rake and clearance tool angles during machining. [6]

3.
    a. We need to cut the half-cylindrical block (shown in black, Figure 1) from solid Tungsten block by Wire EDM. The discharge current varies with respect to time and shown in Figure 1 (sinusoid wave form). The diameter of EDM wire is 100 µm, Overcut is 0.02 mm. Peak current is 10 A, Duty cycle is 0.5. [10]

Tungsten properties: density: 19290 kg/m3, specific heat 138 J/Kg.K, melting point 3410 C, thermal conductivity 166 W/m.K.

Calculate the time taken in cutting this block? Volumetric metal removal rate (R) in EDM: (R, mm^3/s) in EDM: $R = [(664 * I_{avg})/(\text{Melting point})^{1.23}]$. Units of I_{avg} is in amps, and melting point is in °C.

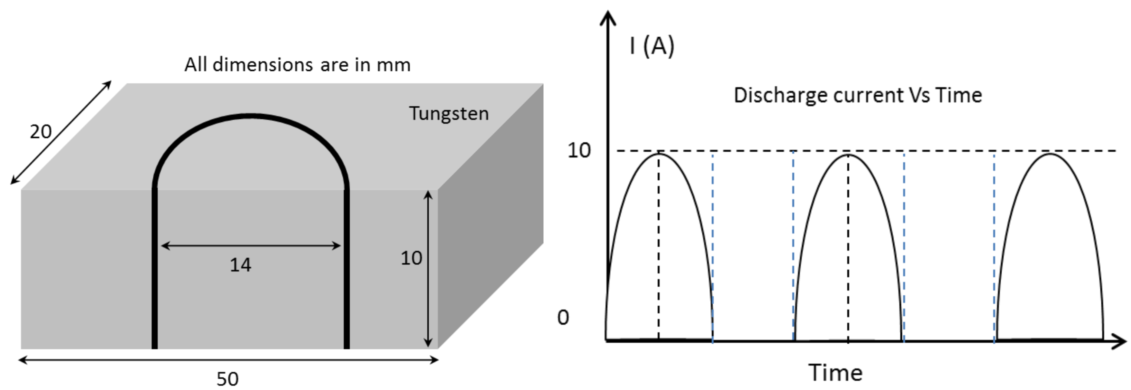

Figure 1: Block (left), Sinusoid waveform of discharge current Vs time (b)

b. Explain the main material properties considered during selection for EDM tool material? [5]
c. You are given following materials as EDM tool materials: Aluminum, Gold, Acrylic, Copper, Graphite, Silicon, and Tungsten. Give your serial order of preference with proper reasons? [5]

4. For the orthogonal cutting of a particular work material, it has been found that the tool-chip contact length is equal to the undeformed chip thickness (t_0) and the mean shear stress at the tool-chip interface is equal to the mean shear stress on the shear plane.
    a. Find the expression for the mean coefficient of friction as a function of shear angle (ϕ) and rake angle (α). [5]
    b. If the tool-chip contact length increases during the machining process and becomes equal to the chip thickness (t_c) and the mean shear stress at the tool-chip interface remains equal to the mean shear stress on the shear plane, find the new expression for the mean coefficient of friction as a function of shear angle (ϕ) and rake angle (α). Also prove that the mean coefficient of friction, μ cannot exceed 4/3, i.e., $\mu \leq 4/3$. [12.5]
    c. Please comment on whether the mean coefficient of friction increases, decreases or remains unchanged with an increase in the tool-chip contact length and briefly explain the reason. Does a limiting value of coefficient of friction exist in metal cutting? Derive a first order approximation for limiting value of coefficient friction, assuming the metal to be perfectly plastic. [7.5]

5.

a. In abrasive water jet (AWJ) machining, abrasive-waterjets (AWJs) are formed by mixing abrasive particles with high-velocity water jets (V_{wj}) in mixing tubes. Derive expression for the abrasive waterjet velocity assuming that after mixing both water and abrasive phases attain the same velocity of V_{awj}. Take l_r as a loading ratio i.e. ratio of the mass flow rate of abrasives ($\dot{m}_{abr}$) to the mass flow rate of water ($\dot{m}_w$). Use momentum conservation and assume that abrasives are introduced at very low velocity. [8]

b. If water jet of diameter 0.3 m flows with velocity 900 m/s and mass flow rate of abrasive is 1 kg/min, determine the abrasive water jet velocity assuming no loss during mixing process. [4]

c. Assuming negligible contribution of water phase in material removal, the material removal rate can be assumed to be proportional to the power of abrasive phase of AWJ. Now, for a given $\dot{m}_w$ show that there exists an optimum loading ratio (l_r) to obtain maximum material removal rate. Give physical significance why the optimum exists. [8]