GOVERNMENT TOOL ROOM & TRAINING CENTER

SUBJECT: ADVANCED MANUFACTURING TECHNOLOGY

SUBJECT CODE: DPM-VIS604

CHAPTER-1 ELECTRIC DISCHARGE MACHINING

PART-A

FILL IN THE BLANKS:

1. The non- metallic electrode material used in EDM isGraphite
2. The commonly used electrode material in EDM is copper
3. In advanced machining processes EDM means Electric discharge Machining
4. The distance between electrode and work piece is called asspark gap
5. EDM is also called asElectric discharge Machining, or Electro Discharge Machining, or spark erosion, or spark machining.
6. In EDM the job is connected to positiveterminal of electric source
7. In EDM the tool (electrode) is connected to negativeterminal of electric source
8. The spark gap distance is0.005 to 0.05mm is maintained
9. In EDM, the overcut is generally 0.025 to 0.2mm on all surface.
10. The EDM is restricted to only electrically conductive (ferrous)materials.
11. The most common dielectric fluid in EDM is Kerosene.
12. A necessary condition for producing discharge is Ionization.
13. In EDM the work piece and electrode are immersed indielectric fluid (Kerosene).
14. 20 to 120 V are the magnitude of voltages used in Electro discharge machining
15. In EDM the temperature that are obtained while machining is 8000 to 12000°C
16. Electro discharge erosionmechanisms is used for material removal in EDM
17. Copper has GoodElectro discharge machining wear and betterconductivity.
18. Overcut is the distance, the spark will penetrate the workpiece from the tool and remove metal from workpiece.
19. The overcut is generally 0.025 to 0.2mm, on all surfaces. In EDM
20. Pressure flushing, also called injection flushing.

MULTIPLE CHOICE QUESTIONS:

1. In advanced machining processes, what is the full form of EDM?
    a. Electro discharge Machining
    b. Electro discharge Manufacturing
    c. Electrical dimensioning Machining
    d. Electrode dimensions Manufacturing

2. Cavities with, which of the following factors can be produced using Electro discharge machining?
    a. Thin walls
    b. Fine features
    c. All of the mentioned
    d. None of the mentioned

3. What is the magnitude of voltages used in Electro discharge machining?
    a. 1 to 20 V
    b. 20 to 120 V
    c. 120 to 220 V
    d. 220 to 320 V

4. What are the values of gaps between the electrodes in EDM?
    a. 0.001 – 0.05 mm
    b. 0.01 – 0.5 mm
    c. 0.1 – 5 mm
    d. 1 – 15 mm

5. How is material removed in Electro discharge machining?
    a. Melt and evaporate
    b. Corrode and break
    c. Mechanical erosion takes place
    d. None of the mentioned

6. What are the values of temperature that are obtained while machining using EDM?
    a. 2000 to 3000°C
    b. 4000 to 6000°C
    c. 8000 to 12000°C
    d. 15000 to 20000°C

7. Which of the following materials can be machined using Electro discharge machining?
    a. Heat resistant alloys
    b. Super alloys
    c. Carbides
    d. All of the mentioned

8. Which of the following mechanisms is used for material removal?
    a. Electro discharge erosion
    b. Magnetic abrasion
    c. Electro chemical dissolution
    d. Mechanical erosion

9. What are the values of gaps between the electrodes in EDM?
    a. 0.001 – 0.05 mm
    b. 0.005 – 0.5 mm
    c. 0.1 – 5 mm
    d. 1 – 15 mm

10. What is the function of feed-control system in Electro discharge machining?
    a. Constant gap
    b. Supply power
    c. Dielectric fluid supply
    d. Work piece holding

11. Copper has _____ Electro discharge machining wear and _____ conductivity.

a. Good, better
b. Good, worse
c. Bad, better
d. Bad, worse

12. Which of the following materials are used as electrodes in EDM?

a. Graphite
b. Copper
c. Brass
d. All of the mentioned

13. Which of the following can be used as dielectric fluids in EDM?

a. Kerosene
b. Fluids
c. Water
d. All of the mentioned

14. Which of the following are the main requirements of dielectric fluids?

a. Viscosity
b. High flash point
c. Minimum odour
d. All of the mentioned

15. Which of the following shapes can be produced using Electro discharge machining?

a. Complex shapes
b. Simple shapes
c. All of the mentioned
d. None of the mentioned

16. Pressure flushing is also called as

a. Jet flushing
b. Injection flushing
c. Suction flushing
d. None.

17.

ANSWERTHE FOLLOWING: (2M)

1. Define EDM.

Ans. Electric discharge machining, also known as spark erosion, electro-erosion or spark machining. EDM is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool (usually cathode) and the work (anode).

2. What is spark gap.

Ans. The distance (Gap) between work piece and the electrode is known as spark gap.Which is essential for to generate spark. 'spark gap' in the ranges of 0.005 to 0.05 mm is maintained between the workpiece and the tool.

3. Write types of spark generator.

Ans. The Spark generating circuit may be one of the following types

1) relaxation generator
2) Pulse generator

4. Write electrode materials used in EDM

Ans. Electrode materials are:

a) Copper,
b) yellow brass,
c) zinc,
d) graphite and some other materials are used for tools

Low wearing tools includes:

a) silver-tungsten,
b) copper-tungsten, and

c) metalized graphite.

d) For commercial applications, copper is best suited for fine machining.

5. What is overcut?

Ans. Overcut is the distance, the spark will penetrate the workpiece from the tool and remove metal from workpiece. Theoretically, it is slightly larger than the gap between the end of the tool and the workpiece. The overcut is generally 0.025 to 0.2 mm, on all surfaces.

6. Write types of flushing.

Ans. **Types of flushing:**

a) Pressure flushing,

b) Suction flushing and

c) Side flushing. Or jet flushing

7. List out any four applications of EDM.

Ans. Applications of EDM:

a) Fine cutting with thread shaped electrode (wire - cutting EDM).

b) Drilling of micro - holes.

c) Thread cutting.

d) Helical profile milling.

e) Rotary forming.

f) Curved hole drilling.

8. List out parts of EDM machine.

Ans. Parts of EDM machine

a) Tool feed

b) Servo control

c) Table

d) Pump

e) Filter

f) Tank

g) DC power generator

9. Write any four process parameters of EDM.

Ans. Following are the process parameters of EDM:

a) Pulse On time (Ton).
b) Pulse Off time (Toff)
c) spark gap
d) Discharge current (Ip)
e) Duty cycle (τ)
f) Voltage (V)
g) Over
h) Dielectric pressure

10. Expand EDM.

Ans. Electric discharge machining, also known as spark erosion, electro-erosion or spark machining.

11. Write types of dielectric fluids.

Ans. Types of dielectric fluids are:

a) kerosene,
b) paraffin,
c) transformer oil
d) try ethylene glycol (with water 40 by volume) or their mixture and
e) certain aqueous solutions.

12. Define Dielectric pressure in process Parameters ofEDM.

Ans. Dielectric pressure- Dielectric pressure is the pressure of the dielectric fluid which surrounds the work piece and the electrode. It is the rate at which this fluid is circulated in the tank.

13. What is Duty cycle (τ) in process Parameters of EDM.

Ans. Duty cycle (τ): It is a ratio of the pulse on-time relative to the total cycle time expressed in percentage. This factor is calculated by dividing the on-time by the total cycle time (on plus offtime).

14. What is the function of spark gap in process Parameters of EDM?

Ans. spark gap: It is gap between the electrode and work piece in which the spark generates for eroding the metal from the work piece. It is very thin gap in the range of 10– 125 µm.

15. What is the function of Discharge current (Ip) in process Parameters of EDM?

Ans. Discharge current (Ip): Current is measured in ampere (A). Discharge current is responsible directly for material removal. It contains energy for melting and evaporation.

PART-B

ANSWERTHE FOLLOWING: (3M)

1. List out the parts of EDM machine.

Ans. Parts of EDM machine

a. Tool feed
b. Servo control
c. Table
d. Pump
e. Filter
f. Fixture (for holding work piece)
g. Tank
h. DC power generator

2. Write types of dielectric fluid used in EDM.

Ans. The common dielectrics used are:

i. Kerosene.
ii. paraffin.
iii. transformer oil.
iv. try ethylene glycol (with water 40 by volume) or their mixture and
v. certain aqueous solutions.

vi. Water, being an electrical conductor, gives a metal removal rate of only about 40 per cent of that obtained when using paraffin as a dielectric.

3. What is over cut. How much it is provided on all surface of electrode in EDM.

Ans. The shape of the area of the cavity produced in the work should theoretically be the same as that of the tool. This, however, is not exactly true because of the over cut.

Overcut is the distance, the spark will penetrate the workpiece from the tool and remove metal from workpiece. Theoretically, it is slightly larger than the gap between the end of the tool and the workpiece. The overcut is generally 0.025 to 0.2 mm, on all surfaces.

4. Explain relaxation generator.

Ans. Relaxation generator: In relaxation generator, The Spark generator supplies the current to a condenser, the discharge from which produces the spark. the workpiece alternatively becomes a positive electrode (anode) or negative electrode (cathode) respectively. on each reversal of polarity, the tool is eroded more than the workpiece. Hence the tool wear is greater with this type of arrangement.

5. Write any six process parameters of EDM.

Ans. Process parameters:

i. Pulse On time (Ton).
ii. Pulse Off time (Toff)
iii. spark gap
iv. Discharge current (Ip)
v. Duty cycle (τ)
vi. Voltage (V)
vii. Over
viii. Dielectric pressure

6. Write types of flushing.

Ans. **Types of flushing:**

- Pressure flushing
- Suction flushing and

- Side flushing or jet flushing

7. List out electrode material used in EDM.

Ans. The electrode material as follows:

- Copper,
- yellow brass,
- zinc,
- graphite and some other materials are used for tools.

Low wearing tools include:

- silver-tungsten,
- copper-tungsten, and
- metalized graphite.

For commercial applications, copper is best suited for fine machining,

8. Define spark gap. How much it is maintained?

Ans. The distance (Gap) between work piece and the electrode is known as spark gap. Which is essential for to generate spark. ‘spark gap' in the ranges of 0.005 to 0.05 mm is maintained between the workpiece and the tool.

9. List out any six advantages of EDM.

Ans. **ADVANTAGES:**

i. Extremely high popularity of the EDM process is due to the following advantages
ii. The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness or brittleness.
iii. Any complicated shape that can be made on the tool can be reproduces on the workpiece.
iv. Highly complicated shapes can be made by fabricating the tool with split sectioned shapes, by welding, brazing or by applying quick setting conductive epoxy adhesives.
v. Time of machining is less than conventional machining processes.

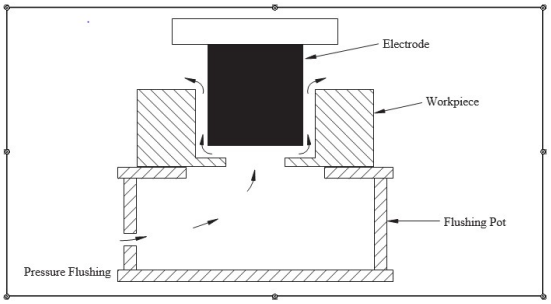
vi. EDM can be employed for extremely hardened workpiece. Hence, the distortion of the workpiece arising out of the heat treatment process can be eliminated.

10. Why flushing is needed in EDM.

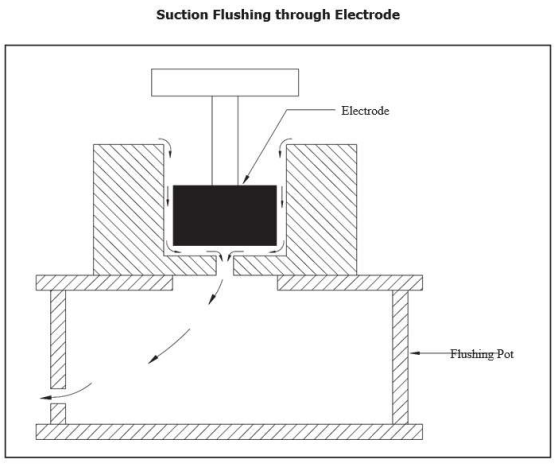
Ans. Flushing is important because eroded particles must be removed from the gap for efficient cutting. Flushing also brings fresh dielectric oil into the gap and cools the electrode and the workpiece. The deeper the cavity, the greater the difficulty for proper flushing. Improper flushing causes erratic cutting. This, in turn, increases machining time. Under certain machining conditions, the eroded particles attach themselves to the workpiece. This prevents the electrode from cutting efficiently. It is then necessary to remove the attached particles by cleaning the workpiece.

11. Draw neat sketch of pressure flushing.

Ans.



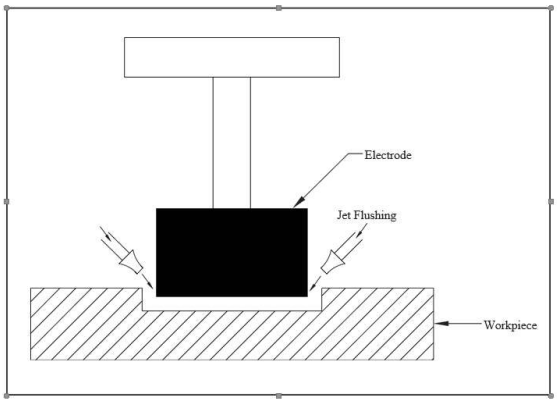
12) Draw neat sketch of Suction Flushing.



Ans.

13) Draw neat sketch of Jet Flushing.

Ans.



14) What is EDM.

Electric discharge machining, also known as spark erosion, electro-erosion or spark machining. EDM is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool (usually cathode) and the work (anode).

15) What is Pulse On time and Pulse Off time.

Pulse On time (Ton): It is the duration of time expressed in micro seconds in which the peak current is ready to flow in every cycle. This is the time in which energy removes the metallic particles from the workpiece.

Pulse Off time (Toff): It is the period of time expressed in micro seconds between the two pulse on time. This time permits the melted particle to coagulate on to the work piece and to be wash away by flushing method of the arcgap.

ANSWERTHE FOLLOWING: (5M)

1. Explain dielectric fluids.

Ans. **Dielectric fluids:**

i. The common dielectrics used are kerosene, paraffin, transformer oil try ethylene glycol (with water 40 by volume) or their mixture and certain aqueous solutions.
ii. Water, being an electrical conductor, gives a metal removal rate of only about 40 per cent of that obtained when using paraffin as a dielectric.
iii. The dielectric should be filtered before reuse so that chip contamination of the fluid will not affect machining accuracy.
iv. The dielectric fluid must circulate freely between the tool and workpiece.
v. Flushing of eroded particle in correct manner makes the machining system efficient.
vi. Provide an effective cooling medium. Be capable of carrying away the swarf particles, in suspension away from the working gap.
vii. Have a good degree of fluidity. Be cheap and easily available.

2. Explain types of electrode material used in EDM process.

Ans. The electrode materials generally used can be classified as

- Metallic materials (copper etc.),
- Non-metallic materials (graphite), and
- Combination of metallic and non-metallic materials (copper graphite).

Copper, yellow brass, zinc, graphite and some other materials are used for tools.Low wearing tools include silver-tungsten, copper-tungsten, and metalized graphite. For commercial applications, copper is best suited for fine machining, aluminium is used for die-sinking, and cast iron for rough machining.

3. Write application of EDM process.

Ans. **APPLICA TION OF EDM:**

i. The electrical discharge machining is used for the manufacture of tools having complicated profiles and a number of other components.
ii. The EDM provides economic advantage for making stamping tools, wire drawing and extrusion dies, forging dies, intricate mould cavities, etc.
iii. It has been extremely used for machining of exotic materials used in aerospace industries, refractory metals, hard carbides, and hard enable steels.
iv. Fine cutting with thread shaped electrode (wire - cutting EDM).
v. Drilling of micro - holes.
vi. Thread cutting.
vii. Helical profile milling.
viii. Rotary forming.
ix. Curved hole drilling.
x. The workpiece in this case is fragile to withstand the cutting tool load during conventional machining.

4. Explain pulse generator.

Ans. **Pulse generator:**

i. The introduction of pulse generator has overcome the drawbacks of relaxation generators. pulse generator is available, fitted with transistorized pulse generator circuit in which reverse pulses are eliminated. These generators consist of electronic switching units which let the current pass periodically.
ii. Modern pulse generator possesses the means of accurate control over discharge duration, pause time and the current.
iii. These factors determine the overcut and hence the accuracy and surface finish. The tool wear is also greatly reduced.
iv. While for finding the work high frequency and low-amperage settings are used, in roughing work low frequency discharges with high amperage are applied.

5. List out advantages of EDM process.

Ans. **ADVANTAGES:**

Extremely high popularity of the EDM process is due to the following advantages

i. The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness or brittleness.
ii. Any complicated shape that can be made on the tool can be reproduces on the workpiece.
iii. Highly complicated shapes can be made by fabricating the tool with split sectioned shapes, by welding, brazing or by applying quick setting conductive epoxy adhesives.
iv. Time of machining is less than conventional machining processes.
v. EDM can be employed for extremely hardened workpiece. Hence, the distortion of the workpiece arising out of the heat treatment process can be eliminated.
vi. No mechanical stress is present in the process. It is due to the fact that the physical contact between the tool and the workpiece is eliminated. Thus, fragile and slender workplaces can be machined without distortion.
vii. Cratering type of surface finish automatically creates accommodation for lubricants causing the die life to improve.
viii. Hard and corrosion resistant surfaces, essentially needed for die making, can be developed

6. Explain function of servo control in EDM.

Ans. Functions of servo control in EDM:

i. Electrohydraulic servo control is usually preferred. The servo gets its input signal from the difference between a selected reference voltage and the actual voltage across the gap.
ii. The signal is amplified and the tool, as it wears a little, is advanced by hydraulic control.
iii. A short circuit across the gap causes the servo to reverse the motion of the tool until the correct gap is established.

7. Explain principal of EDM.

Ans. Principal of EDM:

i. Electric discharge machining, also known as spark erosion, electro-erosion or spark machining.
ii. EDM is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool (usually cathode) and the work (anode).
iii. Fundamentally, the electric erosion effect is understood by the breakdown of electrode material accompanying any form of, electric discharge.
iv. The discharge is usually through a gas, liquid or in some cases through solids.
v. A necessary condition for producing a discharge is ionization of the dielectric, i.e., splitting up of its molecules into ions and electron.

8. Explain overcut in EDM process.

Ans. Overcut:

i. The shape of the area of the cavity produced in the work should theoretically be the same as that of the tool.
ii. This, however, is not exactly true because of the over cut.
iii. Overcut is the distance, the spark will penetrate the workpiece from the tool and remove metal from workpiece.
iv. Theoretically, it is slightly larger than the gap between the end of the tool and the workpiece. The overcut is generally 0.025 to 0.2 mm, on all surfaces.
v. Overcut causes internal corners on the workpiece to have fillets with radius equal to the overcut.
vi. This overcut is a function of the voltage of the spark.
vii. The overcut increases with higher current and decreases with higher frequency.

9. Write disadvantages of EDM process.

Ans. Disadvantage of EDM:

i. The following disadvantages of the process limit its application.
ii. Profile machining of complex contours is not possible at required tolerances.
iii. Machining times are too long.
iv. Machining heats workpiece considerably & hence cause change in surface & metallurgical properties.
v. Excessive tool wear.
vi. High specific power consumption.

10. Explain spark generator.

Ans. The Spark generating circuit may be one of the following types:

1) relaxation generator
2) Pulse generator

Relaxation generator: In relaxation generator, The Spark generator supplies the current to a condenser, the discharge from which produces the spark. the workpiece alternatively becomes a positive electrode (anode) or negative electrode (cathode) respectively. on each reversal of polarity, the tool is eroded more than the workpiece. Hence the tool wear is greater with this type of arrangement.

Pulse generator: The introduction of pulse generator has overcome the drawbacks of relaxation generators. pulse generator is available, fitted with transistorized pulse generator circuit in which reverse pulses are eliminated. These generators consist of electronic switching units which let the current pass periodically.

11. Explain Pulse On time and Pulse Off time in EDM.

Ans. Pulse On time (Ton): It is the duration of time expressed in micro seconds in which the peak current is ready to flow in every cycle. This is the time in which energy removes the metallic particles from the workpiece.

Pulse Off time (Toff): It is the period of time expressed in micro seconds between

the two pulse on time. This time permits the melted particle to coagulate on to the work piece and to be wash away by flushing method of the arcgap.

12. Write the function of duty cycle and voltage in process Parameters of EDM

Ans. Duty cycle (τ): It is a ratio of the pulse on-time relative to the total cycle time expressed in percentage. This factor is calculated by dividing the on-time by the total cycle time (on plus offtime).

Voltage (V): It is a potential difference that can be applied by the power supply in a controlled manner. Voltage is also another main factor which affects the material removal.

13. What are the properties must have in dielectric fluid, in EDM process?

Ans. The essential requirements of a dielectric fluid to be used in EDM process are that they should:

- Remain electrically no conducting until the required break- down voltage has been reached.
- Breakdown electrically in the shortest possible time once the breakdown voltage has been reached.
- Rapidly quench the spark or deionize the spark or spark gap after the discharges have occurred.
- Provide an effective cooling medium.
- Be capable of carrying away the swarf particles, in suspension away from the working gap.
- Have a good degree of fluidity.
- Be cheap and easily available.

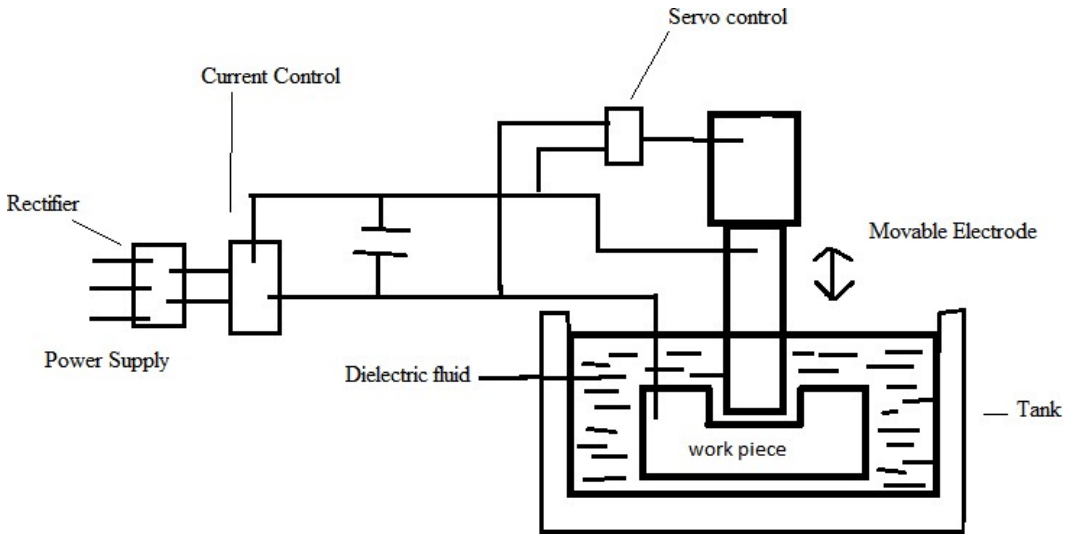
14. Why flushing is needed in EDM? Write types of flushing.

Flushing is important because eroded particles must be removed from the gap for efficient cutting. Flushing also brings fresh dielectric oil into the gap and cools the electrode and the workpiece.

Types of flushing

- Pressure flushing,
- Suction flushing and
- Side flushing. Or jet flushing

15) Draw a neat sketch of EDM machine.



ANSWERTHE FOLLOWING: (8M)

1. Explain EDM working process with neat sketch.

Ans.

