INDIAN INSITUTE OF TECHNOLOGY KHARAGPUR
Mid-Spring Semester 2019-20

Date of Examination: 17.02.2020 Session: FN Duration: 2 hrs Full Marks: 60

Subject No.: MF30604 Subject : Non-traditional Manufacturing Processes

Department/ Centre/ School : Mechanical Engineering Department

Specific Charts/ Graph paper/ Log book etc required: Nil

Special Instructions, if any: Attempt all questions of Part-A and Part-B

Part – A (40 marks)

Q. 1 What are the characteristics of non-traditional machining processes that make them different from conventional machining processes? Name four different non-traditional processes that uses thermal energy for removing materials. [3+2=5 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) Explain with diagram how the effects of variation of sludge concentration (from electrode inlet side to outlet side) in the inter-electrode gap may be taken care of while designing for tool in electrochemical machining.

[3 marks]

Q. 3(c) 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 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 downward **feed rate of the tool.**

[4 marks]

PART B (20 marks)

4. Answer all the following in brief: **(5x2 =10 marks)**
   - i) What is stimulated emission process? Why can't a laser be operated without population inversion?
   - ii) What are the main properties of laser beam that are exploited in laser material processing applications specially for cutting of metal sheets and drilling of micro-holes without any heat affected zone?
   - iii) What are the mechanisms of material removal in laser cutting of metal sheets and drilling holes?
   - iv) What are the factors on which the focal spot diameter of an electron beam depends?
   - v) What is the mechanism of electron beam keyhole welding?

5. (a) A high power Fiber laser operating at 1.07 μm wavelength has 16 mm diameter collimated beam of $M^2 = 30$. The laser beam is focused with the help of a lens of focal length 200 mm on a 5 mm thick steel sheet for cutting it.
   Calculate the focal spot diameter on the surface of the sheet and the maximum cutting speed at 1 kW laser power with oxygen gas assist.
   You may assume that during the cutting process ~60% of the incident laser power is absorbed by the steel sheet and an additional 40% of the absorbed laser power is added by the exothermic oxidation reaction. **(2+3=5 marks)**
   The thermo-physical properties of steel are as the following: Density = 8000 kg/m^3, Specific heat = 500J/kg-K, Melting temperature = 1500^0C, Latent heat of fusion = 300 kJ/kg,

   (b) Good quality of holes of 100 μm diameter without any heat affected zone (HAZ) are to be drilled in a 200 μm thin tungsten sheet with the help of a pulsed electron beam. The specific power, i.e. the electron beam power required to remove one mm^3 material per minute is $12W/(mm^3/min)$, and the thermal diffusivity of tungsten is $5x10^{-5}m^2/s$. What should be the e-beam pulse duration to drill holes without any HAZ with the beam focused to 100 μm spot diameter, and what should be the e-beam power to drill one hole with a single pulse? The e-beam power coupling to the tungsten sheet is ~ 50% during the drilling process. **(2+3=5 marks)**

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