Department of Mechanical Engineering
IIT Kharagpur

NONTRADITIONAL MANUFACTURING PROCESSES: MF30604

Mid. Sem. Exam.: Spring 2017-18 Time: 2 hours Full marks: 60

Attempt all questions of Part-A and Part-B

Part – A (40 marks) (to be answered tentatively in 1 hour 20 minutes)

Q. 1(a) What are the characteristics of non-traditional machining processes that make them different from conventional machining processes? **[3 marks]**

Q. 1(b) What are the different types of masks used in chemical machining and where are they used? **[3 marks]**

Q. 2(a) Justify the following in brief.

(i) De-ionized water is preferred to hydro-carbon oil when used as a dielectric fluid for wire cut EDM.

(ii) Tungsten-copper electrode is preferred while drilling small and high accuracy holes through die-sinking EDM.

(iii) Presence of recast layer for die-sinking EDM may be significant whereas that for wire-EDM is negligible.

(iv) A pulsed DC supply (and not a continuous DC supply) is used in EDM.

(v) When a ferrous work piece is to be machined with a copper tool in EDM, work piece is connected to the negative terminal for higher productivity.

(vi) Orbital cutting arrangement of EDM helps in machining complex shapes.

(2.5 x 6 = 15 marks)

Q. 2(b) For a die-sinking EDM having R-C type pulse generator, following data are given.

Charging resistance=40 Ohm, C=15 μF, Supply voltage= 150 V, Breakdown voltage=120 V, Resistance of the discharge circuit 15 Ohm. The condenser is discharged to a voltage of 5 V during deionization. Calculate

(i) Charging time before break down takes place,

(ii) Minimum charging current,

(iii) Pulse on time of the EDM machine,

(iv) Maximum discharge current, and

(v) Duty factor of the EDM set up.

(1x5=5 marks)

Q. 3(a) Prove that the inter-electrode gap during die-sinking electrochemical machining (ECM), for a given tool feed rate, eventually attains an equilibrium value irrespective of the initial gap setting.

[8 marks]

Q. 3(b) An iron workpiece is machined in an ECM die-sinking machine using a copper tool and aqueous NaCl solution as electrolyte. The copper electrode has a uniform

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interaction area of 100 cm^2. A constant working gap of 0.05 cm is maintained. The ECM machine has a supply voltage of 25 V. Specific resistance of the electrolyte is 5.0 ohm-cm. For iron, atomic weight = 56, valency = 2, density = 7.8 g/cm^3. Faraday's constant = 96500 Coulomb. A current efficiency of 100% may be assumed. Neglect over-voltages at the electrodes.

Calculate the (i) Material removal rate and (ii) Electrode feed rate.

[4+2 =6 marks]

PART B (20 marks) (to be answered tentatively in 40 minutes)

1. State whether the following statements are true or false. Justify your answer in a few sentences. **[5x2=10]**

i. Material removal processes in electron beam machining (EBM) and focused ion beam machining (FIBM) are different.

ii. The depth of penetration of EB in a material is constant irrespective of the accelerating voltage and type of material.

iii. Ga^+ is commonly used in FIB machine.

iv. The method of producing e^- in EBM and Ga^+ ions in FIB is the same.

v. The torch of TIG and that of Plasma arc welding machine have the same construction.

2. An open slit of 500 μm width in a 500 μm thick tungsten sheet is to be cut with an e-beam focused to 500 μm diameter. What should be the e-beam powder and machining speed for cutting the slit without any heat affected zone? The thermal diffusivity of tungsten and the specific power for E-beam machining of tungsten are $6x10^{-5}$ m^2/s and 12 $W/mm^3/min$ respectively. **[5 marks]**

3. The sputtering rate in a focused ion beam machining is given by

$$V(nm/s) = 100.S(M/d)\ J.\ \cos\theta$$

where, S - sputtering yield (atoms/ion), M - atomic (molecular) weight (g) of target,
d - target density (g/cm^3), J - ion current density (A/cm^2) and
θ - angle of incidence

A 10 μm x 10 μm square and 1 μm deep cavity is to be made in a silicon wafer with a focused Ga^+ ion beam at a 10^0 angle of incidence. The sputtering yield of ions accelerated at 30 kV and incident at the 10^0 angle is 10. Estimate the machining time to make the cavity at 10 nA ion current.

Silicon atomic weight = 28 g and density = 2.34 g/cm^3.

[5 marks]

**** End of question paper ****

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