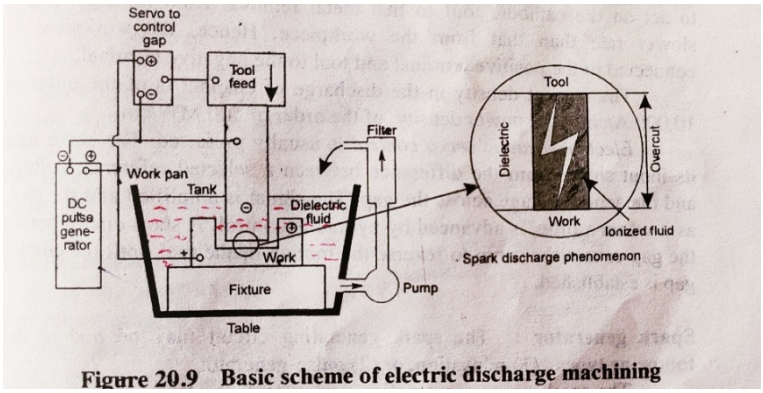
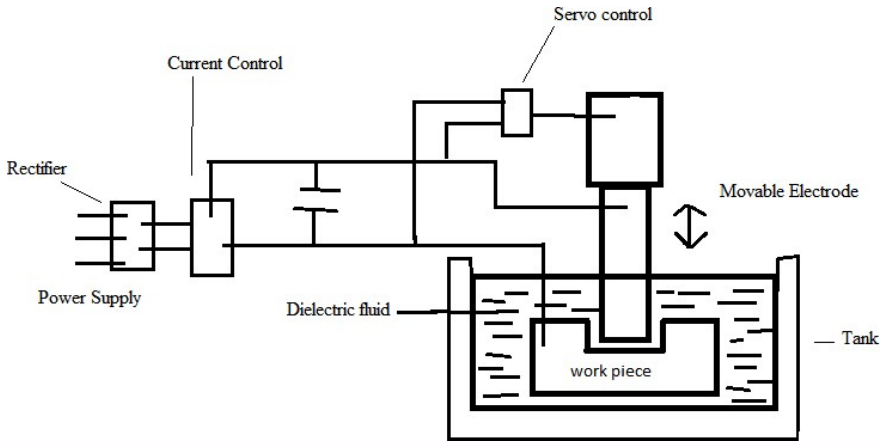


Figure 20.9 Basic scheme of electric discharge machining



WORKING PROCESS:

i. The workpiece and the tool are electrically connected to a D. C electric power supply.

ii. The workpiece is connected to the positive terminal of the electric source,
so that it becomes the anode. The tool is the cathode.

iii. A gap, known as the 'spark gap' in the ranges of 0.005 to 0.05 mm is maintained between the workpiece and the tool.

iv. Suitable dielectric slurry, which is nonconductor of electricity is forced through spark gap at pressure of 2kgf/cm^2 or less.

v. When a suitable voltage in the range of 50 to 450 V is applied, the dielectric breaks down and electrons are emitted from the cathode and the gap is ionized.

vi. In fact, a small ionized fluid column is formed owing to formation of an avalanche of electrons in the spark gap where the process of ionization collision takes place.

vii. When more electrons collect in the gap the resistance drops causing electric spark to jump between the work piece surface and the tool.

viii. Each electric discharge or spark causes a focused stream of electrons to move with a very high velocity and acceleration from the cathode towards the anode and ultimately creates compression shock waves on both the

electrode surface, particularly at high spots on the workpiece surface, which are closest to the tool.

ix. The generation of compression shock waves develops a local rise in temperature.

x. The whole sequence of operation occurs within a few microseconds.

xi. However, the temperature of spot hit by electrons is of the order of 10,000C.

xii. This temperature is sufficient to melt a part of the metals.Thus, material removed from the work piece.

2. List out advantages and disadvantages of EDM process.

Ans. The advantages & disadvantages of EDM process:

ADVANTAGES:

i. Extremely high popularity of the EDM process is due to the following advantages

ii. The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness or brittleness.

iii. Any complicated shape that can be made on the tool can be reproduces on the workpiece.

iv. Highly complicated shapes can be made by fabricating the tool with split sectioned shapes, by welding, brazing or by applying quick setting conductive epoxy adhesives.

v. Time of machining is less than conventional machining processes.

vi. EDM can be employed for extremely hardened workpiece. Hence, the distortion of the workpiece arising out of the heat treatment process can be eliminated.

vii. No mechanical stress is present in the process. It is due to the fact that the physical contact between the tool and the workpiece is eliminated. Thus, fragile and slender workplaces can be machined without distortion.

viii. Cratering type of surface finish automatically creates accommodation for lubricants causing the die life to improve.

ix. Hard and corrosion resistant surfaces, essentially needed for die making, can be developed.

DISADVANTAGES:

i. The following disadvantages of the process limit its application.
ii. Profile machining of complex contours is not possible at required tolerances.
iii. Machining times are too long.
iv. Machining heats workpiece considerably & hence cause change in surface & metallurgical properties.
v. Excessive tool wear.
vi. High specific power consumption.

3. Explain types of spark generators in details.

Ans. The Spark generating circuit may be one of the following types:

1. Relaxation generator
2. Pulse generator

Relaxation generator: In relaxation generator, the Spark generator supplies the current to a condenser, the discharge from which produces the spark. the workpiece alternatively becomes a positive electrode (anode) or negative electrode (cathode) respectively. on each reversal of polarity, the tool is eroded more than the workpiece. Hence the tool wear is greater with this type of arrangement.

Pulse generator: The introduction of pulse generator has overcome the drawbacks of relaxation generators. pulse generator is available, fitted with transistorized pulse generator circuit in which reverse pulses are eliminated. These generatorsconsist of electronic switching units which let the current pass periodically.

Modern pulse generator possesses the means of accurate control over discharge duration, pause time and the current.

These factors determine the overcut and hence the accuracy and surface finish. The tool wear is also greatly reduced.

While for finding the work high frequency and low-amperage settings are used, in roughing work low frequency discharges with high amperage are applied.

4. Write essential requirements (properties) of dielectric fluid in EDM.

Ans. The essential requirements of a dielectric fluid to be used in EDM process are that they should:

I. Remain electrically no conducting until the required break- down voltage has been reached.
II. Breakdown electrically in the shortest possible time once the breakdown voltage has been reached.
III. Rapidly quench the spark or deionize the spark or spark gap after the discharges have occurred.
IV. Provide an effective cooling medium.
V. Be capable of carrying away the swarf particles, in suspension away from the working gap.
VI. Have a good degree of fluidity.
VII. Be cheap and easily available.

5. What Is EDM? Write application of EDM.

Ans. EDM is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool (usually cathode) and the work (anode).

APPLICATION OF EDM:

i. The electrical discharge machining is used for the manufacture of tools having complicated profiles and a number of other components.
ii. The EDM provides economic advantage for making stamping tools, wire drawing and extrusion dies, forging dies, intricate mould cavities, etc.
iii. It has been extremely used for machining of exotic materials used in aerospace industries, refractory metals, hard carbides, and hard enable steels.
iv. Fine cutting with thread shaped electrode (wire - cutting EDM).

v. Drilling of micro - holes.
vi. Thread cutting.
vii. Helical profile milling.
viii. Rotary forming.
ix. Curved hole drilling.
x. The workpiece in this case is fragile to withstand the cutting tool load during conventional machining

6. What is spark gap? Explain electrode material used in EDM.

Ans. The distance (Gap) between work piece and the electrode is known as spark gap.The electrode materials generally used can be classified as:

a. Metallic materials (copper etc.),
b. Non-metallic materials (graphite), and
c. Combination of metallic and non-metallic materials (copper graphite).

3. Copper, yellow brass, zinc, graphite and some other materials are used for tools.
4. Low wearing tools include silver-tungsten, copper-tungsten, and metalized graphite.
5. For commercial applications, copper is best suited for fine machining, aluminium is used for die-sinking, and cast iron for rough machining.
6. One of the advantages of EDM is due to the fact that a tool made of a material softer than the workpiece material and which is a good conductor of electricity can be used to machine a material of any hardness.

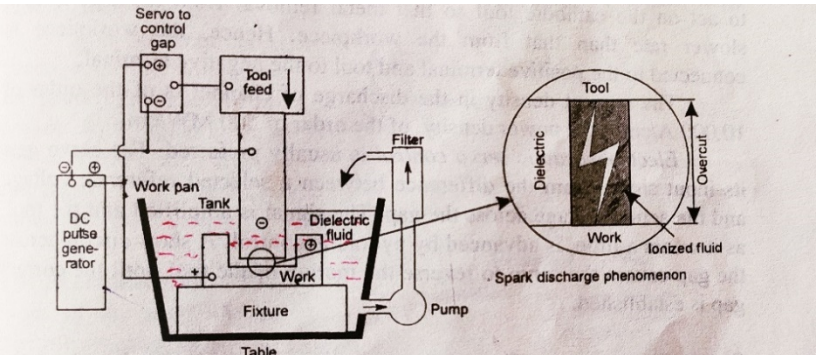


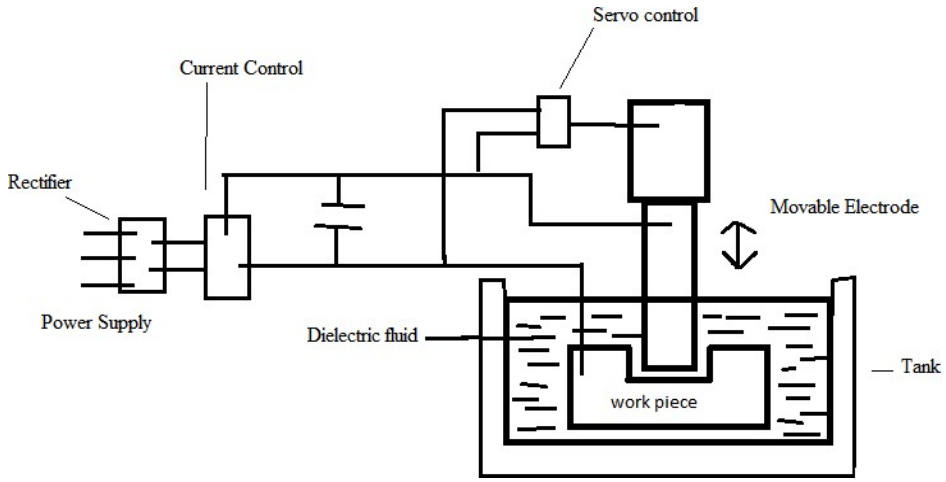
Figure 20.9 Basic scheme of electric discharge machining

7. Draw a line diagram of EDM machine and show its parts.

8. Explain dielectric fluids.

Ans. Dielectric fluid:

i. The common dielectrics used are kerosene, paraffin, transformer oil try ethylene glycol (with water 40 by volume) or their mixture and certain aqueous solutions.



ii. Water, being an electrical conductor, gives a metal removal rate of only about 40 per cent of that obtained when using paraffin as a dielectric.

iii. The dielectric should be filtered before reuse so that chip contamination of the fluid will not affect machining accuracy.

iv. The dielectric fluid must circulate freely between the tool and workpiece.

v. Flushing of eroded particle in correct manner makes the machining system efficient.
vi. Provide an effective cooling medium. Be capable of carrying away the swarf particles, in suspension away from the working gap.
vii. Have a good degree of fluidity. Be cheap and easily available.

9. Explain overcut in EDM process. Write advantages of EDM.

Ans. **OVERCUT:**

i. The shape of the area of the cavity produced in the work should theoretically be the same as that of the tool.
ii. This, however, is not exactly true because of the over cut.
iii. Overcut is the distance, the spark will penetrate the workpiece from the tool and remove metal from workpiece.
iv. Theoretically, it is slightly larger than the gap between the end of the tool and the workpiece. The overcut is generally 0.025 to 0.2 mm, on all surfaces.
v. Overcut causes internal corners on the workpiece to have fillets with radius equal to the overcut.
vi. Another effect of overcut is to cause the radius of the cavity in the workpiece slightly larger than the corresponding radius of the tool nose.

ADVANTAGES: Extremely high popularity of the EDM process is due to the following advantages:

i. The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness or brittleness.
ii. Any complicated shape that can be made on the tool can be reproduces on the workpiece.
iii. Highly complicated shapes can be made by fabricating the tool with split sectioned shapes, by welding, brazing or by applying quick setting conductive epoxy adhesives.
iv. Time of machining is less than conventional machining processes.

v. EDM can be employed for extremely hardened workpiece. Hence, the distortion of the workpiece arising out of the heat treatment process can be eliminated.
vi. No mechanical stress is present in the process. It is due to the fact that the physical contact between the tool and the workpiece is eliminated. Thus, fragile and slender workplaces can be machined without distortion.
vii. Cratering type of surface finish automatically creates accommodation for lubricants causing the die life to improve.

10. With neat sketch explain types of flushing.

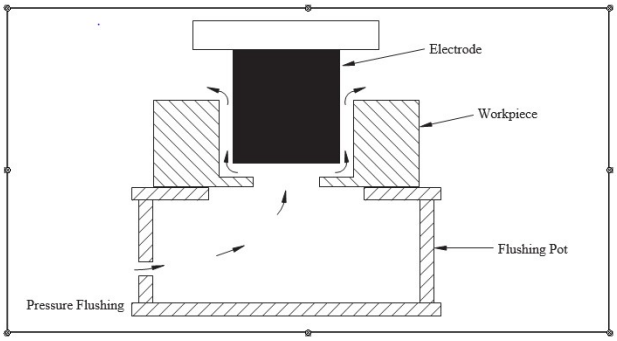
Ans. Flushing is important because eroded particles must beremoved from the gap for efficient cutting. Flushing also brings fresh dielectric oil into the gap and cools the electrode and the workpiece. The deeper the cavity, the greater the difficulty for proper flushing.

Improper flushing causes erratic cutting. This, in turn,increases machining time. Under certain machining conditions, the eroded particles attach themselves to the workpiece. This prevents the electrode from cutting efficiently. It is then necessary to remove the attached particles by cleaning the workpiece.

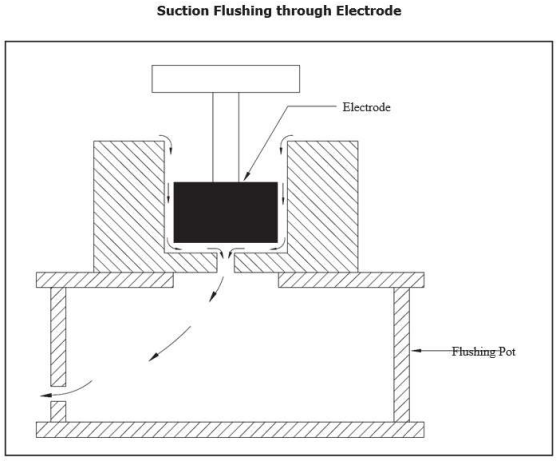
Types of flushing:

- Pressure flushing,
- Suction flushing and
- Side flushing. Or jet flushing

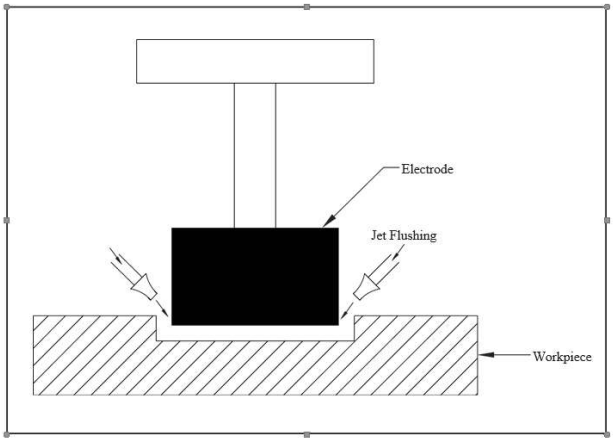
i. PressureFlushing: Pressure flushing, also called injection flushing, is the most common and preferred method for flushing. One great advantage of pressure flushing is that the operator can see the amount of oil that is being used for flushing. With pressure gauges, this method of flushing is simple to learn anduse.



ii. SuctionFlushing: Suction or vacuum flushing can be used to remove eroded gap particles.Suction flushing can be done through the electrode, or through the workpiece,



iii. JetFlushing: Jet or side flushing is done by tubes or flushing nozzles which direct the dielectric fluid into the gap. Pulse flushing is usuallyused along with jetflushing.



11. Explain process parameters of EDM.

Ans. The following are the process parameters of EDM:

(a) **Pulse On time (Ton):** It is the duration of time expressed in micro seconds

in which the peak current is ready to flow in every cycle. This is the time in which energy removes the metallic particles from the workpiece.

(b) **Pulse Off time (Toff):** It is the period of time expressed in micro seconds between the two pulse on time. This time permits the melted particle to coagulate on to the work piece and to be wash away by flushing method of the arcgap.

(c) **spark gap:** It is gap between the electrode and work piece in which the spark generates for eroding the metal from the work piece. It is very thin gap in the range of 10– 125 µm.

(d) **Discharge current (Ip)**: Current is measured in ampere (A). Discharge current is responsible directly for material removal. It contains energy for melting and evaporation.

(e) **Duty cycle (τ):** It is a ratio of the pulse on-time relative to the total cycle time expressed in percentage. This factor is calculated by dividing the on-time by the total cycle time (on plus offtime).

(f) **Voltage (V):** It is a potential difference that can be applied by the power supply in a controlled manner. Voltage is also another main factor which affects the material removal.

(g) **Over cut** – It is a measurement of clearance between tool and work piece after completing each experiment by outline of the toolmaterial.

(h) **Dielectric pressure**- Dielectric pressure is the pressure of the dielectric fluid which surrounds the work piece and the electrode. It is the rate at which this fluid is circulated in the tank.

12. What is spark gap? Write what are the process parameters of EDM machining.

Ans. The distance (Gap) between work piece and the electrode is known as spark gap.

Machining Parameters of EDM are:

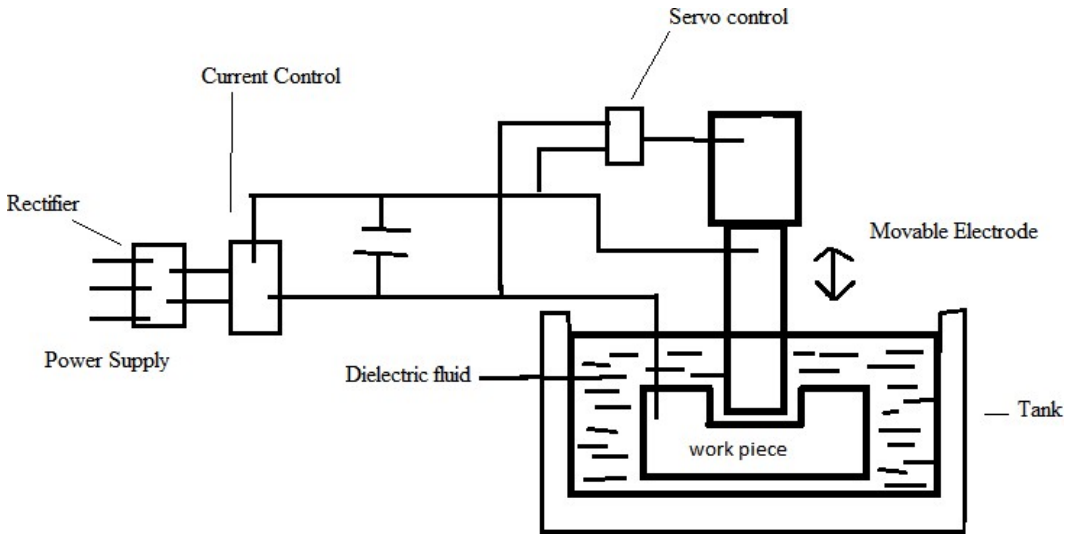
- Pulse On time (Ton).
- Pulse Off time (Toff)
- spark gap

- Discharge current (Ip)
- Duty cycle (τ)
- Voltage (V)
- Over
- Dielectric pressure

13. Explain the principal of EDM with neat sketch.

Ans. Principal of EDM:

- Electric discharge machining, also known as spark erosion, electro-erosion or spark machining.
- EDM is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool (usually cathode) and the work (anode).
- Fundamentally, the electric erosion effect is understood by the breakdown of electrode material accompanying any form of, electric discharge.
- The discharge is usually through a gas, liquid or in some cases through solids.
- A necessary condition for producing a discharge is ionization of the dielectric, i.e., splitting up of its molecules into ions and electron.



14. Explain electrode? And write different electrode materials used in EDM.

Ans. Electrode:

- The shape of the tool will be basically the same as that of the product desired except that an allowance is made for side clearance and overcut.
- For broaching small holes' solid rods may be used but for larger ones, hollow tools are preferred.
- Dielectric may then be pumped through hollow tool.
- If an object is having a geometrical shape or is having symmetry about some axis, a tool equal to only a part of the object will be sufficient for complete machining the object. Such segmented tools are especially useful for machining complex shapes that do not require close accuracy.
- It may sometimes be convenient to use a series of simpler tool rather than a complex single tool, to produce a particular cavity.
- The material used for the tool influences the tool wear and the side clearance and hence, in turn, it has considerable influence on the rate of metal removal, finish obtained, and the production rate.

The electrode materials generally used can be classified as

- Metallic materials (copper etc.),
- Non-metallic materials (graphite), and
- Combination of metallic and non-metallic materials (copper graphite).
- Copper, yellow brass, zinc, graphite and some other materials are used for tools.
- Low wearing tools include silver-tungsten, copper-tungsten, and metalized graphite.
- For commercial applications, copper is best suited for fine machining, aluminium is used for die-sinking, and cast iron for rough machining.

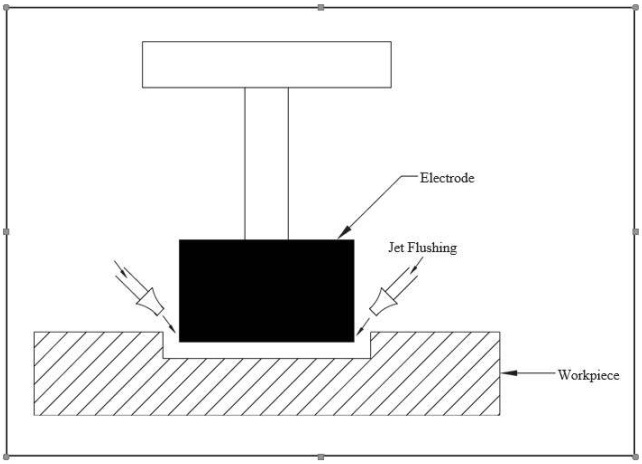
15. What is the function of servo control? And draw a neat sketch of Jet flushing.

Ans. Function of Servo control:

- Electrohydraulic servo control is usually preferred. The servo gets its input signal from the difference between a selected reference voltage and the actual voltage across the gap.
- The signal is amplified and the tool, as it wears a little, is advanced by hydraulic control.
- A short circuit across the gap causes the servo to reverse the motion of the tool until the correct gap is established.

JetFlushing

Jet or side flushing is done by tubes or flushing nozzles which direct the dielectric fluid into the gap. Pulse flushing is usuallyused along with jetflushing.



CHAPTER-2 WIRE ELECTRIC DISCHARGE MACHINING.

PART-A

FILL IN THE BLANKS:

1. Graphite type of material is used for electrical discharge
2. Advance manufacturing technology is combination of innovative and processes.
3. The diameter of wire used in wedm ranges from 0.1 to 0.25mm.
4. In EDM process the metal removed is carried out by melting and evaporation of work piece.
5. Brass wire used as cutting tool in WEDM.
6. Purposes of resin used in WEDM to maintain conductivity.

7. In WEDM only conductor material can be machined.
8. In wedm ionized mineral water is used as coolant.
9. The full form of WEDM is wire electric discharge machine.
10. Wire electric discharge (ED) machining is based on the same principle as that of die-sink EDM
11. The only difference between die-sink EDM and wire cut EDM is the electrode used for the machining
12. During wire cut EDM, the size of the cavity produced by the wire while machining depends upon electric current
13. Sparking gap is the distance between the workpiece and the electrode wire
14. The absolute minimum inner corner radius is the wire radius plus the sparking gap width_
15. The wire ED machines have 2-5 programmable axes.
16. Which of the following component of the wire cut EDM machine does not get heated… Electrode wire
17. Which of the following material properties sets restrictions to use wire cut EDMElectrical conductivity?
18. The electrode wires are usually made form brass
19. WEDM conductivity maintain by ionized mineral water
20. Normally in wedm brass wire diameter is 0.20mm

MULTIPLE CHOICE QUESTIONS:

1. A thin metallic wire used in wire-cut EDM is kept submerged in a tank of _____

   a) dielectric fluid

   b) pure water

   c) molten metal

   d) kerosene

2. Wire-cut EDM can cut plates of thickness upto _____

   a) 50mm

   b) 100mm

c) 300mm

d) 500mm

3. In WEDM, the wire is held tight between_____

   a) upper and lower nozzles

   b) upper and lower diamond guides

   c) upper and lower groves in the handle

   d) upper and lower pulleys

4. The upper guide can move independently about_____

   a) x-axis

   b) y-axis

   c) x-y-w axes

   d) z-u-v axes

5. In the wire-cut EDM process, de-ionizing units are used for controlling the _____

   a) feed rate

   b) resistivity

   c) burr formation

   d) temperature of the wire

6. In the wire-cut EDM process, water is also used for _____

   a) cooling

   b) increasing the feed rate

   c) flushing away the burr

   d) controlling the cutting speed

7. He WEDM process requires _____

   a) lower initial investment

   b) lesser cutting forces

   c) a skilled operator

   d) a coolant pump

8. Electrically conductive materials are cut by WEDM process by _____ mechanism.

   a) Thermal

   b) electro-thermal

   c) electro-dynamic

   d) fused metal

9. In Electrical discharge machining (EDM), the spark gap is kept between ___mm to___mm.

   a. 5 to 5

   b. 05, 0.5

   c. 005, 0.05

   d. 0005, 0.005

10. In Electrical discharge machining, the temperature developed is of the order of

   a. 2,000°C

   b. 6,000°C

   c. 10,000°C

   d. 14,000°C

11. Which of the following is not true in case of Electrical discharge machining (EDM)?

   a. Erosion takes place both on Work piece and the tool.

   b. Gap between tool and work piece is controlled by servo mechanism.

   c. The electrode (tool) is made of graphite or copper.

   d. The size of impression on work piece is exactly the same as that on electrode (tool).

12. In Electron beam machining, workpiece is held in

   a. vacuum chamber

   b. dielectric medium

   c. electrolyte

   d. none of these

13.In Electron beam machining, as the electrons strikes the work piece

a) Their kinetic energy is converted into heat
b) They get scattered
c) Mechanical erosion in work piece takes place
d) Electro-chemical etching takes place

14. What is the full form of LBM in advanced machining processes?

a. Laser Beam Manufacturing

b) Laser Beam Machining

c) Light Blast Manufacturing

d) Light Beam Machining

15. LBM offers a good solution for which material properties below?

a) Thermal conductivity

b) Specific heat

c) Boiling temperature

d) All of the mentioned

16. Which of the following are the properties of a laser?

a) Highly collimated

b) Monochromatic

c) Coherent light beam

d) All of the mentioned

17. Laser beam machining uses which type of power sources for machining?

a) Very low power

b) Low power

c) Medium power

d) High power

18. n advanced machining processes, what is the full form of AWJM?

a) Automated Water Jet Machining

b) Automated Water Jet Manufacturing

c) Abrasive Water Jet Machining

d) Abrasive Water Jet Manufacturing

19. What are all the types of materials, which can be machined using AWJM?

a) Glass

b) Ceramics

c) Concrete

d) All of the mentioned

20. When compared to the conventional machining, how many times faster, is the Abrasive water jet machining?

a) 5 times

b) 10 times

c) 15 times

d) 20 times

ANSWERTHE FOLLOWING: (2M)

1.What materials can wire EDM cut?

Ans. Virtually any conductive material can be cut using Wire EDM. This would include all metals, including steel, aluminium, brass, titanium, and alloys and super alloys of all types.

2.How accurate is Wire EDM?

Ans. Wire EDM is extremely accurate. Many machines move in increments of 40 millionths of an inch (. 00004") (. 001 mm), some in 10 millionths of an inch.

3. Accuracy of Wire EDM?

Ans. Wire EDM is extremely accurate. Many machines move in increments of 40 millionths of an inch (. 00004") (Machines can achieve accuracies of +/-).

4. When compared to the conventional machining, how many times faster, is the Abrasive water jet machining?

Ans. Its 10times faster comparatively.

5. What is the meaning of spark gap in wire edm?

Ans. The spark gap is the physical distance the electric current has to jump off the wire to burn the workpiece when wire EDMing.

6. Write one advantageof wedm.

Ans. Creates simple or complex shapes or patterns that would be challenging to produce with conventional cutting tools.

7. In WEDM, what is the range of temperature?

Ans. Eelectric spark produces intense heat with **temperatures** reaching 8000 to 12000 degrees Celsius, melting almost anything.

PART-B

ANSWERTHE FOLLOWING: (3M)

1. What is wire edm?

Ans. Wire electrical discharge machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal work piece. ... Instead of cutting the material, EDM melts or vaporizes it, leaving little debris and providing a very accurate line.

2. What is the meaning of spark gap in wire edm

Ans. The spark gap is the physical distance the electric current has to jump off the wire to burn the workpiece when wire EDMing. Wire EDMing requires a combination of small mechanical and, especially, electrical changes to occur thousands of times per second to be stable and consistent, he added

3. Write advantages of wedm

Ans. Creates simple or complex shapes or patterns that would be challenging to produce with conventional cutting tools. NC controlled cutting patterns can be completed quickly on a wide range of stainless-steel alloys while maintaining a low Ra surface roughness.

4. What is the difference between wedm and edm

Ans. A **Wire EDM** or **WEDM** uses thin conductive wire, usually brass, to electrically discharge power and erode a path in or on a work piece much like a band saw, while a die sinker uses shaped or sized electrodes, usually graphite or copper to erode a work piece.

5. What is the material used for wedm as a cutting tool

Ans. In wire electrical discharge machining (**WEDM**), also known as wire-**cut** EDM and wire **cutting**, a thin single-strand metal wire, usually brass, is fed through the workpiece, submerged in a tank of dielectric fluid, typically deionized water.

6. What is the difference between cnc and conventional machine?

Ans. CNC stands **for** Computerized Numerical Control meaning that a **CNC** lathe is controlled by a computer. It moves automatically. Within the other hand, in **conventional** lathes series, all the movements are manually done by the operator. ... **Conventional** Lathes are the pioneer **of manufacturing**.

7. What is the maximum temperature of wedm?

An electrical spark is created between an electrode and a workpiece. The spark is visible evidence of the flow of electricity. This electric spark produces intense heat with **temperatures** reaching 8000 to 12000 degrees Celsius, melting almost anything.

8. What is resin?

Ans. Ion is an ion-exchange **resin** developed specially for wire **EDM**. It keeps the resistivity of the dielectric fluid to an appropriate level and helps to ensure stable machining performance.

9. What is wire edm?

Wire electrical discharge machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal work piece. Instead of cutting the material, EDM melts or vaporizes it, leaving little debris and providing a very accurate line.

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ANSWERTHE FOLLOWING: (5M)

1. What is wedm?

Ans. Wire Electrical Discharge Machining (**WEDM**) is an indispensable non- traditional machining process, capable of producing complex two and three-dimensional shapes with good accuracy and precision to satisfy the present-day requirements of the manufacturing industries.

2. What are the main parts of WEDM and explain wire guide

Ans. EDM system consists of **four basic components** tool electrode and work piece, pulsed power supply system, dielectric supply system and electrode feeding system. Wire guide A device used to enter tight spaces, e.g., obstructed valves or channels, within the body, or to assist in inserting, positioning, and moving a catheter. Guidewires vary in size, length, stiffness, composition, and shape of the tip.

3. What do you understand about Di-electric fluid?

A liquid dielectric is a dielectric material in liquid state. Its main purpose is to prevent or rapidly quench electric discharges. Dielectric liquids are used as electrical insulators in high voltage applications, e.g. transformers, capacitors, high voltage cables, and switchgear (namely high voltage switchgear).

4. What are the Components of a Wire EDM system?

Ans. Although available in several models, all kinds of EDM machines have the following components in common.

- Computerized Numerical Control (CNC)
- Power Supply
- Mechanical Section comprises of worktable, workstand, taper unit, and wire drive mechanism.
- Dielectric System

5. What are the advantages of wedm?

Ans. Better dies and moulds can be produced from wire **EDM** cutting for lower cost. Because any electrically conductive material can be efficiently machined using wire **EDM** machining, no matter how hard or fragile, machining takes less time and can be completed in one process. Because of this, wire **EDM** also produces less waste.

6.What is the disadvantage of wedm?

Ans. **Disadvantages** of Electrical Discharge Machining The additional time and cost used for creating electrodes for Ram/Sink **EDM**. Reproducing sharp corners on the work piece is difficult due to electrode wear.

7. What is spark gap and explain

Ans. **Spark gap** consists of an arrangement of two conducting electrodes separated by a **gap** usually filled with a gas such as air, designed to allow an electric **spark** to pass between the conductors.

8. What is the application of wedm?

Ans. Wire **EDM** is most commonly used in mould and dies manufacturing processes, particularly for extrusion dies and blanking punches. **EDM** can be used in everything from prototypes to full production runs, and is most often used to manufacture metal components and tools.

9. What are the Personal Safety Precautions to be taken during the Machining Process?

Ans. The machining process can be dangerous in case if you don't pay attention to some basic safety precautions. Stringently follow the guidelines below throughout the process.

- Do not touch the component being cut during the process
- Do not touch the brass wire when it is in operation
- Rectify immediately in case any leakage of deionized water from the machine
- Use rubber gloves and protective shoes throughout the process
- Refrain from wearing conductive ornaments like watch and gold

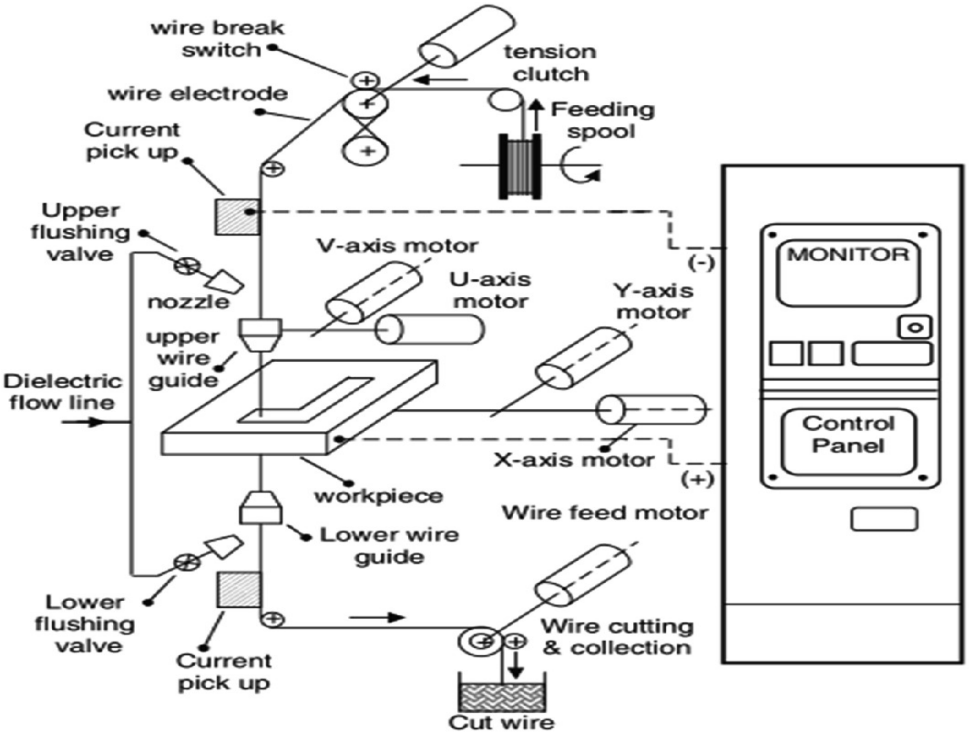
10. What are the properties of di-electric fluid

Ans. A good liquid dielectric should have high dielectric strength, high thermal stability and inertness against the construction materials used, non-**flammability** and low toxicity, good heat transfer properties, and low cost.

ANSWERTHE FOLLOWING: (5M)

1. What is wedm? Draw line diagram of wedm and label its parts.

Wire EDM machining (Electrical Discharge Machining) is an electro thermal production process where a thin single strand metal wire, along with de-ionised water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks, while preventing rust.



2. Explain the principle of wire EDM process.

Ans. Wire cut EDM machineputs impulse voltage between electrode wire and workpiece through impulse source, controlled by servo system, to get a certain gap, and realize impulse discharging in the working liquid between electrode wire and workpiece. Numerous tiny holes appear due to erosion of impulse discharging,

Electrode wire is connecting to cathode of impulse power source, and workpiece is connecting to anode of impulse power source. When workpiece is approaching electrode wire in the insulating liquid and gap between them getting small to a certain value, insulating liquid was broken through; very shortly, discharging channel forms, and electrical discharging happens. And release huge high temperature instantaneously, up to more than 10000 degree centigrade, the eroded workpiece is cooling down swiftly in working liquid and flushed away.

3. Explain about the wire material, & dielectric fluid a of wire EDM.

WEDM, the workpiece material is eroded by a series of discrete sparks between the workpiece and a traveling wire electrode immersed in a liquid dielectric medium. These

electrical discharges melt and vaporize minute amounts of the work material, which are then ejected and flushed away by the dielectric

dielectric fluid serves two main purposes. First, it acts as a semiconductor between the electrode and workpiece to facilitate a stable and controlled spark gap ionization condition. Second, it also acts as a flushing agent to wash and remove the eroded debris from the spark gap area

4.Explain: spark gap, resin, inwedm

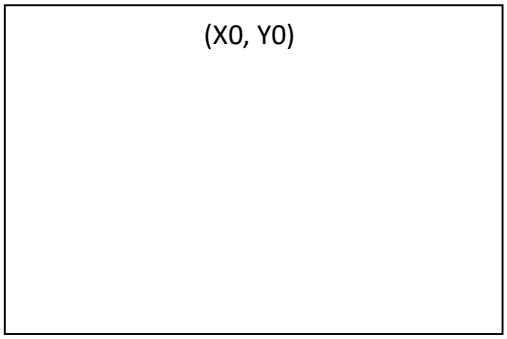
Ans. The **spark gap** is the physical distance the electric current has to jump off the wire to burn the workpiece when wire EDM If the **spark gap** is too small **for** the wire diameter, the **spark** produces a short circuit, which can damage the workpiece and break the wire.

RESIN. Ion exchange **resin** provides the removal of metallic contaminants in the water from wire erosion **machine** and reduces the conductivity in water. Its raw material is high-grade virgin **resin**. This material can be used safely in all types of **EDM machine** for water treatment.

5.Make simple program of 100mm square punch in WEDM.

SIZE: - X=100,

Y=50



G 90 G 92 X0 Y 5.

E9080 D150

M17

G41 G01 X0 Y0

G01 X 50 Y0

G01 X 50 Y-50

X-50 Y-50

X-50 Y0

X -2.Y0

M00

X0.2 Y0

M01

G 40 G01 X0 Y0.

G00X0Y5.

M02

6. What are the advantages and dis advantages of WEDM.

Ans. **Advantages:**Better dies and moulds can be produced from wire EDM cutting for lower cost. Because any electrically conductive material can be efficiently machined using wire EDM machining, no matter how hard or fragile,

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Disadvantages of Electrical Discharge Machining The slow rate of material removal. The additional time and cost used for creating electrodes for Ram/Sink **EDM**. Reproducing sharp corners on the work piece is difficult due to electrode wear.

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11. What is wire cut process?

During the wire cutting process there is no direct contact between the wire and the work piece which allows for machining without causing any distortion in the path of the wire, or the shape of the material. To accomplish this, the wire is very rapidly charged to a desired voltage.

12.What is EDM wire made of?

In wire electrical discharge machining (WEDM), also known as wire-cut EDM and wire cutting, a thin single-strand metal wire, usually brass, is fed through the work piece, submerged in a tank of dielectric fluid, typically deionized water.

13. What is the principle of EDM?

Principles of EDM

Electrical Discharge Machining (EDM) is a controlled metal-removal process that is used to remove metal by means of electric spark erosion. In this process an electric spark is used as the cutting tool to cut (erode) the workpiece to produce the finished part to the desired shape.

14. What are the advantages of EDM?

Advantages of EDM include machining of: Complex shapes that would otherwise be difficult to produce with conventional cutting tools. Extremely hard material to very

close tolerances. Very small work pieces where conventional cutting tools may damage the part from excess cutting tool pressure.

15. What is CNC EDM wire cut?

Wire electrical discharge machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal workpiece. ... Instead of cutting the material, EDM melts or vaporizes it, leaving little debris and providing a very accurate line.

16.What is CNC EDM wire cut?

Wire electrical discharge machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal workpiece. ... Instead of cutting the material, EDM melts or vaporizes it, leaving little debris and providing a very accurate line.

17.What is wire EDM technology?

Share: Wire electrical discharge machining (EDM) is a process of metal machining in which a tool discharges thousands of sparks to a metal workpiece. ... Instead of cutting the material, EDM melts or vaporizes it, leaving little debris and providing a very accurate line.

18.What is wire EDM used for?

What is Wire EDM machining? Wire EDM machining (Electrical Discharge Machining) is an electro thermal production process where a thin single strand metal wire, along with de-ionised water (used to conduct electricity) allows the wire to cut through metal by the use of heat from electrical sparks, while preventing rust.

21. What is wire cut process?

During the wire cutting process there is no direct contact between the wire and the work piece which allows for machining without causing any distortion in the path of the wire, or the shape of the material. To accomplish this, the wire is very rapidly charged to a desired voltage.

22. What materials can wire EDM cut?

Virtually any conductive material can be cut using Wire EDM. This would include all metals, including steel, aluminium, brass, titanium, and alloys and super alloys of all types.

23. How accurate is Wire EDM?

Wire EDM is extremely accurate. Many machines move in increments of 40 millionths of an inch (. 00004") (. 001 mm), some in 10 millionths of an inch.

24. What are advantages of wedm

Better dies and molds can be produced from wire EDM cutting for lower cost. Because any electrically conductive material can be efficiently machined using wire EDM machining, no matter how hard or fragile, machining takes less time and can be completed in one process. Because of this, wire EDM also produces less waste.

CHAPTER-3 ELECTRO CHEMICAL MACHINING

PART-A

FILL IN THE BLANKS:

1. The solution present in electro chemical machining is known as Electrolyte
2. High velocity Flowover the electrode surface is one of the key factors in ECM.
3. In ECM most commonly used electrolyte is the solution ofSodium Chloride
4. Surface roughness in chemical machining is 0.2 to 1.5 µm
5. Electrolyte used in ECM is NaCl and $NaNO_3$
6. Voltage range in ECM is 2 to 35 V
7. Current range in ECM is 50 to 40,000 A
8. Flow rate of electrolyte in ECM is 20 lpm/100 A current
9. Over cut in ECM is 0.2 mm to 3 mm
10. Feed rate in ECM is 0.5 mm/min to 15 mm/min
11. Electrode material in ECM is Copper, brass and bronze
12. The dilution of electrolyte in ECM is 100 g/l to 500 g/l

13. Pressure of electrolyte in ECM 0.5 to 20 bar
14. Direct Current is used for power supply in ECM.
15.

MULTIPLE CHOICE QUESTIONS:

1. Electrolyte used in ____ machining process
    a. CHM
    b. ECM
    c. USM
    d. EDM

2. In electro chemical machining
    a. Both tool & work piece are stationary
    b. Both tool & work piece moves
    c. Tool is stationary & work piece moves
    d. Tool moves & work piece is stationary

3. In ECM, using sodium chloride solution is that its electrical conductivity is fairly constant from PH value _____.
    a. 0 to 3
    b. 0 to 13
    c. 0 to 23
    d. 0 to 33

4. “when some quantity of electricity is passed through several electrolytes, the mass of the substance deposited are promotional to their respective chemical equivalent or equivalent weight”.
    a. Faradays 1st law
    b. Faradays 2nd law
    c. Faradays 0th law

d. None

5. Temperature range in ECM is
   a. 20°C to 50°C
   b. 30°C to 50°C
   c. 40°C to 50°C
   d. 25°C to 50°C

6. Working gap in ECM is
   a. 0.1 to 0.5mm
   b. 0.1 to 1mm
   c. 0.05 to 1mm
   d. 0.1to 2mm

7. Feed rate in ECM is
   a. 0.5 mm/min to 15 mm/min
   b. 0.6 mm/min to 15 mm/min
   c. 0.7 mm/min to 15 mm/min
   d. 0.8 mm/min to 15 mm/min

ANSWERTHE FOLLOWING: (2M)

1. State Faraday's 1st Law?

Ans. Faradays first law of electrolysis states that "the mass of the substance (m) deposited or liberated at any electrode is directly proportional to the quality of electricity or charge (q) passed".

2. State Faraday's 2nd Law?

Ans. Faradays second law of electrolysis states that "when some quantity of electricity is passed through several electrolytes, the mass of the substance deposited are promotional to their respective chemical equivalent or equivalent weight".

3. What is electro chemical machining?

Ans. Electro Chemical Machining (ECM) Electrochemical machining (ECM) is a non-traditional machining process uses the principle of Faraday to remove metal from the workpiece.

4. Write two applications of ECM.

Ans. Application

- The ECM process is used for die sinking operation, profiling and contouring, drilling, grinding, trepanning and micro machining.
- It is used for machining steam turbine blades within closed limits.

5. Write two disadvantages of ECM.

Ans. Disadvantages**:**

- The risk of corrosion for tool, w/p and equipment increases in the case of saline and acidic electrolyte.
- Electrochemical machining is capable of machining electrically conductive materials only.

6. What are the applications of ECM process any two?

Ans. Applications are:

- Pre sinking operations
- Drilling jet energy turbine blades

ANSWERTHE FOLLOWING: (3M)

1. What are the applications of ECM process?

   Ans. Applications are:

   - Pre sinking operations
   - Drilling jet energy turbine blades
   - Multiple hole drilling
   - Machining steam turbine blades with close limits

2. Explain electrolysis of copper on iron?

Ans. When copper electrode is used in the electrolysis of copper surface solution, the mass loss of copper from the positive anode should be equal to the mass of copper gained and deposited on the negative cathode electrode.

Important elements of ECM

1) Electrolysis

2) Tool(cathode)

3) Workpiece (anode)
4) D.C power supply

3. Write types of electrolytes used in ECM?

   Ans. Types are:

   - Common salt (NaCl)
   - Sodium chlorate (NaClO3)
   - Sodium Nitrate (NaNO2)
   - Sulphuric acid (H2SO4)
   - Sodium hydrate (NaOH)

4. What are the factors effecting in accuracy of the parts produced by ECM?

   Ans. There are a number of factors which govern the accuracy of the parts produced by ECM. The major ones are:

   - Machining voltage
   - Temperature of the electrolyte.
   - Feed rate of electrode
   - Concentration of electrolyte.

5. Explain about electrolyte?

   Ans. The common electrolytes are sodium chloride, sodium nitrate, potassium chloride, sodium hydroxide, sodium fluoride, sulphuric acid and sodium chlorate. These solutions on reaction produce an insoluble compound in the form of sludge.

6. What is the use of electrochemical machining?

Ans. Electrochemical machining. Electrochemical machining (ECM) is a method of removing metal by an electrochemical process. It is normally used for mass production and is used for working extremely hard materials or materials that are difficult to machine using conventional methods. Its use is limited to electrically conductive materials.

7. What is an electrolyte in machining?

Ans. Electrolyte: In Electro Chemical Machining an electrolyte acts as a current carrier. The electrolyte in Ecm should have high electrical conductivity, low viscosity, high specific heat, chemical stability, resistance to form a passivating film on the workpiece surface, non-corrosives and non-toxicity.

8. What is the difference between electrochemical and ECM?

Ans. In ECM the material removal takes place at atomic level so it produces a mirror finish surface. This process is used to machine only conductive materials. ECM working is opposite to the electrochemical or galvanic coating or deposition process.

9. Write the modules or equipment's of ECM.

Ans. The ECM system has the following modules or Main Equipment of ECM:

i. Power Supply
ii. Electrolyte filtration and delivery system
iii. Tool Feed system
iv. Working Tank

10. Explain workpiece holding system in ECM.

Ans. Work piece and work holding system:

In this process, work piece should be well electric conductive. Only electric conductive material can be machined by this method. Work piece take as anode in this process. The work holding devices should have non-conductive property.

11. What are the function of electrolyte?

Ans. The main functions of electrolytes in ECM are

- It carries the current between the tool and the work piece

- It removes products of machining and other insoluble products from the cutting region

ANSWERTHE FOLLOWING: (5M)

1. Write a short note on Electrolysis?

Ans. The common electrolyte used are sodium chlorine, sodium nitrate, potassium chloride, sodium hydroxide, sodium fluoride,sulphuricacid, sodiumchloride, these solutions on reaction produced an insoluble compound in the form of sludge. The main functions of electrolytes in ECM are

- It carries the current between the tool and the workpiece
- It removes products of machining and other insoluble products from the cutting region
- It dissipates heat produced in the operation
- The essential characterize of insulator includes good electrical conductivity
- Non toxicity and chemical stability
- Non corrosive property
- Low viscosity and high specific heat

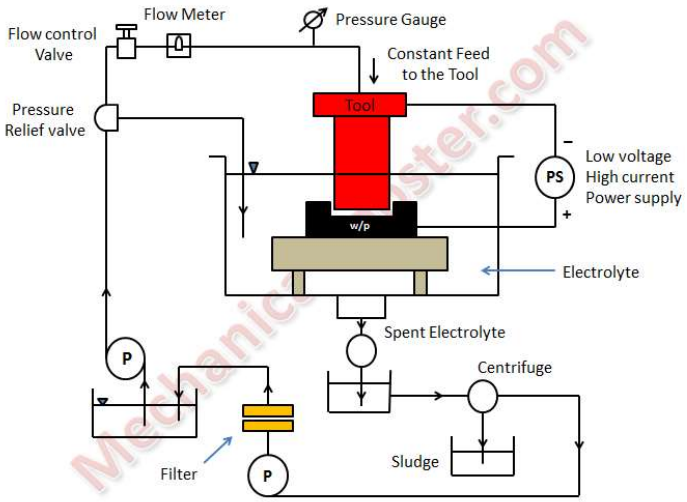
2. Write the types of electrolytes with an example which are used in ECM process?
    - Common salt (NaCl) – alloyed and unalloyed steel
    - Sodium chlorate (NaClO3) - steel
    - Sodium Nitrate (NaNO2) – copper alloys
    - Sulphuric acid (H2SO4) – nickel, chromium cobalt alloys
    - Sodium hydrate (NaOH) – tungsten and molybdenum

3. State Faraday's 1^{st} and 2^{nd} Law?

Ans. Faradays first law of electrolysis states that "the mass of the substance (m) deposited or liberated at any electrode is directly proportional to the quality of electricity or charge (q) passed".

Faradays second law of electrolysis states that “when some quantity of electricity is passed through several electrolytes, the mass of the substance deposited are promotional to their respective chemical equivalent or equivalent weight”.

4. Draw a diagram of ECM process.



5. Explain working of ECM.

Ans. Working of Electrochemical Machining**:**

- First, the workpiece is assembled in the fixture and the tool is brought close to the workpiece. The tool and workpiece are immersed in a suitable electrolyte.
- After that, a potential difference is applied across the w/p (anode) and tool (cathode). The removal of material starts. The material is removed in the same manner as we have discussed above in the working principle.
- Tool feed system advances the tool towards the w/p and always keeps a required gap in between them. The material from the w/p comes out as positive ions and combine with the ions present in the electrolyte and precipitates as sludge. Hydrogen gas is liberated at the cathode during the machining process.
- Since the dissociation of the material from the w/p takes place at atomic level, so it gives excellent surface finish.
- The sludge from the tank is taken out and separated from the electrolyte. The electrolyte after filtration again transported to the tank for the ECM process.

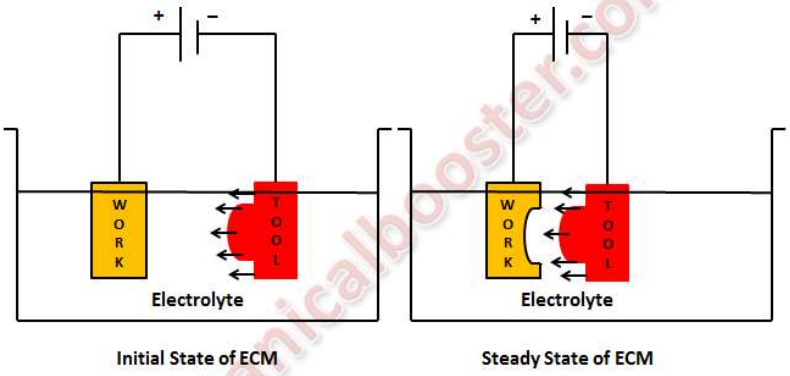
6. Which all process parameters are consider in ECM.

   Ans. The following are the process parameters:

   1. Power supply.
      - Type
      - Voltage
      - Current
      - Current density.
   2. Electrolyte
      - Material
      - Temperature
      - Flow rate
      - Pressure
      - Dilution
   3. Working gap
   4. Feed rate
   5. Overcut
   6. Electrode material
   7. Surface roughness.

ANSWERTHE FOLLOWING: (8M)

1. Explain principle of working of ECM process?



Working Principle of Electrochemical Machining

Electro chemical machining is a process of removing material metal without the use of mechanical or thermal energy. Basically, electrical energy is combined with chemical to form the workpiece.

The electrolyte is pumped through the gap between the tools (anode) while a direct current is passed through the workpiece (anode) while a direct current is passed through the cell at low voltage so as the dissolve metal from the workpiece.

Electrolytes are different from the metallic conductors of electricity in that current is carried not by electron but atoms, or group of atoms.

Electrolytes are substances are substance that become ions in solution and acquire the capacity to conduct electricity. the electrolyte has three main functions in the ECMprocess. t carries the current between the tool and the workpiece, it removes the product of the reaction from the cutting region, and it removes the heat product by the current flow I the operation.

Electrolyte must have high conductivity, low toxicity and electrochemical stability. The rate of material removal In ECM is governed by faradays law and is function of current density. Primary variable that affect the current density and MRR are voltage, feed, and feed rate, electrolyte conductivity, electrolyte flow rate and material of the work piece. Therefore, electrolyte must be selective carefully.

An extremely useful tool for optimization of the ECM process is the polarization curve. Polarization studies can provide important and useful information on the electrolyte properties for the ECM process.

2. Write the advantages and disadvantages of ECM?

Advantages:

- Residual stress is low
- It can machine configurations which are beyond the capability ofconventional machining processes
- Surface finish is in the order of 0.2 to 0.8 microns
- Tool wear is nearly absent
- Extremely thin metal sheets can be easily worked without distortion

Disadvantages:

- The specific power consumption in this process is nearly 100 times more than in turning or milling steel
- Non conducting materials cannot be machined
- Corrosion and rust of ECM machine can be a hazard

3. What is electro chemical machining? Explain the process of ECM?

   Ans. In the EMC process, a cathode (tool) is advance into anode (workpiece). The pressurized electrolyte is injected at a set temperature to the area being out.

   The feed rate of "liquefaction" of the material, the gap between the tool and the workpiece varies within 80-800 micrometers (0.003- 0.030 in).

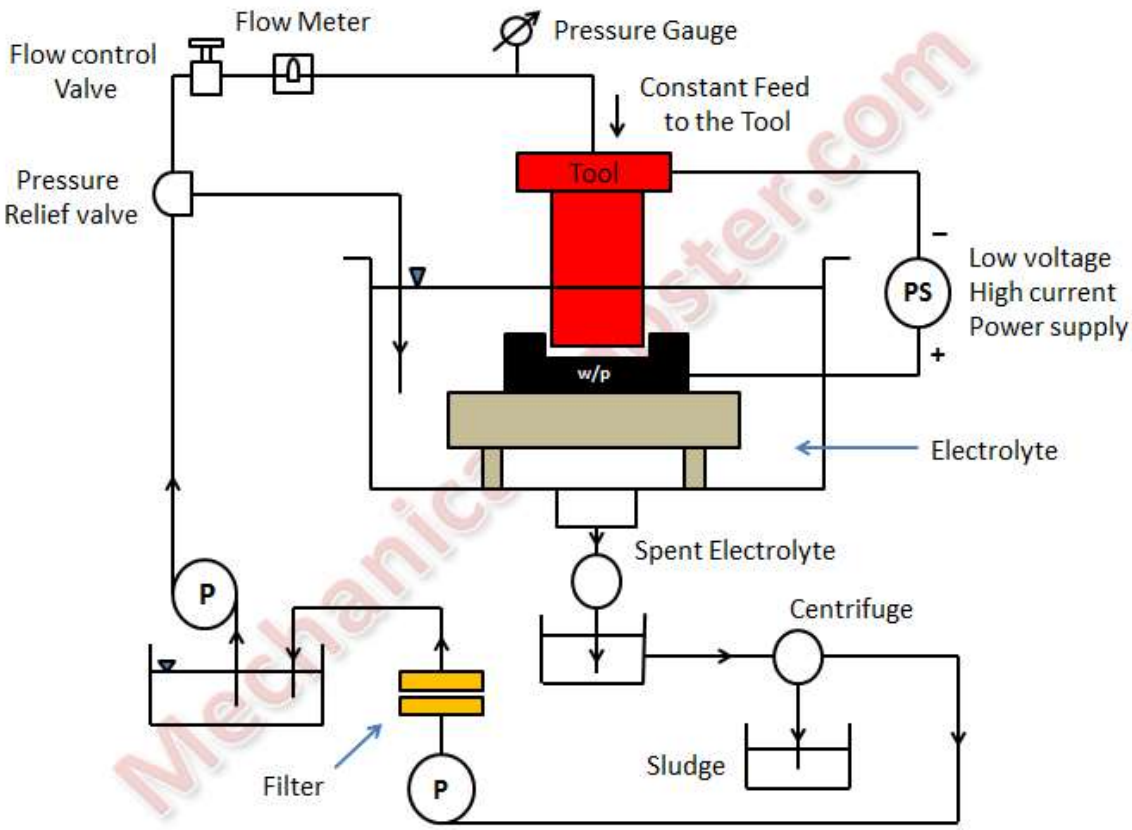
   As electrons cross the gap, material from the workpiece is dissolved, as the tool from the desired shape in the workpiece. The electrolytic fluid carries away the metal by hydroxide formed in the process.

   The ECM process is not widely used to produce complicated Shape such as turbine blades with good Surface finish in difficult to machine materials. If is also widely and effectively used as o de-burring Process.

4. Write the working of WCM

   Ans. The ECM system has the following modules or Main Equipment of ECM:

   a. Power Supply
   b. Electrolyte filtration and delivery system
   c. Tool Feed system
   d. Working Tank



Working of Electrochemical Machining:

- First, the workpiece is assembled in the fixture and the tool is brought close to the workpiece. The tool and workpiece are immersed in a suitable electrolyte.
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- Since the dissociation of the material from the w/p takes place at atomic level, so it gives excellent surface finish.
- The sludge from the tank is taken out and separated from the electrolyte. The electrolyte after filtration again transported to the tank for the ECM process.

5. Write process parameter of ECM.

Ans. Process Parameter

S.no	Parameters	Values
1.	Power Supply	
	Type	Direct Current
	Voltage	2 to 35 V
	Current	50 to 40,000 A
	Current Density	0.1 A/mm2 to 5 A/mm2
2.	Electrolyte	
	Material	NaCl and NaNO3
	Temperature	20°C to 50°C
	Flow rate	20 lpm/100 A current
	Pressure	0.5 to 20 bar
	Dilution	100 g/l to 500 g/l
3.	Working gap	0.1 mm to 2mm
4.	Overcut	0.2 mm to 3 mm
5.	Feed rate	0.5 mm/min to 15 mm/min
6.	Electrode material	Copper, brass and bronze
7.	Surface roughness (Ra)	0.2 to 1.5 µm

6. Principle of Electrochemical Machining:

   Ans. Electrochemical machining works on the Faraday law of electrolysis which state that if two electrode are placed in a container which is filled with a conductive liquid or electrolyte and high ampere DC voltage applied across them, metal can be depleted form the anode (Positive terminal) and plated on the cathode (Negative terminal). This is the basic principle of electrochemical machining. In this machining process, tool is connected with the negative terminal of battery (work as cathode) and work-piece is connected with the positive terminal of battery (work as anode). They both are placed in a electrolyte solution with a small distance. When the DC current supplied to the electrode, metal removed from work-piece. This is basic fundamental of electrochemical machining.

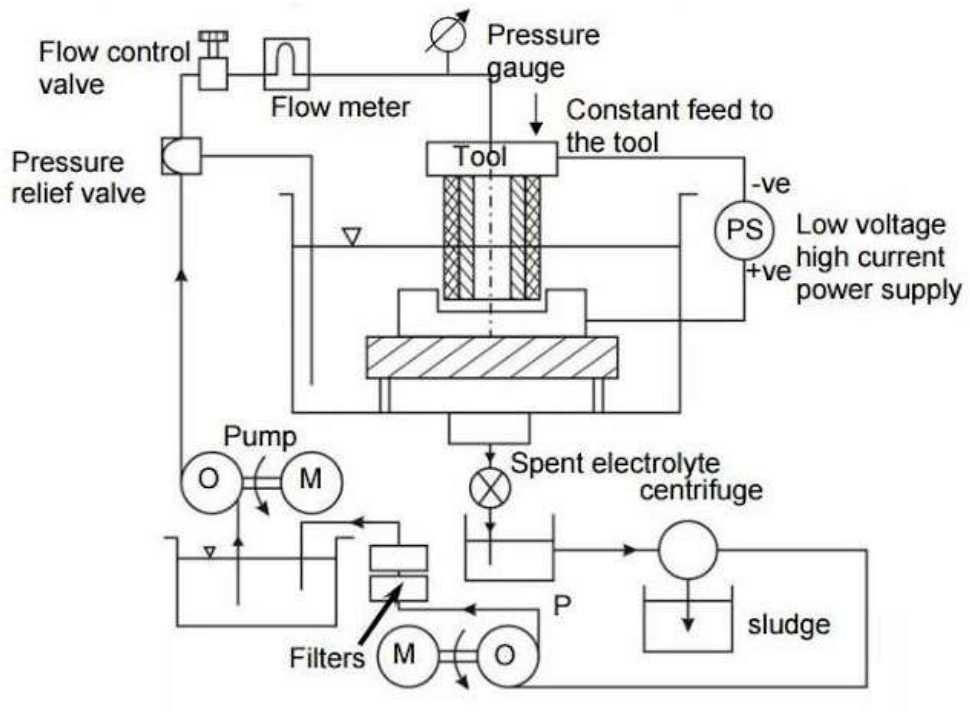


Diagram of Electrochemical Welding

7. Explain equipment's of ECM

Ans. Equipment:

Power supply:

In electrochemical machining process, a high value of direct current around 40000A and low value of potential difference around 10-25V is desirable. The electrodes are place at a inter electro gap which is desirable for machining. If the inter electro gap not too small witch can generate arc or not too high witch is not suitable for machining. It is about 1mm. This high values DC current is form by convert three phase AC current into DC current by using Silicon Controlled Rectifier.

Electrolyte supply and cleaning system:

It consists piping system, storage tank, pump, control valve, pressure gauge, heating or cooling coil etc. in the electrochemical process, the metal removed from work-piece form sludge which should be remove form electrolyte. This system controls the flow and cleaning of electrolyte solution into the container. Piping system is made of SS steel, Glass fibre reinforced plastic, plastic

lined MS or similar other anti-corrosive material. The tank capacity is about 500 gallons for per 10000A of current.

Tool and Tool feed system:

Tool is made by an anti-corrosive material because it has to withstand in corrosive environment for long time. It should also have high thermal conductivity and easily machinable. The dimension accuracy and surface finish of work piece is directly depending on tool dimension. Those part of the tool, which is not required for machining, should be properly insulated because lack of insulation tends to unwanted machining which give dimensional inaccuracy.

Work piece and work holding system:

In this process, work piece should be well electric conductive. Only electric conductive material can be machined by this method. Work piece take as anode in this process. The work holding devices should have non-conductive property.

8. Explain working of ECM.

Ans. Working of Electrochemical Machining:

Electrochemical machining works inverse as electroplating process. Metal is removed form anode into electrolyte and convert into slag form by reacting opposite ions available in electrolyte. This process works as follow.

- In ECM, the electrolyte is so chosen that there is no plating on tool and shape of tool remain unchanged. Generally, NaCl into water takes as electrolyte.
- The tool is connected to negative terminal and work is connected to positive terminal.
- When the current passes through electrode, reaction occur at anode or workpiece and at the cathode or tool. To understand proper working let's take an example or machining low carbon steel.
- Due to potential difference ionic dissociation take place in electrolyte.

$$NaCl \leftrightarrow Na^+ + Cl^-$$

$$H_2O \leftrightarrow H^+ + OH^-$$

- When the potential difference applied between the work piece and tool, positive ions move towards the tool and negative ions towards the work piece.
- Thus, the hydrogen ion moves towards tool. As the hydrogen reaches to the tool, it takes some electron from it and converts into gas form. This gas goes into environment.
- When the hydrogen ions take electron from tool, it creates lack of electron in mixture. To compensate it, a ferrous ion created at the work piece (anode) which gives equal amount of electron in mixture.

$$2H^+ + 2e^- = H_2 \uparrow \text{ at Cathode}$$

$$Fe = Fe^+ + + 2e^- \text{ at Anode}$$

- These Ferrous ions react with opposite chlorine ions or hydroxyl ions and get precipitate in form of sludge.

$$\text{Iron (Fe)} \leftrightarrow Fe^{++} + 2e^-$$

$$Fe^{++} + 2Cl^- \leftrightarrow FeCl_2$$

$$Fe^{++} + 2(OH)^- \leftrightarrow Fe(OH)$$

$$Fecl_2 + 2(OH)^- \leftrightarrow Fe(OH)_2 + 2Cl$$

- This will give ferrous or iron into electrolyte and complete the machining process. This machining process gives higher surface finish because machining is done atom by atom.

CHAPTER-4 CHEMICAL MACHINING.

PART-A

FILL IN THE BLANKS:

1. Pre cleaning is done on the work piece surface in order to achieve **provide good adhesion**
2. Special coatings applied on work piece materials in order to protect them from chemical machining is known as **Maskants**
3. **Chemical dissolution**mechanism is used for the removal of material using Chemical milling process
4. CHM stands for **Chemical machining**
5. Chemical blanking is used to machine the **thin components**

6. Chemical milling is used to machine the **Reduce the weight of w/p**
7. During Chemical milling, depth of etch is controlled by**Time** factor of immersion
8. **Homogeneous** type of metallurgical surfaces is needed in Chemical milling process
9. Chemical reagent and etchant are used in**Chemical**machining method
10. Etchant used in **Chemical machining**process
11. Area is not to be removed are protected by**Maskants**
12. Chemical reagent is known as **Etchant**
13. In selective material removal work is covered by **Maskants**
14. Material removal in downward direction is called **Depth of cut**
15. Material removal in lateral direction is called **Under cut**
16. In chemical machining Scribing plates are used to define **Areas to be exposed**

MULTIPLE CHOICE QUESTIONS:

1. In advanced machining processes, what is the full form of CHM?

   a) **Chemical machining**

   b) Chemical manufacturing

   c) Chemical metal cutting

   d) None of the mentioned

2. Of the following, which mechanism is used for the removal of material using Chemical milling process?

   a) Material Vaporization

   b)**Chemical dissolution**

   c) Mechanical erosion

   d) Mechanical abrasion

3. Which of the following solutions can be used as chemical reactive solution in CHM?

   a) Acidic solution

   b) Alkaline solution

   c)**Both solution**

   d) none of the mentioned

4. By using chemical machining, which of the following can be produced?

   a) Pockets

   b) Contours

   c) Slots

   d) **All of the mentioned**

5. Special coatings applied on work piece materials in order to protect them from chemical reaction are known as?

   a)**Maskants**

   b) Protective coverings

   c) Protective varnishing

   d) none of the mentioned

6. During Chemical milling, depth of etch is controlled by which factor of immersion?

   a)**Time**

   b) Mask method

   c) Mask area

   d) none of the mentioned

7. What are the advantages when we use Chemical milling process?

   a) Weight reduction

   b) No burrs

   c) No stresses

   d) **All of the mentioned**

8. Which of the following, are the other advantages of CHM?

   a) Design changes

   b) Less skilled operator

   c) Minor tooling costs

   d) **All of the mentioned**

9. Good surface quality and absence of burr eliminates which of the following?
   a) Cutting operations
   b) Finishing operations
   c) **Chemical machining**
   d) Drilling operations

10. Which of the following metals can be machined using Chemical milling process?
   a) Copper
   b) Zinc
   c) Steel
   d) **All of the mentioned**

11. Which of the following are the limitations of Chemical milling process?
   a) Disposal of chemicals
   b) Limited scribing accuracy
   c) Surface imperfections
   d) **All of the mentioned**

12. Which type of metallurgical surfaces is needed in Chemical milling process?
   a) **Homogenous**
   b) Heterogeneous
   c) Mixture
   d) none of the mentioned

13. Which of the following is not a limitation of Chemical milling process?
   a) Steep tapers not practical
   b) **Low scrap rates**
   c) Less scribing accuracy
   d) deep narrow cuts

14. Which of the following metals can be machined using Chemical milling process?
   a) Copper

b) Zinc

c) Steel

d) **All of the mentioned**

15. What is the range, between which, the depth of cut in Chemical milling varies?

a) 0.13 – 0. 84 mm

b) 0.93 – 1.56 mm

c) **2.54 – 12.27 mm**

d) 13.3 – 104.56 mm

16. Which of the following non-metallic materials can be machined using Chemical milling process?

a) Plastics

b) Glass

c) Ceramics

d)**All of the mentioned**

17. How many designs can be machined from the same sheet in Chemical milling?

a) Only one

b) Two

c) Three

d) **Multiple**

18. Removal of sharp burrs comes under which application of Chemical milling process?

a) Deep cuts

b) Multiple part machining

c) **Improving surface characteristics**

d) none of the mentioned

19. Chemical milling is used in which of the following application

a) Drilling holes with high depth to diameter ratio

b) Making intricate patterns in thin sheet metal

c) **Removing material to make shallow pockets in metal**

d) Removing plastic material

20. Chemical reagent and etchant are used in____ machining method

a) Electro chemical

b) Plasma arc

c) Ultrasonic

d) **Chemical**

21. Etchant used in _____process

a) ECM

b) EDM

c) **CHM**

d) USM

ANSWERTHE FOLLOWING: (2M)

1. State the principle of chemical machining process?

Ans: Chemical machining (CHM) is the material removal process for the production of desired shapes through selective or overall, of material by controlled chemical attack with acids or alkalis.

2. What is the purpose of etchant in chemical machining?

Ans: The etchant reacts with the work piece in the material to be cut and causes the solid material to be removed. Thus, the metal is removed by the chemical attack of the etchant.

3. Name the etchant used in chemical machining process?

Ans: Ferric Chloride, Cupric Chloride, Nitric acid, Hydrogen fluoride, Iron Chloride, Chromic Acid, HCl Etc.

4. What is the purpose of maskant?

Ans: Masking material is known as Maskant which is used to protect work piece surface from chemical etchant. In other words, maskants protect the portion of work piece metal where material is not to be removed by chemical action of the etchant.

5. Name some maskant used in chemical machining process?

Ans: Polymer, butyl rubber & neoprene, poly vinyl chloride, polyetilien butyl rubber.

6. Name the steps involved in chemical machining?

Ans: Work piece pre cleaning process, Masking and scribing mask, Etching, Damasking.

7. What is photo resist in chemical machining?

Ans: Photo resist in chemical machining is also known as Photochemical machining and is used for produce intricate and precise shapes by using photographic image to cure the photoresist masking on a work piece.

8. What is scribing?

Ans: Scribing is guided by templates to expose the areas that receive chemical machining process.

9. Name the types of chemical machining?

Ans: Chemical milling, Chemical blanking and Chemical engraving

10. List out the chemical resistant material

Ans: Polymer, butyl rubber & neoprene, poly vinyl chloride, polyetilien butyl rubber.

11. Define etchant

Ans: The etchant are chemical reagents, reacts with the work piece in the material and solid material to be removed. Thus the metal is removed by the chemical attack of the etchant.

12. List out the different types of etchant

Ans: Ferric Chloride, Cupric Chloride, Nitric acid, Hydrogen fluoride, Iron Chloride, Chromic Acid, HCl Etc

13. Which of the following tools required to CHM?

Ans: Tools required to CHM Etchant tank, etchant, resistant material, agitator, heating coil

14. What is chemical machining?

Ans: Chemical machining (CHM) is the material removal process for the production of desired shapes through selective or overall of material by controlled chemical attack with acids or alkalis.

15. What is the purpose of CHM?

Ans: The purpose of CHM is

- To Reduce Weight of W/P
- To machine the small thickness component
- To achieve Fine finish & burr free component

16. Describe cleaning of work piece?

Ans: The work piece has to be cleaned to remove dirt, oil, grease, dust & rust. Good cleaning provides the good adhesion between work and maskant. Ultrasonic and chemical cleaning is done.

17. Define under cut

Ans: under cut is defined as material removal in lateral direction.

18. Define depth of cut

Ans: Depth of cut is defined as material removal in downward direction.

19. Define etch factor

Ans: Etch Factor are

- Type of material to be etched

- Type of maskant to be applied
- The material removal rate is desired

20. Define MRR

Ans: The material removal is defined as amount of the work material dissolved in chemical. The material removal rate is depending on the etchant. MRR expressed as mm/min

ANSWERTHE FOLLOWING: (3M)

1. What is chemical milling?

Ans: Chemical milling is also called as counter milling etching is used to mainly produce three-dimensional shape by selective or overall removal of material from the relatively large surface areas. The main purpose is to achieve shallow but complex profiles, reduction of weight by removing the unwanted materials.

2. What is chemical blanking?

Ans: Chemical blanking is used to chiefly on thin sheet and foils. In most application photoresist is used to define the location on the work piece from the where material is to be removed.

3. Write any four limitations of chemical machining process?

Ans: Limitations of chemical machining process

- Fillet radius is approximately equal to depth of cut
- Extremely deep cuts are usually not cost effective
- A homogenous metal structure is normally required for good results
- Welds and castings often produce pitted surfaces when chemically milled
- Process costs depend on the quality of the original work piece (thickness variation, presence of surface scratches and corrosion)
- It is impractical to make grooves of width less than twice the depth
- Hazardous chemicals used in the process present difficult safety, waste disposal and air pollution problems

- A relatively high level of operator skill is required for PCM
- Suitable photographic facilities are not always available

4. List the properties of etchant?

Ans: Properties of etchant

- Etchant should have high etch rate.
- It should have yield good surface finish.
- Etchant should give minimum undercut.
- It should be compatible maskant
- It should be economic
- It should be safe to use

5. List the properties of maskant?

Ans: Properties of maskant

- Tough enough to withstand chemical abrasion
- It should adhere well to work piece
- It should be easy to scribe
- It should not react easily with etchant
- It should not loose properties at high temperature
- It should be easy to rem

6. How the work piece will prepare for chemical machining?

Ans: the work piece material has to be cleaned to remove dirt, oil, grease, rust. Good cleaning produces good adhesion between the work material and maskant, Ultrasonic and chemical cleaning is commonly used

7. Define etchant, name the any two etchant

Ans: The etchant are chemical reagents, reacts with the work piece in the material and solid material to be removed. Thus the metal is removed by the chemical attack of the etchantFerric Chloride, Nitric acid, Hydrogen, HCl Etc

8. Which of the following tools required to CHM?

Ans:Tools required to

- CHM Etchant tank,
- Pre Cleaning Solutions
- etchant
- resistant material
- agitator
- heating coil

9. What are the factors considered while selecting the etchant?

Ans: Factors considered while selecting the etchant

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

10. What are the properties of Chemical resistant material?

Ans:properties of Chemical resistant material

- Tough enough to withstand chemical abrasion
- It should adhere well to work piece
- It should be easy to scribe
- It should not react easily with etchant
- It should not loose properties at high temperature
- It should be easy to rem

11. What are the properties of Etching material?

Ans: Properties of etchant

- Etchant should have high etch rate.
- It should have yield good surface finish.
- Etchant should give minimum undercut.
- It should be compatible maskant

- It should be economic
- It should be safe to use

12. Define maskant? list the types of maskants?

Ans: Maskant which protect work piece surface from chemical etchant. In another words maskants protect the portion of work piece metal where material is not to be removed by chemical action of the etchant. Types of maskants Polymer, butyl rubber & neoprene, poly vinyl chloride, polyetilien butyl rubber.

13. Mention the steps involved in CHM

Ans: Steps involved in CHM

- Work piece pre cleaning process,
- Masking and scribing mask,
- Etching,
- Damasking.

14. Mention the steps involved in Chemical blanking

Ans: Steps involved in Chemical blanking

- Work piece preparation
- Preparation Masters
- Making photo resist
- Etching,

15. Mention the steps involved in Chemical Milling

Ans: Steps involved in Chemical Milling

- cleaning
- Masking
- scribing
- Etching,
- Damasking.

16. List the some of the process parameters

Ans: Process parameters

- Reagent (etchant) type
- Concentration of solution
- Operating temperature
- Etching medium
- Etching time

17. How do you select the etchant?

Ans: The etchant selected as below

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

18. Define damasking

Ans: Mask removal is done by hand stripping or by immersing the masked part into damasking solution. After the part damasked it is cleaned or dried and then inspected.

19. List the characteristics of etchant

Ans: characteristics of etchant

Should have High concentration rate of etch

Should have Less Toxic

Should have Good material removal rate

Should economically affordable

20. What is selective Chemical machining

Ans: Selective Chemical machining is the work covers with the chemical resistant material layer and thereby preventing chemical action on these areas. Area where the material is removal is required, is left unprotected, then the work is placed in chemical solution there is remove of material from unprotected areas

ANSWERTHE FOLLOWING:(5M)

1. **Distinguish between Chemical machining and Electro Chemical machining**

Ans: Chemical machining and Electro Chemical machining

Chemical machining	Electro Chemical machining
• As the name suggests, CHM is one chemical energy based NTM process • Here material is removed in ionic form due to controlled dissolution by chemical etchant • Etchant slowly dissolves metal to realize machining • It is independent of electrical conductivity of workpiece metal. So, it can be applied for conductive and non-conductive materials • No additional electrode is necessary as the chemical reaction takes place between etchant and workpiece • No power supply is necessary as the process is not related to electrical energy • Here suitable etchant (based on workpiece material) is employed. Typical etchant include $FeCl_3$, $CuCl_3$, $FeNO_3$, HNO_3 and HF • Chemical etchants are highly corrosive and thus the process	• It is one electrical energy based NTM process • Here also material is removed in ionic form but due to controlled electro-chemical dissolution of work metal • Electrolyte Rapidly dissolves metal to realize machining • The workpiece must be electrically conductive as it is used as anode of the electrolytic cell • An electrode having curvature according to intended shape is absolutely required to complete the electrical circuit • One DC power supply is required to maintain desired potential difference between cathode (tool electrode) and anode (workpiece) • Instead of etchant, appropriate electrolyte is applied in ECM. Typical electrolyte include NaCl and $NaNO_3$ • The etchant is not such corrosive

possesses a risk to the operator	and thus the process is somewhat risk-free towards operator

2. Write advantage of Chemical machining

Ans: Advantages of chemical machining

- Easy weight reduction
- No effect of workpiece materials properties such as hardness
- Simultaneous material removal operation
- No burr formation
- No stress introduction to the workpiece
- Low capital cost of equipment
- Easy and quick design changes 8. Requirement of less skilled worker
- Low tooling costs
- The good surface quality
- Using decorative part production
- Low scrap rates (3%

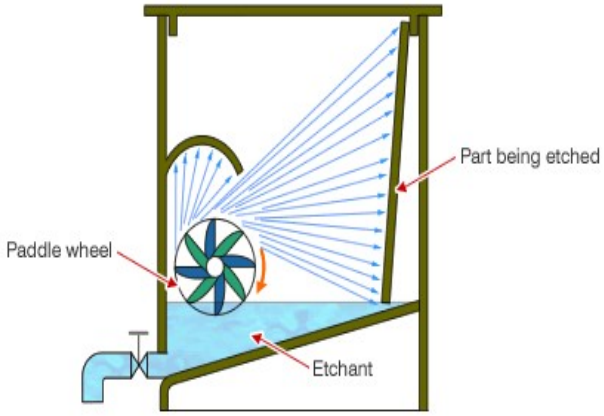
3. Write the disadvantage of Chemical machining

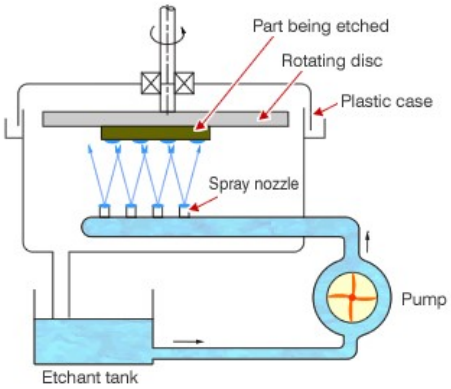
Ans: Disadvantage of Chemical machining

- Difficult to get sharp corner
- Difficult to chemically machine thick material (limit is depended on workpiece material, but the thickness should be around maximum 10 mm)
- Scribing accuracy is very limited, causes less dimensional accuracy
- Etchants are very dangerous for workers
- Etchant disposals are very expensive

4. Explain Chemical blanking

Chemical Blanking Process: Chemical blanking is a process of producing a part from thin sheet metal by chemically etching the periphery of the desired shape. The material is removed by chemical dissolution. Chemical blanking is used for parts that are otherwise typically produced by mechanical blanking presses from thin plates and foil material. With mechanical presses, vibrations, backlash, and part dis





Paddle type etching machine Spray type etching machine

Chemical blanking process has several steps

Workpiece pre cleaning process:The surface of the workpiece metal is cleaned thoroughly, degreased and pickled by acid and alkalis. Pre cleaning is of utmost importance in order to remove oil, grease, dirt, rust or any foreign substance for the work surface so as to produce a good adhesion of the masking material. The material is allowed to dry

Masking: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant. A suitable maskant, say a polymer, rubber, or any other material is selected based on the workpiece material. The maskant is applied on the work surface by various methods like dip, brush, spray, roller, electro-coating, and as well as adhesive tapes

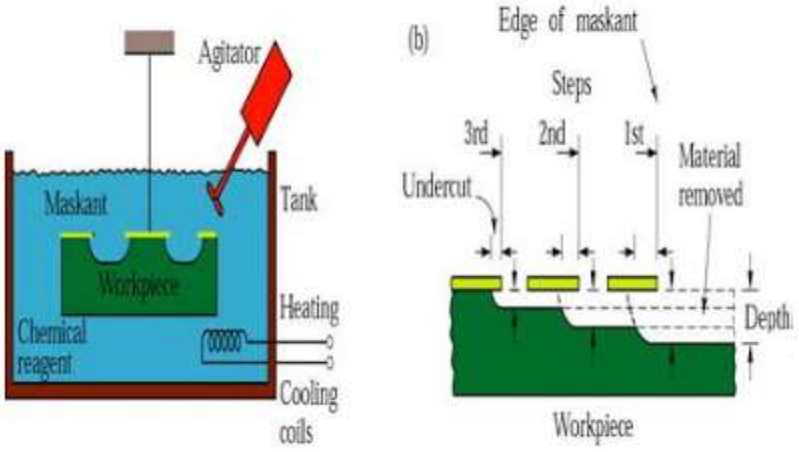
Etching: Removal of material from the workpiece take place by etching process. The workpiece metal is either sprayed continuously with a selected etchant like ferric chloride on those portions where the material is to

removed, or immersed in a tank of agitated etchant, where the etchant chemically attacks those portions not masked. Erosion of the work material take place both inward and laterally from the exposed(unmasked) surface the work material is converted in to metallic salt, which is the dissolved and carried away in the etchant solution. There are two application of material through etching. Immersion type and Spray type.

Demasking: When etching is completed, the mask is removed either through mechanical or chemical means Any etchant on the material is also removed with a wash or clear, cold water. A deoxidizing bath may also be required in order to remove the oxide films left on the surface of the work material.

5. Explain Chemical milling

Ans. Chemical milling mainly used to produce shapes by selective or overall removal of metal parts from relatively large surface areas. The main purpose is to produce shallow cavities with complex profiles on plates, sheets, forgings, generally for the overall reduction of weight. This process has been used on a wide variety of metals with depths of metal removal as large as 12 mm. Chemical milling entails four important steps:



Workpiece pre cleaning process: The workpiece material has to be cleaned in the beginning of chemical machining process. The cleaning operation is carried out to remove the oil, grease, dust, rust or any substance from the surface of material. A good cleaning process produces a good adhesion of the masking material. There are two cleaning methods; mechanical and chemical methods. The most widely used cleaning process is chemical method due to less damages occurred comparing to mechanical one. Ultrasonic cleaning

machine is applied with using special cleaning solution and heating is beneficial during the cleaning process

Masking and Scribing mask: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant. The selected masking material should be readily strippable mask, which is chemically impregnable and adherent enough to stand chemical abrasion during etching. Scribing mask is guided by templates to expose the areas that receive chemical machining process. The selection of mask depends on the size of the workpiece material, the number of parts to be produced, and the desired detail geometry. Silkscreen masks are preferred for shallow cuts requiring close dimensional tolerances.

Etching: This step is the most important stage to produce the required component from the sheet material. This stage is carried out by immerse type etching machine. The workpiece material is immersed into selected etchant and the uncovered areas were machined. This process is generally carried out in elevated temperatures which are depended on the etched material. Then the etched workpiece is rinsed to clean etchant from machined surface.

4. Cleaning masking material: Final step is to remove masking material from etched part. The inspections of the dimensions and surface quality are completed before packaging the finished part.

6. Write the typical application if Explain Chemical machining

• Chemical machining process is widely used to manufacture geometrically complex and precision parts for aerospace, electronics and automotive and many other industries.

• Semiconductor fabrication industries.

• Aerospace industry to remove shallow layers of material from large aircraft components, missile skin panels, and extruded parts for airframes.

• Etching is used widely to manufacture integrated circuits and Microelectromechanical systems. In addition to the standard, liquid-based techniques, the semiconductor industry commonly uses plasma etching

• High Precision Parts and Decorative Items

•Thinning and sizing

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• High Precision Parts and Decorative Items

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• Burr free components

8. What are the factors considered while selecting the etchant?

Ans: Factors considered while selecting the etchant

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

9. List the some of the process parameters Explain any one

Ans: Process parameters

- Reagent (etchant) type
- Resistant material
- Concentration of solution
- Operating temperature

- Etching medium
- Etching time

Resistant material: Resistant material which protect work piece surface from chemical etchant. In another words maskants protect the portion of work piece metal where material is not to be removed by chemical action of the etchant.

10. List out the advantage of Chemical machining

Ans: Advantages of chemical machining

- Easy weight reduction
- No effect of work piece materials properties such as hardness
- Simultaneous material removal operation
- No burr formation
- No stress introduction to the work piece
- Low capital cost of equipment
- Easy and quick design changes 8. Requirement of less skilled worker
- Low tooling costs
- The good surface quality
- Using decorative part production
- Low scrap rates

11. List out some disadvantage of Chemical machining

Ans: Disadvantage of Chemical machining

- Difficult to get sharp corner
- Difficult to chemically machine thick material (limit is depended on workpiece material, but the thickness should be around maximum 10 mm)
- Scribing accuracy is very limited, causes less dimensional accuracy
- Etchants are very dangerous for workers
- Etchant disposals are very expensive
- Highly skill operators are required
- Handling of disposal of chemicals is difficult
- Scribing accuracy is very limited
- Surface must be metallurgical homogeneous

12. What are the application of CHM?

Ans: Application of CHM

- This is used for large volume of unwanted material removal
- Use to make the shallow cuts in large thin sheets
- Used to reduce the weight for aircraft component
- Used to machine the helicopter vent screen
- Used to produce high detailed components
- Used to machine the electrical circuit chips
- Used to remove the decarburize layer from the low alloy steels
- Used to produce the steps webs
- Used to produce the detailed engraving

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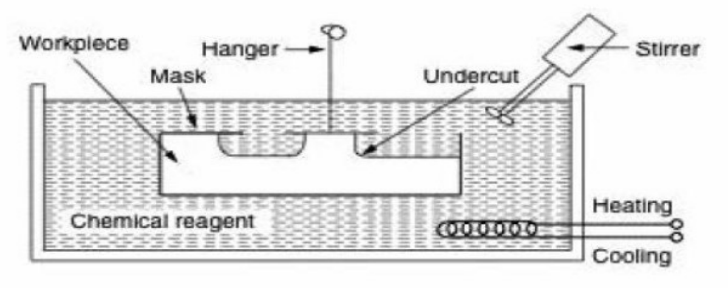
14. Draw the setup of CHM process and label the parts

Ans:



15. List out the important process characteristics and explain any one

Ans: important process characteristics

- Metal removal rate
- Accuracy
- Hydrogen embrittlement

Metal removal rate: Material removal rate depends on the etchant. Etchant that remove metal faster tend to have many side-effects such as

- Reduction in surface finish
- Increased undercutting
- Higher heating point
- Greater change of etch rate with temperature
- Attack on the bond between the maskant and workpiece.

The etch rate is generally limited to 0.02 to 0.04 mm/min Etch rate can be as high as 0.1-0.2 mm/min where surface finish and accuracy are not important. In aircraft industry, metal removal rate for aluminium is about 140-150 cm/min

16. Define the followings

a) Etching b) Damasking c) masking d) Cleaning of w/p

Ans: Etching: This step is the most important stage to produce the required component from the sheet metal. This stage is carried out by immersing the workpiece in a selected etchant Where the removal of material is carried out to chemical attack

Demasking: Mask removal is done by hand stripping or by immersing the masked part in a suitable demasking solution. After the part is demasked, it is cleaned and inspected.

Masking: The mask is usually applied by dip method, flow coat or airless spray method. The type of mask and number of coats depend on the size and configuration and material of the part. Aluminium and magnesium are usually given two coats whereas steel is given four or more coats. After the coat is applied, part is cured for 3 to 24 hours, depending on the size of the part. Suitable curing temperature must be maintained for good masking

Precleaning: Cleaning is required to ensure good adhesion of maskant and uniform dissolution of the metals. Different cleaning methods are used. Refractory materials like tungsten are cleaned by wiping with solvent only. It is difficult to clean porous materials because the cleaning solvents get trapped.

17. Describe the factors on which selection of resistant material and Etchant

Ans: The etchant selected as below

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

factors of resistant material

- Tough enough to withstand chemical abrasion
- It should adhere well to work piece
- It should be easy to scribe
- It should not react easily with etchant
- It should not loose properties at high temperature
- It should be easy to Remove
- It should be easy to make profile

18. Write a short note on chemical blanking

Ans: Chemical blanking is used to chiefly on thin sheet and foils. In most application photoresist is used to define the location on the work piece from the where material is to be removed.

Workpiece pre cleaning process:The surface of the workpiece metal is cleaned thoroughly, degreased and pickled by acid and alkalis. Pre cleaning is of utmost importance in order to remove oil, grease, dirt, rust or any foreign substance

Masking: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant. A suitable maskant, say a polymer, rubber, or any other material is selected based on the workpiece material.

Etching: Removal of material from the workpiece take place by etching process. The workpiece metal is immersed in a tank of agitated etchant or etchant is sprayed on workpiece, where the etchant chemically attack those portions not masked. Erosion of the work material take place both inward and laterally from the exposed(unmasked)

surface The work material is converted in to metallic salt, which is the dissolved and carried away in the etchant solution

Demasking: When etching is completed, the mask is removed either through mechanical or chemical means Any etchant on the material is also removed with a wash or clear, cold water. A deoxidizing bath may also be required in order to remove the oxide films left on the surface of the work material.

19. Write a short note on chemical milling

Ans: Chemical millingmainly used to produce shapes by selective or overall removal of metal parts from relatively large surface areas. The main purpose is to produce shallow cavities with complex profiles on plates, sheets, forgings, generally for the overall reduction of weight. This process has been used on a wide variety of metals with depths of metal removal as large as 12 mm. Chemical milling entails four important steps:

Workpiece pre cleaning process: The workpiece material has to be cleaned in the beginning of chemical machining process. The cleaning operation is carried out to remove the oil, grease, dust, rust or any substance from the surface of material.

Masking and Scribing mask: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant.

Etching: This step is the most important stage to produce the required component from the sheet material. This stage is carried out by immerse type etching machine. The workpiece material is immersed into selected etchant and the uncovered areas were machined.

Cleaning masking material: Final step is to remove masking material from etched part. The inspections of the dimensions and surface quality are completed before packaging the finished part.

20. How the chemical machining differs from electro chemical machining?

Ans:

Chemical machining	Electro Chemical machining
• As the name suggests, CHM is one chemical energy based NTM process • Here material is removed in ionic	• It is one electrical energy based NTM process

form due to controlled dissolution by chemical etchant • Etchant slowly dissolves metal to realize machining • It is independent of electrical conductivity of workpiece metal. So it can be applied for conductive and non-conductive materials • No additional electrode is necessary as the chemical reaction takes place between etchant and workpiece • No power supply is necessary as the process is not related to electrical energy • Here suitable etchant (based on workpiece material) is employed. Typical etchant include $FeCl_3$, $CuCl_3$, $FeNO_3$, HNO_3 and HF • Chemical etchants are highly corrosive and thus the process possesses a risk to the operator	• Here also material is removed in ionic form but due to controlled electro-chemical dissolution of work metal • Electrolyte Rapidly dissolves metal to realize machining • The workpiece must be electrically conductive as it is used as anode of the electrolytic cell • An electrode having curvature according to intended shape is absolutely required to complete the electrical circuit • One DC power supply is required to maintain desired potential difference between cathode (tool electrode) and anode (workpiece) • Instead of etchant, appropriate electrolyte is applied in ECM. Typical electrolyte include NaCl and $NaNO_3$ • The etchant is not such corrosive and thus the process is somewhat risk-free towards operator

21. What do you mean by etching and damasking?

Ans: <u>Etching:</u> Removal of material from the workpiece take place by etching process. The workpiece metal is immersed in a tank of agitated etchant or etchant is sprayed on workpiece, where the etchant chemically attack those portions not masked. Erosion of the work material take place both inward and laterally from the exposed(unmasked)

surface The work material is converted in to metallic salt, which is the dissolved and carried away in the etchant solution

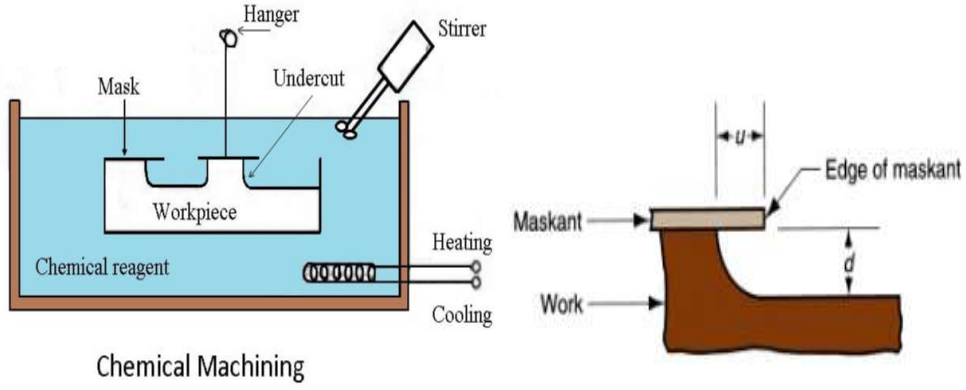
Demasking: When etching is completed, the mask is removed either through mechanical or chemical means Any etchant on the material is also removed with a wash or clear, cold water. A deoxidizing bath may also be required in order to remove the oxide films left on the surface of the work material.

ANSWERTHE FOLLOWING:(8M)

1. **What is chemical machining? Briefly explain steps involved in it?**

Ans. Chemical machining is well known as non-traditional machining process and is controlled by chemical dissolution of the machines work piece material by contact with a strong chemicals' reagent. It is also known as a chemical etching. Mostly all the material from metal to ceramics can be chemically machined.

PROCEDURE FOR CHEMICAL MACHININ



Chemical Machining

Workpiece pre cleaning process: The surface of workpiece metal is cleaned thoroughly, degreased and pickled by acid or alkalis. Pre cleaning is the most important method to remove oil, grease, dirt, rust, or any foreign substance from the work surface to produce a good adhesion of masking material.

Masking and scribing mask: Masking involves covering the portion of the workpiece metal where material is not to be removed by the chemical action .masking with adhesive types or paints is a common practice although rubber (elastomers) and plastics are also used. Since it is difficult to apply maskant on small surface, the maskant is initially applied on a large surface

Etching: The unmasked surface of the workpiece is machined chemically with selected etchant. Etching is carried out by immersing the work material in a tank of agitated etchant. The process is carried out at high temperature depending on the etched material. Temperature control and agitation during chemical machining. Erosion of the work material takes place from the exposed surface. The work piece is converted into metallic salt, which is then dissolved and carried away in the etchant solution.

Damasking: When etching is completed the mask is removed either through mechanical or chemical means. any etchant on the work material is also removed by cold water to clean. A deoxidizing bath may also be required in order to remove the oxide coating or films left on the surface of the work material

2. State the advantage of following

a) Cleaning of w/p b) Maskant c) Chemical milling d) Chemical blanking

Ans. Cleaning of w/p: The surface of workpiece metal is cleaned thoroughly, degreased and pickled by acid or alkalis. Pre cleaning is the most important method to remove oil, grease, dirt, rust, or any foreign substance from the work surface to produce a good adhesion of masking material.

Maskant: Masking material is known as Maskant which is used to protect work piece surface from chemical etchant. In another words maskants protect the portion of work piece metal where material is not to be removed by chemical action of the etchant.

Chemical Blanking: Chemical blanking is a process of producing a part from thin sheet metal by chemically etching the periphery of the desired shape. The material is removed by chemical dissolution. Chemical blanking is used for parts that are otherwise typically produced by mechanical blanking presses from thin plates and foil material. With mechanical presses, vibrations, backlash, and part dis

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3. Briefly explain about Chemical blanking and Chemical milling

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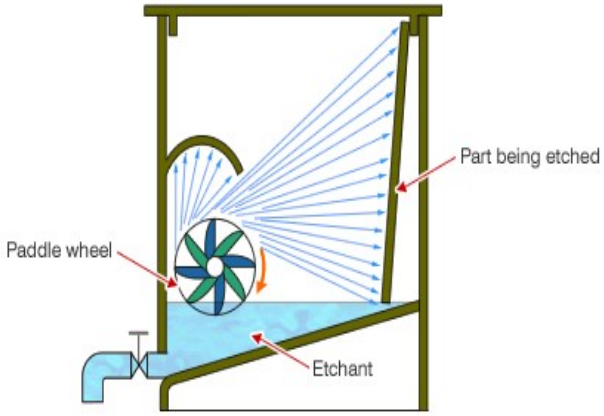

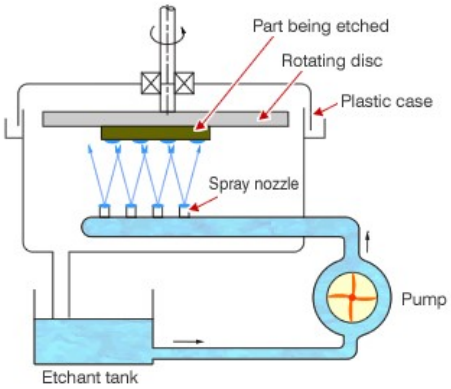

Paddle type etching machine Spray type etching machine

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Etching: Removal of material from the workpiece take place by etching process. The workpiece metal is either sprayed continuously with a selected etchant like ferric chloride on those portions where the material is to removed, or immersed in a tank of agitated etchant, where the etchant chemically attacks those portions not masked. Erosion of the work material take place both inward and laterally from the exposed(unmasked) surface the work material is converted in to metallic salt, which is the dissolved and carried away in the etchant solution. There are two application of material through etching. Immersion type and Spray type.

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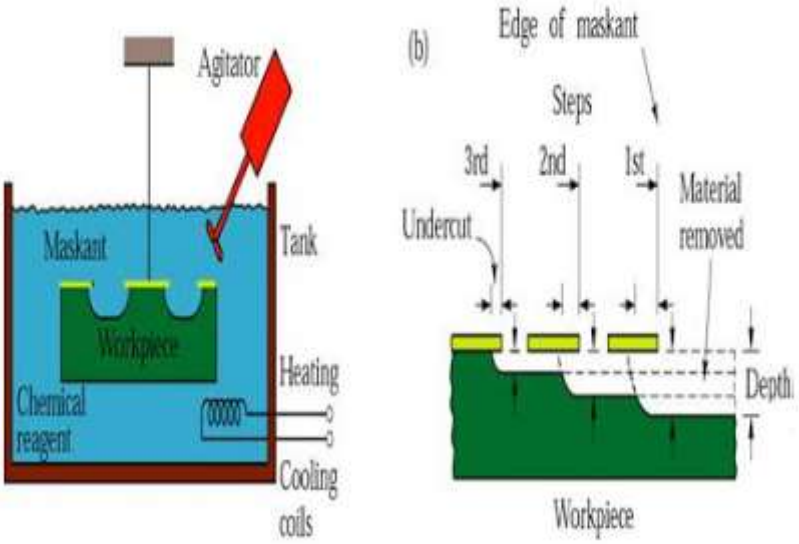
Chemical milling mainly used to produce shapes by selective or overall removal of metal parts from relatively large surface areas. The main purpose is to produce shallow cavities with complex profiles on plates, sheets, forgings, generally for the overall reduction of weight. This process has been used on a wide variety of metals with depths of metal removal as large as 12 mm. Chemical milling entails four important steps:



Workpiece pre cleaning process: The workpiece material has to be cleaned in the beginning of chemical machining process. The cleaning operation is carried out to remove the oil, grease, dust, rust or any substance from the surface of material. A good cleaning process produces a good adhesion of the masking material. There are two cleaning methods; mechanical and chemical methods. The most widely used cleaning process is chemical method due to less damages occurred comparing to mechanical one. Ultrasonic cleaning machine is applied with using special cleaning solution and heating is beneficial during the cleaning process

Masking and Scribing mask: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant. The selected masking material should be readily strippable mask, which is chemically impregnable and adherent enough to stand chemical abrasion during etching. Scribing mask is guided by templates to expose the areas that receive chemical machining process. The selection of mask depends on the size of the workpiece material, the number of parts to be produced, and the desired detail geometry. Silkscreen masks are preferred for shallow cuts requiring close dimensional tolerances.

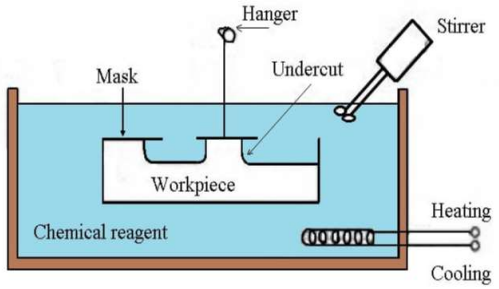
Etching: This step is the most important stage to produce the required component from the sheet material. This stage is carried out by immerse type etching machine. The workpiece material is immersed into selected etchant and the uncovered areas were machined. This process is generally

carried out in elevated temperatures which are depended on the etched material. Then the etched workpiece is rinsed to clean etchant from machined surface.

Cleaning masking material: Final step is to remove masking material from etched part. The inspections of the dimensions and surface quality are completed before packaging the finished part.

4. **Draw the setup of CHM process and label the parts**

Ans:



Chemical Machining

5. **List out the important process characteristics and explain any Two**

Ans: important process characteristics

- Metal removal rate
- Accuracy
- Surface finish
- Hydrogen embrittlement

Metal removal rate: Material removal rate depends on the etchant. Etchant that remove metal faster tend to have many side-effects such as

- Reduction in surface finish
- Increased undercutting
- Higher heating point
- Greater change of etch rate with temperature
- Attack on the bond between the maskant and workpiece.

The etch rate is generally limited to 0.02 to 0.04 mm/min Etch rate can be as high as 0.1-0.2 mm/min where surface finish and accuracy are not important. In aircraft industry, metal removal rate for aluminium is about 140-150 cm/min

Accuracy: The undercutting is same as in chemical blanking operation. Undercut per edge is approximately equal to the depth of cut. Etch factor in chemical contouring is defined as the undercut divided by the depth of cut. Allowance for and undercut must be made in design itself. With optimum time, temperature solution control, accuracies of the range of t 0.01 mm can be achieved on relatively shallow depths of the cut Maximum taper, when produced by controlled slow immersion or withdrawal is usually 0.08 mm for 100 mm depth in steel and 0.08 mm for aluminium alloys. Sharp radii cannot be produced in cutting direction

6. **Define the followings**

a) Etching b) Damasking c) masking d) Cleaning of w/p

Etching: Removal of material from the workpiece take place by etching process. The workpiece metal is immersed in a tank of agitated etchant or etchant is sprayed on workpiece, where the etchant chemically attack those portions not masked. Erosion of the work material take place both inward and laterally from the exposed(unmasked) surface The work material is converted in to metallic salt, which is the dissolved and carried away in the etchant solution

Demasking: When etching is completed, the mask is removed either through mechanical or chemical means Any etchant on the material is also removed with a wash or clear, cold water. A deoxidizing bath may also be required in order to remove the oxide films left on the surface of the work material.

Masking: Masking involves covering the portions of the workpiece metal where material is not to be removed by the chemical action of the etchant.

Cleaning of w/p: Final step is to remove masking material from etched part. The inspections of the dimensions and surface quality are completed before packaging the finished part.

7. **List the some of the process parameters Explain any Two**

Ans: important process characteristics

- Metal removal rate
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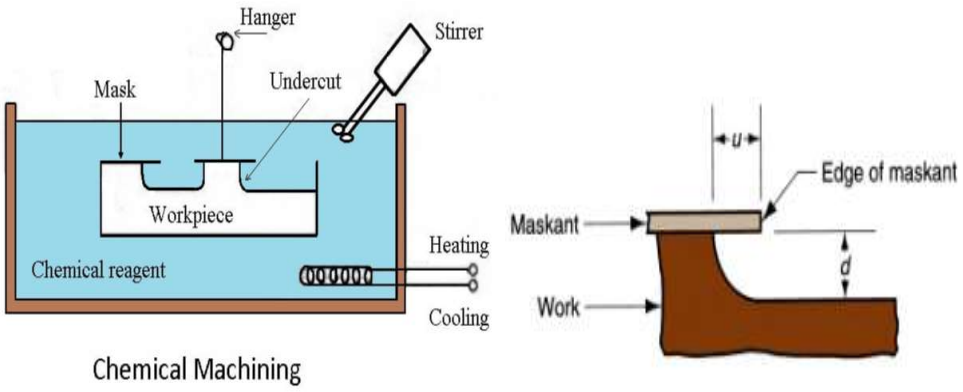
8. **Explain with sketch important steps involved in CHM Process**

Ans: Steps involved in Chemical machining



Chemical Machining

Workpiece pre cleaning process: The surface of workpiece metal is cleaned thoroughly, degreased and pickled by acid or alkalis. Pre cleaning is the most important method to remove oil, grease, dirt, rust, or any foreign substance from the work surface to produce a good adhesion of masking material.

Masking and scribing mask: Masking involves covering the portion of the workpiece metal where material is not to be removed by the chemical action .masking with adhesive types or paints is a common practice although rubber (elastomers) and plastics are also used. Since it is difficult to apply maskant on small surface, the maskant is initially applied on a large surface

Etching: The unmasked surface of the workpiece is machined chemically with selected etchant. Etching is carried out by immersing the work material in a tank of agitated etchant. The process is carried out at high temperature depending on the etched material. Temperature control and agitation during chemical machining. Erosion of the work material takes place from the exposed surface. The work piece is converted into metallic salt, which is then dissolved and carried away in the etchant solution.

Damasking: When etching is completed the mask is removed either through mechanical or chemical means. any etchant on the work material is also removed by cold water to clean. A deoxidizing bath may also be required in order to remove the oxide coating or films left on the surface of the work material.

9. **Explain the process parameter of CHM**

Ans: Process parameters

- Reagent (etchant) type
- Resistant material
- Concentration of solution

- Operating temperature
- Etching medium
- Etching time

Resistant material: Resistant material which protect work piece surface from chemical etchant. In another words maskants protect the portion of work piece metal where material is not to be removed by chemical action of the etchant

Etching medium: The etching medium has an important role to play in the metal removal rate in chemical machining Table 93 shows some of the commonly used etchants and the work materials Etchants are added with additives and inhibitors to get good surface quality and uniform MRR. Etching medium should not result in diffusion of atomic hydrogen in titanium and steel. In case of aluminium alloys, intercrystallite corrosion can be avoided using suitable additives and inhibitors.

10. Distinguish between CHM and ECM

Ans:

Chemical machining	Electro Chemical machining
• As the name suggests, CHM is one chemical energy based NTM process • Here material is removed in ionic form due to controlled dissolution by chemical etchant • Etchant slowly dissolves metal to realize machining • It is independent of electrical conductivity of workpiece metal. So it can be applied for conductive and non-conductive materials • No additional electrode is necessary as the chemical reaction takes place between etchant and workpiece	• It is one electrical energy based NTM process • Here also material is removed in ionic form but due to controlled electro-chemical dissolution of work metal • Electrolyte Rapidly dissolves metal to realize machining • The workpiece must be electrically conductive as it is used as anode of the electrolytic cell • An electrode having curvature according to intended shape is absolutely required to complete the

• No power supply is necessary as the process is not related to electrical energy • Here suitable etchant (based on workpiece material) is employed. Typical etchant include $FeCl_3$, $CuCl_3$, $FeNO_3$, HNO_3 and HF • Chemical etchants are highly corrosive and thus the process possesses a risk to the operator	electrical circuit • One DC power supply is required to maintain desired potential difference between cathode (tool electrode) and anode (workpiece) • Instead of etchant, appropriate electrolyte is applied in ECM. Typical electrolyte include NaCl and $NaNO_3$ • The etchant is not such corrosive and thus the process is somewhat risk-free towards operator

11. List out the advantage and Disadvantage of chemical milling process

Ans: Advantages of chemical milling

- Easy weight reduction
- No effect of work piece materials properties such as hardness
- Simultaneous material removal operation
- No burr formation
- No stress introduction to the work piece
- Low capital cost of equipment
- Easy and quick design changes 8. Requirement of less skilled worker
- Low tooling costs
- The good surface quality
- Using decorative part production
- Low scrap rates

Disadvantage of Chemical milling

- Difficult to get sharp corner
- Difficult to chemically machine thick material (limit is depended on workpiece material, but the thickness should be around maximum 10 mm)
- Scribing accuracy is very limited, causes less dimensional accuracy

- Etchants are very dangerous for workers
- Etchant disposals are very expensive
- Highly skill operators are required
- Handling of disposal of chemicals is difficult
- Scribing accuracy is very limited
- Surface must be metallurgical homogeneous

12. List out the advantage and Disadvantage of chemical blanking process

Ans: Advantages of chemical blanking

- Easy weight reduction
- No effect of work piece materials properties such as hardness
- Simultaneous material removal operation
- No burr formation
- No stress introduction to the work piece
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13. Describe the factors on which selection of resistant material and Etchant

Ans: The etchant selected as below

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

factors of resistant material

- Tough enough to withstand chemical abrasion
- It should adhere well to work piece
- It should be easy to scribe
- It should not react easily with etchant
- It should not loose properties at high temperature
- It should be easy to Remove
- It should be easy to make profile

14. What are the merits demerits of Chemical machining?

Ans: Merits of chemical blanking

- Easy weight reduction
- No effect of work piece materials properties such as hardness
- Simultaneous material removal operation
- No burr formation
- No stress introduction to the work piece
- Low capital cost of equipment
- Easy and quick design changes 8. Requirement of less skilled worker
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Demerits of Chemical blanking

- Difficult to get sharp corner

- Difficult to chemically machine thick material (limit is depended on workpiece material, but the thickness should be around maximum 10 mm)
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- Etchants are very dangerous for workers
- Etchant disposals are very expensive
- Highly skill operators are required
- Handling of disposal of chemicals is difficult
- Scribing accuracy is very limited
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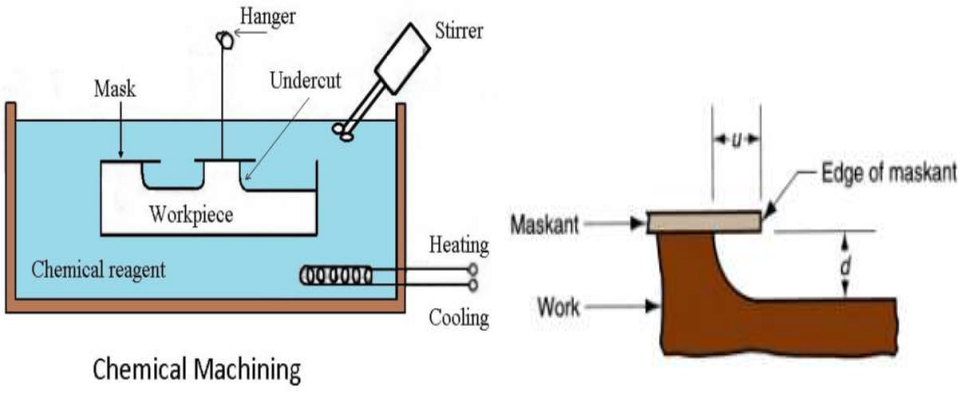
15. What do you mean by chemical machining? List the various steps involved in chemical machining

Ans: : Steps involved in Chemical machining



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16. List out the factors for the selection material resistant and Etchant

Ans: The etchant selected as below

- Type of material to be etched
- Type of maskant to be applied
- The material removal rate is desired
- Operating condition
- Requirement of surface finish
- Economics involved in material removal

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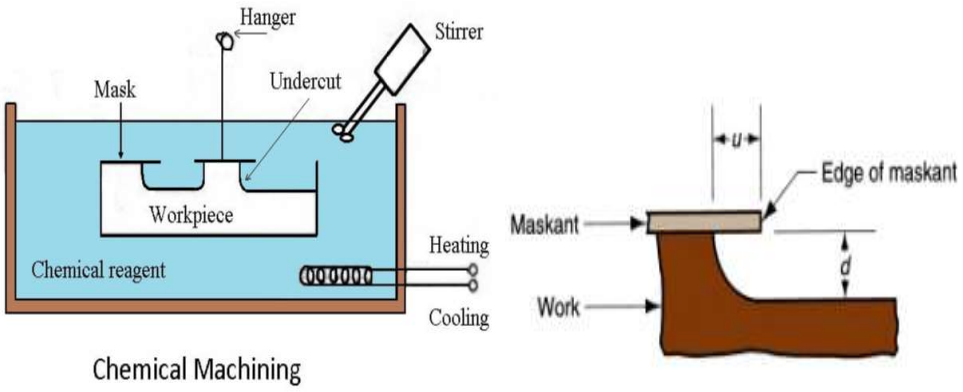
17. With a neat diagram show the step involved in chemical machining process

Ans:Steps involved in Chemical machining



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18. What are the process parameters involved in chemical machining? Explainany two briefly

Ans: Process parameters

- Reagent (etchant) type
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- Operating temperature
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CHAPTER-5 ULTRASONIC MACHINING.

PART-A

FILL IN THE BLANKS:

1. Elaborate USM Ultrasonic machaining
2. The Horn or Concentratorare used to hold tool in USM
3. In USM process Abrasive slurryis flowed between tool &workpiece.
4. USM is used to machine hard &Brittle materials.
5. The ultrasonic frequency ranges from 0.02 to 0.05mm
6. Al_2O_3 is Aluminium Oxide
7. Sic Is Silicon carbide
8. MRR means Material Removal Rate
9. In USM electrical energy is converted in to Mechanical Energy
10. Pump is used to force the abrasive slurry in to machining zone

MULTIPLE CHOICE QUESTIONS:

1. In USM electrical energy converted in to

a. Hydraulic energy

b. Pneumatic energy

c. Mechanical vibrations

d. All of the above

2. The metal removal rate (MRR) in USM is

a. Average

b. Low

c. High

d. None of the above

3. The frequency of head is range from_____ to _____kHz

a. 1to 10 KHz

b. 0 to 40 KHz

c.50 KHz to 100 KHz

d. 20 to 40 KHz

4. The gap in between tool and work piece in the range from _____to_____

a. 0.02 to 0.05mm

b.0.5mm to 1mm

c.1.5mm to 4mm

d.2 to 6 mm

5. The machining system of USM contains which of the following components?

a) Magnetostriction

b) Concentrator

c) Tools and slurry

d) All of the mentioned

6. Ultrasonic machining (USM) can be classified as which of the following type of non-traditional machining process?

a) electrical

b) optical

c) mechanical

d) chemical

7. What is the full form of USM in advanced machining process?

a) Ultrasound manufacturing

b) Ultrasonic machining

c) UV spectrum manufacturing

d) Ultra sonar machining

8. In Ultrasonic Machining, magnetostriction converts magnetic energy into which type of energy?

a) Mechanical energy

b) Electrical energy

c) Thermal energy

d) None of the mentioned

9. What is the value of the amplitude obtained without mechanical amplifier?

a) 0.0001 – 0.001 µm

b) 0.001 – 0.1 µm

c) 1 – 10 µm

d) 10 – 100 µm

10. State whether the following statement is true or false.

“In USM, tool tips must have low resistance and fatigue strength.”

a) True

b) False

11. At what rate slurry is pumped through nozzle in USM?

a) 10 L/min

b) 25 L/min

c) 50 L/min

d) 75 L/min

12. USM removes materials using ____ tool?

a) Perpendicularly rotating

b) Perpendicularly oscillating

c) Axially oscillating

d) Inclined oscillating

13. Which is softer material in USM?

a) Tool

b) Work piece

c) Both of them

d) None of the mentioned

14. By which of the following means, material is removed in USM?

a) Mechanical abrasion

b) Microchipping

c) Cavitation

d) All of the mentioned

15. The following mechanisms, which one is dominant in material removal?

a) Hammering

b) Cavitation

c) Microchipping

d) None of the mentioned

16. Ultrasonic Machining can be used for which of the following processes and applications?

a) Drilling

b) Sinking and contouring

c) Polishing

d) All of the mentioned

17. One of the following factors, which one affects the accuracy of parts?

a) Steady abrasive flow

b) Accurate feed

c) Unsteady abrasive flow

d) Ultrasonic frequency

ANSWERTHE FOLLOWING:(2M)

1. Define USM

Ans: USM is the Ultrasonic machining process, in which the machining process will be carried by oscillating head& abrasive slurry.

2. How the USM process works?

Ans: In USM the electrical energy is converted in to mechanical oscillation and by impinging the abrasive grains against the work piece.

3. Name the element used to convert electrical energy converted in to mechanical oscillation?

Ans: The element used to convert electrical energy to mechanical oscillation is by Transducer

4. Name any two abrasive material used in USM

Ans: The two types of abrasive material are

- Aluminium oxide
- Silicon carbide

5. What is rate of slurry in USM?

Ans.Slurry is pumped through nozzle at the rate of 25 L/min, L- litres.

ANSWERTHE FOLLOWING:(3M)

1. List out the common Horn or concentrator used in USM

Ans: The commonly used tool holder or Horns are

- Tapered or Conical
- Exponential
- Stepped

2. Define the abrasive material used in USM

Ans:Abrasive slurry consists of very hard particles. It is filled into the machining zone. Abrasive slurry can be recycled with the help of pump. Normally very hard slurry like, Al2o3, Silicon carbide (Sic), boron carbide or diamond dust.

3. What is transducer? List out the types of transducer

Ans: Transducer The high frequency electrical signal is transmitted to traducer which converts it into high frequency low amplitude vibration. Essentially transducer converts electrical energy to mechanical vibration. There are two types of transducer used 1. Piezo electric transducer 2. Magneto-strictive transducer.

4. Write about material removal rate in USM

Ans:Material removal rate USM can be applied to machine nearly all materials; however, it is not economical to use USM for materials of hardness less than 50 HRC. Generally, the workpiece materials are of stainless steel, cobalt-base heat-resistant steels, germanium, glass, ceramic, carbide, quartz and semiconductors. It is highly useful in the machining of materials that cannot be machined by any conventional machining process that are ceramic and glass.

ANSWERTHE FOLLOWING:(5M)

1. Construct the neat diagram of different types of Horns used in USM

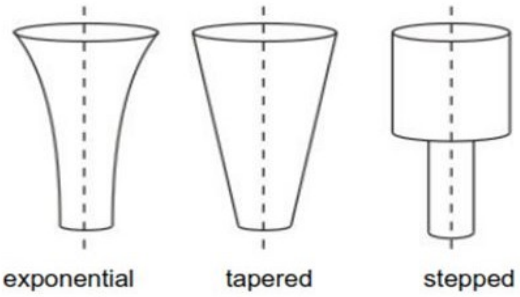
Ans:

Different Horns used in USM

The horn or concentrator can be of different shape like

- Tapered or conical
- Exponential
- Stepped

Machining of tapered or stepped horn is much easier as compared to the exponential one



2. List out the characteristics of USM process

Ans:Characteristics of USM are

Material removal mechanism:	Fracture of work material due to impact in grains.
Medium:	Abrasive Slurry
Tool Material:	Brass and mild steel
Frequency:	20 to 40 KHz
Material removal rate:	0.02 to 1mm/min
Work material:	Hard and brittle semiconductor glass and ceramic
Abrasive:	Aluminium oxide, silicon carbide, boron carbide.
Grain size:	100 to 800(Grade Number)
Gap size:	0.02 to 0.05mm
Process parameters:	Frequency amplitude grain size slurry concentrator and feed force.

3. Classify different applications of USM

Ans: Applications of USM are

- This process is generally applied for the machining of hard and brittle materials like carbides glass, ceramics, precious stones, titanium etc.
- Itis used for punch and die in tool making.
- The workpiece material is normally removed in the form of very fine chips so generated surface quality extremely good.

- Used for machining round, square, irregular shaped holes and surface impressions.
- Machining, wire drawing, punching or small blanking dies.

4.Write in brief about tool holder or Horn Used in USM Process

Ans. Tool holder. OR Horn. The tool holder holds and connects the tool to the transducer. It virtually transmits the energy and, in some cases, amplifies the amplitude of vibration. Material of tool should have good acoustic properties, high resistance to fatigue cracking. Due measures should be taken to avoid ultrasonic welding between transducer and tool holder. Commonly used tool holders are Monel, titanium, stainless steel. Tool holders are more expensive, demand higher operating cost. Tool holder can be classified as: Amplifying Tool Holder Non-Amplifying Tool Holder They give as much as 6 times increased tool motion. It is achieved by stretching and relaxing the tool holder material. MRR = 10 times the non-amplifying tool. Non amplifying tool holders have circular cross section and give same amplitude at both ends.

5. List out the Process capability of USM process

Ans. Process capability

- Can Machine work piece harder than 40 HRC to 60 HRC like carbides, ceramics, tungsten glass that cannot be machined by conventional methods
- Tolerance range 7 micron to 25 microns
- Holes up to 76 microns have been drilled hole depth up to 51mm have been achieved easily. Hole depth of 152mm deep is achieved by special flushing techniques.
- Aspect ratio 40:1 has been achieved
- Linear material removal rate -0.025 to 25mm/min
- Surface finish -0.25 micron to 0.75 micron
- Non directional surface texture is possible compared to conventional grinding
- Radial over cut may be as low as 1.5 to 4 times the mean abrasive grain size.

6. List out the advantages & disadvantages of USM process

Ans. Advantages:

1. It can be used machine hard, brittle, fragile and nonconductive material

2. No heat is generated in work, therefore no significant changes in physical structure of work material

3. Non-metal (because of the poor electrical conductivity) that cannot be machined by EDM and ECM can very well be machined by USM.

4. It is burr less and distortion less processes.

5. It can be adopted in conjunction with other new technologies like EDM, ECG, ECM.

Disadvantages:

1. Low Metal removal rate

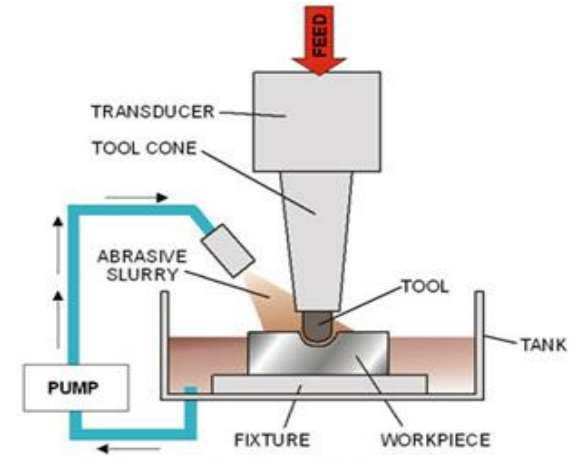
2. It is difficult to drill deep holes, as slurry movement is restricted.

3. Tool wear rate is high due to abrasive particles. Tools made from brass, tungsten carbide, MS or tool steel will wear from the action of abrasive grit with a ratio that ranges from 1:1 to 200:1

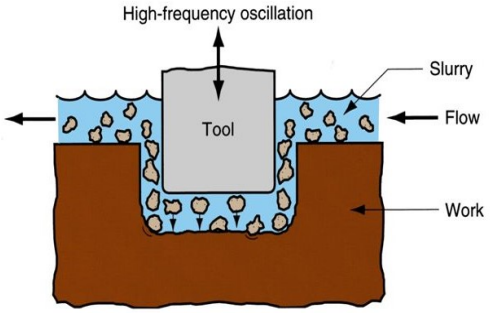
4. USM can be used only when the hardness of work is more than 45 HRC.

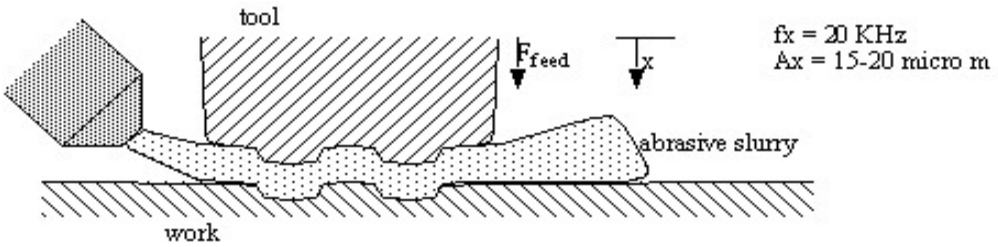
ANSWERTHE FOLLOWING:(8M)

1. Explain USM process with neat sketch



Ultrasonic Machining





Ultra-Sonic Machining (USM)

Ultrasonic machining (USM) is one of the non-traditional machining processes. Working principle of these process resembles with conventional and metal cutting as in this process abrasives contained in a slurry are driven at high velocity against the workpiece by a tool vibrating at low amplitude and high frequency.

Ultra-sonic machining is the process of material removal by repetitive impacts of high frequency abrasive particles against the work piece.

The process involves a tool vibrating at ultra-sonic frequency up to 20kHz to 40 kHz and a continuous flow of abrasive slurry in a small gap of about 0.02 to 0.05mm between the

tool and the work piece. The vibrating tool cause impact of abrasive grains in the slurry against the tool and the work piece surface. The work piece machined using this technique are generally hard and brittle and the impact of grains causes fracture at the work surface at the removal of material is in form of small particles from cutting zone.

The tool material is tough and ductile to keep tool wear at low due to impact of abrasive. The acoustic head consist of high frequency generator magnets sensitive transducer which converts mechanical motion into high frequency vibration and a concentration to amplifier vibration.

Consider an abrasive grain in the gap between the tool and the work piece when the vibrating tool moves to its bottom position as shown in figure. The grain penetrates the work piece as well as a tool this micro indentation generates a fracture in the brittle work material leading to material removal in the of small fracture material. The abrasive particles outside the tool work piece interface zone remain in active and do not contribute to material removal. The machined surface is replica (mirror) of the tool formed and by feeding the tool into the work piece holes and impression can be produced.

2. List out the advantages& disadvantages of USM process

Ans: Advantages of USM process are listed below:

- Its main advantages is the work piece after machining is free from any residual stress as to concentrated force or heat is subject to it during the machining process.
- Extremely hard and brittle materials can be machined, there machining is very difficult by conventional methods.
- Very good dimensional accuracy and surface finish can be obtained.
- Operational cost is low.
- The process is environmentally friendly as itis noiseless and no chemical and heating is used.

<u>Disadvantages of USM</u>

The process of USM have some disadvantages and limitations as described below:

- Its metal removal rate(MRR) is very low and it can be used for large machining cavities.
- Its initial setup cost and cost of tool is very high; frequency tool replacement is required as tool wear takes place in this operation.
- Not recommended for soft and ductile material due to their ductility.
- Power consumption is quite high.
- Slurry may have to be replaced frequently.

3. Construct the schematic diagram of USM machine and label the parts.

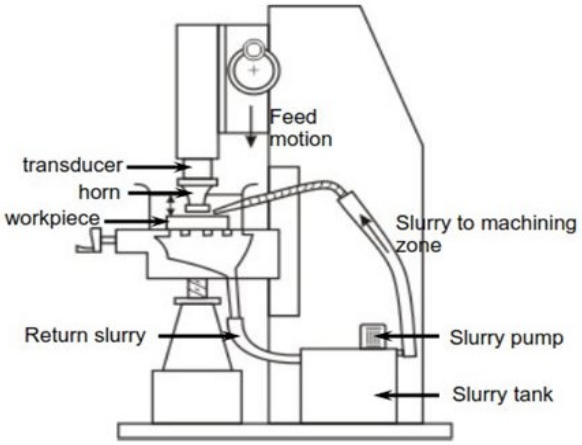
The typical elements of an USM are:

• Slurry delivery and return system

• Feed mechanism to provide a downward feed force on the tool during machining

• The transducer, which generates the ultrasonic vibration

• The horn or concentrator, which mechanically amplifies the vibration to the required amplitude of 15 – 50 μm and accommodates the tool at its tip



4. Explain material removal in USM process.

Ans. Material removal models in USM Theoretical analysis and experimental results have revealed that USM is a form of abrasion and material removal in the form of small grains by four mechanisms

1. Throwing of abrasive grains
2. Hammering of abrasive grains
3. Cavitation's in the fluid medium arising out of ultrasonic vibration of tool.
4. Chemical erosion due to micro –agitation

Material removal due to throwing and hammering is significant and MR due to cavitation's and chemical erosion can be ignored.

Abrasive particles are assumed to be spherical in shape having diameter dg. Abrasive particles move under high frequency vibrating tool.

There are two possibilities when the tool hit the particle. Ø If the size of the particle is small and gap between the tool and work is large, then particle will be thrown by tool to hit the work piece. Ø If the size of the particle is large and gap between tool and work is small, then particle is hammered over the work surface.

5. List out the applications of USM process.

Ans. Applications

- Machining of cavities in electrically non-conductive ceramics
- Used to machine fragile components in which otherwise the scrap rate is high
- Used for multistep processing for fabricating silicon nitride (Si3N4) turbine blades
- Large number of holes of small diameter. 930 holes with 0.32mm has been reported (Benedict, 1973) using hypodermic needles
- Used for machining hard, brittle metallic alloys, semiconductors, glass, ceramics, carbides etc.
- Used for machining round, square, irregular shaped holes and surface impressions.
- Used in machining of dies for wire drawing, punching and blanking operations
- USM can perform machining operations like drilling, grinding and milling operations on all materials which can be treated suitably with abrasives.
- USM has been used for piercing of dies and for parting off and blanking operations.
- USM enables a dentist to drill a hole of any shape on teeth without any pain
- Ferrites and steel parts, precision mineral stones can be machined using USM
- USM can be used to cut industrial diamonds
- USM is used for grinding Quartz, Glass, ceramics

- Cutting holes with curved or spiral centre lines and cutting threads in glass and mineral or metal-ceramics

CHAPTER-6 ABRASIVE JET MACHINING.

PART-A

FILL IN THE BLANKS:

1. Surface finish produced by AJM is 0.25 to 1.25 micron.
2. The size of abrasive particles in AJM is 10to 50 microns.
3. Distance between nozzle tip & work piece is ---- to ---- mm.
4. Aluminium oxide&Silicon carbideabrasives are generally used in AJM.
5. For best cutting result, size of abrasive used is --- to ---- µm.
6. Nitrogen gas is generally used in AJM process.
7. The inside diameter of the nozzle is mm.
8. The pressure of gas is 2-8kgf/cm^2.
9. The nozzle tip is made of tungsten carbide or sapphirematerial.
10. Material removal rate is 16mm3/minfor cutting glass, in AJM.
11. General accuracy of AJM is ±0.1mm.
12. Consumption of air is 0.008 m3 /minin AJM.
13. Life of nozzle for tungsten carbide is 20-30 hrs.
14. Life of nozzle for sapphire is 300 hrs.
15. Abrasive flow rate varies from 2 to 4 gm/min
16. Mixing ratio of abrasive in AJM isVolume flow rate of abrasives/Volume flow rate of gas.
17. The sieve is made to vibrate at 50-60 Hzand mixing ratio is controlled by the amplitude of vibration of sieve.

MULTIPLE CHOICE QUESTIONS:

1. The carrier gas in AJM also serves as

   a. Etchant

b. Coolant

c. Filter

d. None

2. In AJM material removal takes place by

a. Gas

b. Abrasive

c. Pressure

d. None.

3. Nozzles are mainly made of?

a. WC & sapphire

b. HSS & CS

c. HSC & MS

d. None.

4. Which abrasive is used in AJM?

a. Aluminium oxide

b. Silicon carbide

c. Dolomite

d. All of above.

5. The cross section of the nozzles in AJM is

a. Circular

b. Rectangular

c. both a & b

d. None

6. AJM stands for

a. Air Jet Machining

b. Abrasive Jet Machining

c. Angular Jet Machining

d. None

7. The flow pressure of air is controlled by ---- in AJM

a. Regulator

b. Pump

c. Filter

d. None.

8. In abrasive jet machining, workpiece material is removed by which of the following means?

a. Vaporization

b. Electroplating

c. Mechanical abrasion

d. Corrosion.

9. Which type of materials can be machined using AJM?

a. Glass

b. Ceramics

c. Hard materials

d. All of the above

10. In machining system of AJM, which is the medium of carrying the abrasive grains for machining?

a. Liquids

b. Gases

c. Any fluids

d. None

11. Which of the following gas, should never be used as carrier of abrasive?

a. Nitrogen

b. CO_2

c. Oxygen

d. Air

12. What is the frequency of mixing chamber, consisting of gas &abrasives.

a. 10Hz

b. 30Hz

c. 50Hz

d. 70Hz

13. What are the processes where AJM can be used?

a. Cutting

b. Cleaning

c. Deburring

d. All of the above

14. Abrasive jet machining process can be used for

a) Conductors

b) Insulators

c) Metals

d) All of the mentioned

15. 4. For machining of plastic material which of the unconventional process can be used effectively?

a) Electro chemical machining

b) Electron beam machining

c) Abrasive jet machining

d) None of the mentioned

16. Metal removal rate in abrasive jet machining increases with

a) Increase in abrasive flow rate

b) Decrease in abrasive flow rate

c) Decrease in grain size of abrasives

d) Increase in grain size of abrasives

17. Mixing ratio in abrasive jet machining is defined as a ratio of

a) Mass flow rate of abrasive to mass flow rate of gas

b) Mass flow rate of gas to mass flow rate of abrasive

c) Velocity of gas to velocity of abrasive

d) None of the mentioned

18. In AJM material removal rate is given by

a. $KNd^3v^{3/2}\left[\frac{\rho}{12H}\right]$

b. $KNdv\left[\frac{\rho}{12H}\right]$

c. $KNd^3v^{3/2}\left[\frac{\rho}{H}\right]$

d. $KNd^3v^{3/2}\left[\frac{\rho}{12}\right]$

ANSWERTHE FOLLOWING:(2M)

1. Which all are the abrasive particles used in AJM?

Ans. Aluminium oxide, silicon carbide, dolomites & glass beads are used as abrasive in AJM.

2. On which the material removal rate is dependent in AJM?

Ans. MRR mainly depends on abrasive size, stand-off distance & flow pressure.

3. Write the materials used for manufacturing nozzles in AJM.

Ans. Tungsten carbide & Sapphire are used for nozzle manufacturing.

4. What is the cross section of nozzles made of sapphire material?

Ans. Round cross section is preferred for sapphire material.

5. What is the cross section of nozzles made of Tungsten carbide material?

Ans. Round sections & rectangular cross sections are preferred for tungsten carbide.

6. How many hours' tungsten carbide nozzles are used?

Ans. 20-30hrs tungsten carbide nozzles are used.

7. How work piece is cooled in AJM process?

Ans. Workpiece is cooled by carrier gas.

8. Which maskants are used in AJM process while operating soft materials?

Ans. Rubber, copper & plastics are used as maskants.

9. Why oxygen is not used as carrier gas in AJM?

Ans. Oxygen is not used because it causes a violent chemical reaction with abrasive or workpiece.

10. What is standoff distance in AJM?

Ans. Stand-off distance: Standoff distance is defined as the distance between the face of the nozzle and the work surface of the work.

PART-B

ANSWERTHE FOLLOWING: (3M)

1. Define AJM.

Ans. Definition: In abrasive jet machining, a focused stream of abrasive particles, carried by high pressure air or gas is made to impinge on the work surface through a nozzle and the work material is made to impinge on the work surface through a nozzle and work material is removed by erosion by high velocity abrasive particles.

2. What are limitations of AJM process? (any 3)

Ans. 1. Limited capacity due to low MRR. MRR for glass is 40 gm/minute

2 Abrasives may get embedded in the work surface, especially while machining softmaterial like elastomers or soft plastics.

3. The accuracy of cutting is hampered by tapering of hole due to unavoidable flaringof abrasive jet.

3. Write advantages of AJM. (any 3)

Ans. 1. Process is free from chatter and vibration as there is no contact between the tool and work piece

2. Capital cost is low and it is easy to operate and maintain AJM.

3. Thin sections of hard brittle materials like germanium, mica, silicon, glass and ceramics can be machined.

4. Write disadvantages of AJM. (any 3)

Ans. 1. Stray cutting is difficult to avoid

2. A dust collection system is a basic requirement to prevent atmospheric pollutionand health hazards.

3. Nozzle life is limited (300 hours)

4. Abrasive powders cannot be reused as the sharp edges are worn and smallerparticles can clog the nozzle.

5. Write application of AJM. (any 3)

Ans. 1. This is used for abrading and frosting glass more economically as compared toetching or grinding

2. Cleaning of metallic smears on ceramics, oxides on metals, resistive coating etc.

3. AJM is useful in manufacture of electronic devices, drilling of glass wafers, de burring of plastics, making of nylon and Teflon parts permanent marking on rubber stencils, cutting titanium foils

6. Write the character of carrier gas.

Ans. The character of carrier gases is:

- Gas should be non-toxic
- Should be cheap & easily available.
- It should not excessively spread when discharged from nozzle into atmosphere.

7. Explain about mixing chamber.

Ans. Machining chamber It is well closed so that concentration of abrasive particles around the working chamber does not reach to the harmful limits. Machining chamber is equipped with vacuum dust collector. Special consideration should be given to dust collection system if the toxic material (like beryllium) are being machined.

8. Which all gases are used as carrier gases in AJM.

Ans. Gases used as carrier gas in AJM are:

- Nitrogen gas
- Air
- Carbon dioxide

9. Which are the AJM process criteria?

Ans. Following are the AJM process criteria

1. Material removal rate
2. Geometry and surface finish of work piece
3. wear rate of the nozzle.

10. Which controls are used for relative motion between workpiece & nozzle in AJM?

Ans. The main controls used in AJM are:

- Cam drives
- Pantographs
- Trace mechanisms.

ANSWERTHE FOLLOWING: (5M)

1. Write the process parameters (Characteristics) of AJM.

Ans. Process parameters

- Abrasives
  - a) material – Al_2O_3, SiC, Glass beads, Crushed glass Sodium bi carbonate
  - b) shape – irregular/regular
  - c) Size – 10 to 50 microns
  - d) Mass flow – 2-20 gm/min
- Carrier Gas
  - a) Composition – Air, CO2, N2

b) Density – 1.3 kg/m3

c) Velocity - 500 to 700 m/s

d) Pressure - 2 to 10 bar

e) Flow rate - 5 to 30 microns

- Abrasive Jet

a) Velocity - 100 to 300 m/s

b) Mixing ratio – Volume flow rate of abrasives/Volume flow rate of gas

c) Standoff distance – SOD- 0.5 to 15mm.

d) Impingement angle – 60 to 90 deg.

- Nozzle

a) Material – WC/Sapphire

b) Diameter – 0.2 to 0.8 mm

c) Life – 300 hours for sapphire, 20 to 30 hours for WC

2. Discuss abrasive materials used in AJM.

Ans. ABRASIVES: Aluminium oxide (Al_2O_3) Silicon carbide (SiC) Glass beads, crushed glass and sodium bicarbonate are some of abrasives used in AJM. Selection of abrasives depends on MRR, type of work material, machining accuracy.

Abrasives Grain Sizes Application

Abrasives	Grain Sizes	Application
Aluminum oxide(Al_2O_3)	12, 20, 50 microns	Good for cleaning, cutting and deburring
Silicon carbide (SiC)	25,40 micron	Used for similar application but for hard material
Glass beads	0.635 to 1.27mm	Gives matte finish
Dolomite	200 mesh	Etching and polishing
Sodium bi carbonate	27 micros	Cleaning, deburring and cutting of soft material Light finishing below 50^0C

3. Discuss surface finish in AJM.

Ans. The surface finish depends on abrasive size

Particle size (in microns)	Surface roughness (in microns)
10	0.152 to 0.203
25 to 27	0.355 to 0.675

50 0.965 to 1.27

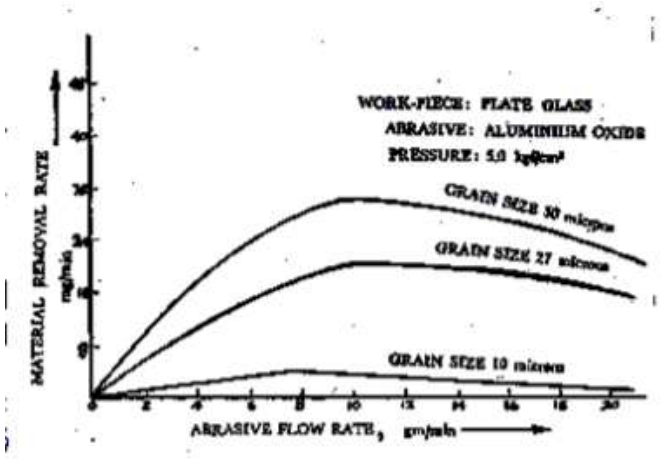
4. Write the process capability of AJM.

Ans. Process capability of AJM:

1. Material removal rate – 0.015 cm3/min
2. Narrow slots – 0.12 to 0.25mm ± 0.12mm
3 Surface finish -0.25 micron to 1.25 micron
4 Sharp radii up to 0.2mm is possible
5. Steel up to 1.5mm, Glass up to 6.3mm is possible to cut
6. Machining of thin sectioned hard and brittle materials is possible.

5. Write Effect of abrasive flow rate and grain size on MRR

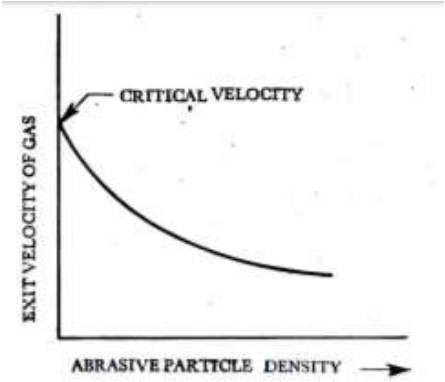
Ans. Effect of abrasive flow rate and grain size on MRR: It is clear from the figure that at a particular pressure MRR increase with increase of abrasive flow rate and is influenced by size of abrasive particles. But after reaching optimum value, MRR decreases with further increase of abrasive flow rate. This is owing to the fact that Mass flow rate of gas decreases with increase of abrasive flow rate and hence mixing ratio increases causing a decrease in material removal rate because of decreasing energy available for erosion.



6. Write effect of exit gas velocity & abrasive particle density.

Ans. Effect of exit gas velocity and abrasive particle density: The velocity of carrier gas conveying the abrasive particles changes considerably with the change of abrasive particle density as indicated in figure. The exit velocity of gas can be increased to critical velocity when the internal gas pressure is nearly twice the pressure at exit of nozzle for

the abrasive particle density is zero. If the density ofabrasive particles is gradually increased exit velocity will go on decreasing for the same pressure condition. It is due to fact that Kinetic energy of gas is utilized for transporting the abrasive particle.



7. Write the Physics of the Process:

Ans. Physics of the Process:

- Fine particles (0.025mm) are accelerated in a gas stream
- The particle is directed towards the focus of machining
- As the particles impact the surface, it causes a micro fracture, and gas carriesfractured particles away
- Brittle and fragile work better

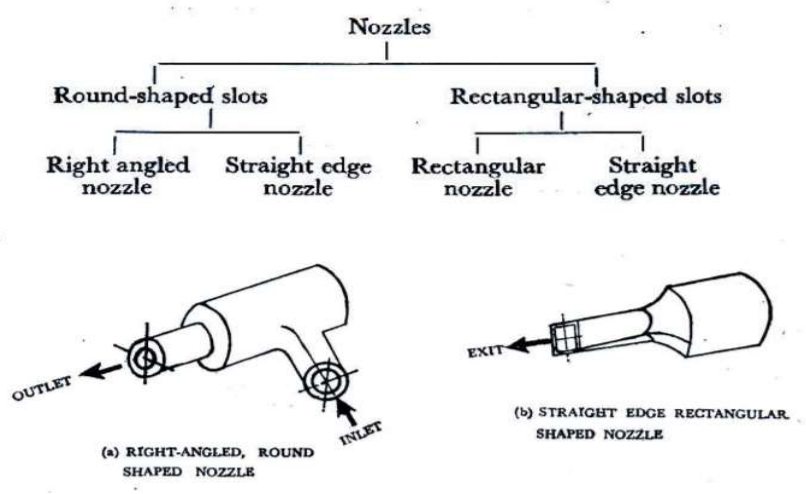
8. Explain gas propulsion system.

Ans. Gas Propulsion System:

Supplies clean and dry air. Air, Nitrogen and carbon dioxide to propel the abrasive particles. Gas may be supplied either from a compressor or a cylinder. In case of a compressor, air filter cum drier should be used to avoid water or oil contamination of abrasive powder. Gas should be non-toxic, cheap, easily available. It should not excessively spread when discharged from nozzle into atmosphere. The propellant consumption is of order of 0.008 m^3/min at a nozzle pressure of 5 bar and abrasive flow rate varies from 2 to 4 gm/min for fine machining and 10 to 20 gm/min for cutting operation.

9. List the types of nozzles & its materials.

Ans. AJM nozzle is usually made of tungsten carbide or sapphire (usually life – 300 hours for sapphire, 20 to 30 hours for WC) which has resistance to wear. The nozzle is made of either circular or rectangular cross section and head can be head can be straight, or at a right angle. It is so designed that loss of pressure due to the bends, friction etc is minimum possible. With increase in wear of a nozzle, the divergence of jet stream increases resulting in more stray cutting and high inaccuracy.



(a) RIGHT-ANGLED, ROUND SHAPED NOZZLE

(b) STRAIGHT EDGE RECTANGULAR SHAPED NOZZLE

NOZZLE MATERIAL	ROUND SHAPE NOZZLE DIAMETER, MM	RECTANGULAR SHAPE SLOT, DIMENSION, MM	LIFE OF NOZZLE, HOURS
Tungsten Carbide (WC)	0.2 to 1.0	0.075 × 0.5 to 0.15 × 2.5	12 to 30
Sapphire	0.2 to 0.8	—	300

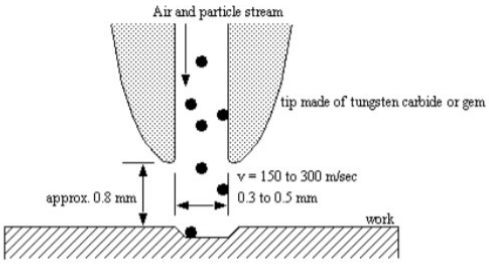
ANSWERTHE FOLLOWING: (8M)

1. Explain working principle of AJM with neat schematic diagram.

Ans. Process:

In Abrasive jet machining abrasive particles are made to impinge on work material at

high velocity. Jet of abrasive particles is carried by carrier gas or air. The highvelocity stream of abrasives is generated by converting pressure energy of carriergas or air to its Kinetic energy and hence high velocity jet. Nozzles directs abrasivejet in a controlled manner onto work material. The high velocity abrasive particlesremove the material by micro-cutting action as well as brittle fracture of the workmaterial.



This is a process of removal of material by impact erosion through the action of concentrated high velocity stream of grit abrasives entrained in high velocity gasstream. AJM is different from shot or sand blasting, as in AJM, finer abrasive grits areused and parameters can be controlled more effectively providing better control over product quality.

In AJM, generally, the abrasive particles of around 50 microns grit size wouldimpinge on the work material at velocity of 200 m/s from a nozzle of ID 0.5mm witha standoff distance of around 2mm. The kinetic energy of the abrasive particleswould sufficient to provide material removal due to brittle fracture of the work pieceor even micro cutting by the abrasives.

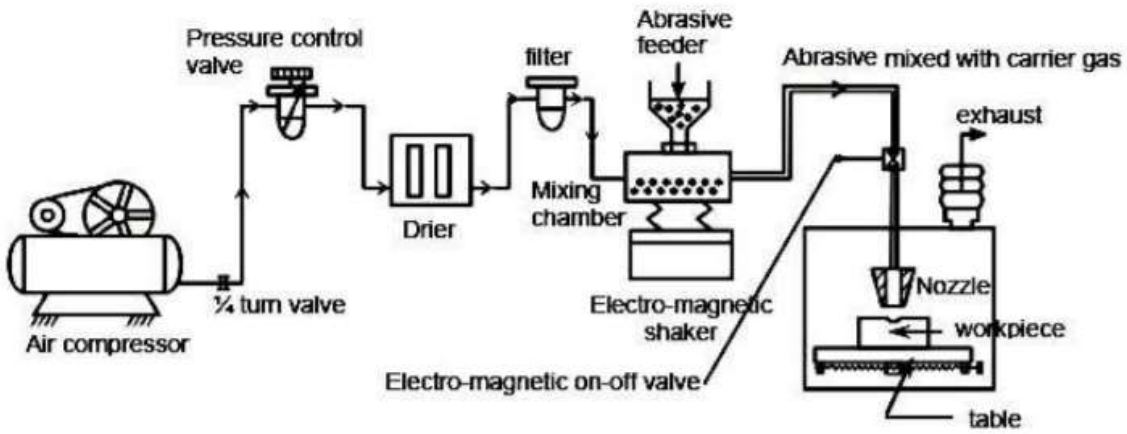
Physics of the Process:

- Fine particles (0.025mm) are accelerated in a gas stream
- The particle is directed towards the focus of machining
- As the particles impact the surface, it causes a micro fracture, and gas carriesfractured particles away
- Brittle and fragile work better

2. Explain AJM elements & there influences.

Ans. Equipment:

A schematic layout of AJM is shown above. The gas stream is then passed to thenozzle through a connecting hose. The velocity of the abrasive stream ejectedthrough the nozzle is generally of the order of 330 m/sec.Abrasive jet Machining consists of



1. Gas propulsion system
2. Abrasive feeder
3. Machining Chamber
4. AJM Nozzle
5. Abrasives

Gas Propulsion System:

Supplies clean and dry air. Air, Nitrogen and carbon dioxide to propel the abrasiveparticles. Gas may be supplied either from a compressor or a cylinder. In case of acompressor, air filter cum drier should be used to avoid water or oil contamination ofabrasive powder. Gas should be non-toxic, cheap, easily available. It should notexcessively spread when discharged from nozzle into atmosphere. The propellantconsumption is of order of 0.008 m^3/min at a nozzle pressure of 5 bar and abrasiveflow rate varies from 2 to 4 gm/min for fine machining and 10 to 20 gm/min forcutting operation.

Abrasive Feeder.

Required quantity of abrasive particles is supplied by abrasive feeder. The filletedpropellant is fed into the mixing chamber where in abrasive particles are fed througha sieve. The sieve is made to vibrate at 50-60 Hz and mixing ratio is controlled bythe amplitude of vibration of sieve. The particles are propelled by carrier gas to amixing chamber. Air abrasive mixture moves further to nozzle. The nozzle impartshigh velocity to mixture which is directed at work piece surface. Non-Traditional MachiningIt is well closed so that concentration of abrasive particles around the workingchamber does not reach to the harmful limits. Machining chamber is equipped withvacuum dust

collector. Special consideration should be given to dust collectionsystem if the toxic material (like beryllium) are being machined.

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ABRASIVES

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Dolomite	200 mesh	Etching and polishing
Sodium bi carbonate	27 micros	Cleaning, deburring and cutting of soft material Light finishing below 50^0C

3. Discuss about effects of various parameters on MRR in AJM.

Ans. For successful utilization of AJM process, it is necessary to analyse the following process criteria.

1. Material removal rate
2. Geometry and surface finish of work piece
3. wear rate of the nozzle

However, Process criteria are generally influenced by the process parameters as

enumerated below:

- Abrasives
    a) material – Al_2O_3 Sic Glass beads Crushed glass Sodium bi carbonate
    b) shape – irregular/regular
    c) Size – 10 to 50 microns
    d) Mass flow – 2-20 gm/min
- Carrier Gas
    a) Composition – Air, CO_2, N_2
    b) Density – 1.3 kg/m3
    c) Velocity - 500 to 700 m/s
    d) Pressure - 2 to 10 bar
    e) Flow rate - 5 to 30 microns
- Abrasive Jet
    a) Velocity - 100 to 300 m/s
    b) Mixing ratio – Volume flow rate of abrasives/Volume flow rate of gas
    c) Stand-off distance – SOD- 0.5 to 15mm.
    d) Impingement angle – 60 to 90 deg.
- Nozzle
    a) Material – WC/Sapphire
    b) Diameter – 0.2 to 0.8 mm
    c) Life – 300 hours for sapphire, 20 to 30 hours for WC

4. Write advantages of AJM.

Ans. Advantages:

1. High surface finish can be obtained depending upon the grain sizes

2. Depth of damage is low (around2.5 microns)

3. It provides cool cutting action, so it can machine delicate and heat sensitive material

4.Process is free from chatter and vibration as there is no contact between the tool
and work piece

5.Capital cost is low and it is easy to operate and maintain AJM.

6.Thin sections of hard brittle materials like germanium, mica, silicon, glass and ceramics can be machined.

7.It has the capability of cutting holes of intricate shape in hard materials.

5. Write the effect of mixing ration on MRR.

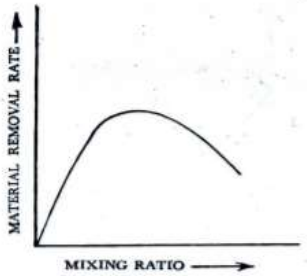
Ans. Effect of Mixing ratio on MRR

Increased mass flow rate of abrasive will result in a decreased velocity of fluid and will thereby decreases the available energy for erosion and ultimately the

MRR. It is convenient to explain to this fact by term MIXING RATIO.

Which is defined as:

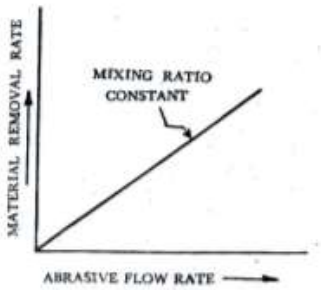
$$\text{Mixing ratio} = \frac{\text{Volume flow rate of carrier gas}}{\text{Volume flow rate of carrier gas}}$$



The effect of mixing ratio on the material removal rate is shown above.

The material removal rate can be improved by increasing the abrasive flow rate provided the mixing ratio can be kept constant. The mixing ratio is unchanged only by simultaneous increase of both gas and abrasive flow rate. An optimum value of mixing ratio that gives maximum MRR is predicted by trial and error. In place of Mixing ratio, the mass ratio (α) may be easier to determine. Which is defined as:

$$\alpha = \frac{\text{Mass flow rate of carrier gas}}{\text{Mass flow rate of carrier gas and abrasive}} = \frac{m_a}{m_{a+g}}$$



6. Write applications of AJM.

Ans. Applications:

1. This is used for abrading and frosting glass more economically as compared toetching or grinding.

2. Cleaning of metallic smears on ceramics, oxides on metals, resistive coatingetc.

3. AJM is useful in manufacture of electronic devices, drilling of glass wafers, deburring of plastics, making of nylon and Teflon parts permanent marking onrubber stencils, cutting titanium foils.

4. Deflashing small castings, engraving registration numbers on toughened glass used for car windows.

5. Used for cutting thin fragile components like germanium, silicon etc.

6. Register treaming can be done very easily and micro module fabrication for electrical contact, semiconductor processing can also be done effectively.

7. Used for drilling, cutting, deburring etching and polishing of hard and brittle materials.

8. Most suitable for machining brittle and heat sensitive materials like glass, quartz,
sapphire, mica, ceramics germanium, silicon and gallium.

9. It is also good method for deburring small hole like in hypodermic needles and for small milled slots in hard metallic components.

7. Write limitations of AJM.

Ans. Limitations of AJM:

1. Limited capacity due to low MRR. MRR for glass is 40 gm/minute

2 Abrasives may get embedded in the work surface, especially while machining softmaterial like elastomers or soft plastics.

3. The accuracy of cutting is hampered by tapering of hole due to unavoidable flaringof abrasive jet.

4. Stray cutting is difficult to avoid

5. A dust collection system is a basic requirement to prevent atmospheric pollutionand health hazards.

6. Nozzle life is limited (300 hours)

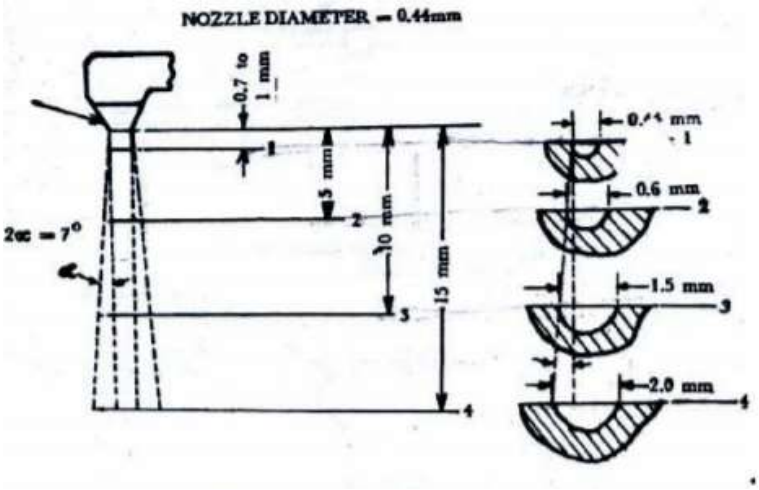
7. Abrasive powders cannot be reused as the sharp edges are worn and smallerparticles can clog the nozzle.

8. Short stand-off distances when used for cutting, damages the nozzle.

8. Explain stand-off distance.

Ans. Stand-off distance:

Standoff distance is defined as the distance between the face of the nozzle and the work surface of the work. SOD has been found to have considerable effect on the work material and accuracy. A large SOD results in flaring of jet which leads to poor accuracy.



It is clear from figure that MRR increase with nozzle tip distance or Standoff distance up to certain distance and then decreases. Penetration rate also increases with SOD and then decreases. Decrease in SOD improves accuracy, decreases kerfwidth, and reduces taper in machined groove. However light operation like cleaning, frosting etc are conducted with large SOD. (say 12.5 to 75mm)

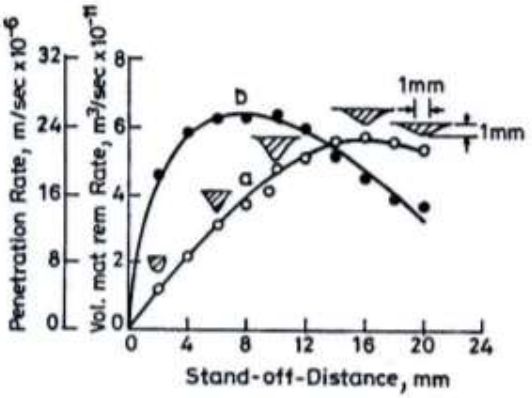


Fig. 2.2 Effects of stand-off-distance on material removal rate (• penetration rate, ○ volumetric material removal rate) [*Verma and Lal, 1984*].

CHAPTER-7 WATER JET MACHINING.

PART-A

FILL IN THE BLANKS:

1. Velocity of water jet stream that is used in Water jet machining is about 900 m/sec
2. In WJM, diameter of the nozzle's ranges between 0.10 – 0.30 mm
3. The material thickness value of work piece range between 0.8 – 25 mm
4. For non-metallic materials high pressure and lower flow ratesare used in deburring.
5. Abrasive particlesenhance the cutting ability of the water jet.
6. Water jet machining has multi directional cutting capacity.
7. Due to high maintenance, WJM cannot be used for mass production
8. The intensifier is to increase the inlet water pressure to5bars to 4000
9. The life that is expected from the nozzle, which is a part of machining system, is 200 hrs.
10. Typical tube diameter values range between6 to 14 mm
11. Water jet machining is also called as Water jet cutting
12. The flow of the water is regulated with the help of the flow regulator
13. Accumulator stores the high pressurized water temporary.
14. Hydraulic intensifier increases the pressure of water to very high pressure
15. Nozzle is used to convert the pressure energy of water into kinetic energy in water jet machining

MULTIPLE CHOICE QUESTIONS:

1. What is the full form of WJM in advanced machiningprocesses?

   a) Water Jack Manufacturing

   b) Water JetMachining

   c) Water JetManufacturing

d) Water Jack Manufacturing

2. What is the key element of water jet machining for materialremoval?

   a) ToolHolder

   b) Workpiece

   c) Waterjet

   d) Powersource

3. What is the velocity of water jet stream in water jetmachining?

   a) 100m/sec

   b) 300m/sec

   c) 700m/sec

   d) 900m/sec

4. Which of the following is not a part of machining system of Waterjet machining?

   a) Transducer

   b) Accumulator

   c) Jet cuttingnozzle

   d) Hydraulicpump

5. What is the general power rating of the hydraulic pump, used inWJM?

   a) 10kW

   b) 20kW

   c) 30kW

   d) 40kW

6. Intensifier increases the pressure water by which of the following values?

   a) 10 – 100MPa

   b) 100 – 200MPa

   c) 200 – 400MPa

d) 400 – 1000 MPa

7. On which property of water, will the accumulator in Water jetmachining relyon?
   a) Density
   b) Compressibility
   c) Viscosity
   d) Velocity

8. What are the values of typical tube diameters in the machining system in WJM?
   a. 0.1 to 1mm
   b. 1 to 6 mm
   c. 6 to 14mm
   d. 14 to 25mm

9. What is the expected life of the nozzles used inWJM?
   a) 10hrs
   b) 20hrs
   c) 100hrs
   d) 200hrs

10. Which of the following does not damage the nozzle used in Waterjet machining?
    a. Particles ofdirt
    b. Mineraldeposits
    c. Water
    d. All of thementioned

11. What are the uses of catcher in machining system of Water jetmachining?
    a. Collectingdirt
    b. Collection ofdebris

c. Reduce noise levels

d. All of thementioned

12. In the following materials, Water jet machining can be used on which typeof material?

a. Metals

b. Plastics

c. Ceramics

d. All of thementioned

13. What are the processes and applications, where Water jet machining canbe used?

a. Cutting

b. Drilling

c. Deburring

d. All of thementioned

14. In cutting of rocks using water jet machining, which type of pressure isneeded?

a. Lowpressure

b. Mediumpressure

c. Highpressure

d. None of thementioned

15. In deburring, which combination removes the material fromnon-metallic materials?

a. High pressure and low flowrate

b. High pressure and high flowrate

c. Low pressure and low flowrate

d. Low pressure and high flowrate

ANSWERTHE FOLLOWING: (2M)

1) Write types of abrasive particle used in WJM.

Ans. The most commonly used abrasive particles in AWJM are garnet and aluminum oxide. Sand (Si02) and glass beads are also used as abrasive.

2) Define WJM.

Ans. Water jet machining also called as Waterjet cutting is a non –traditional machining process in which high velocity jet of water is used to remove materials from the surface of the workpiece. WJM can be used to cut softer materials like plastic, rubber or wood.

3) How much water does waterjet use?

Ans. It costs approximate one-gallon water per minute during process depending on the cutting head orifice size

4) What is industrial water jet?

Ans. A water jet cutter, also known as a water jet or waterjet, is an industrial tool capable of cutting a wide variety of materials using a very high-pressure jet of water, or a mixture of water and an abrasive substance.

5) How does water jet cut work?

Ans. Water jet cutting works by forcing a large volume of water through a small orifice in the nozzle. The constant volume of water traveling through a reduced area causes the particles to accelerate

6) What is the work of accumulator in WJM?

Ans. It stores the high pressurized water temporary. It supplies that fluid when a large amount of pressure energy is required. It eliminates pressure fluctuation conditions in the machining process.

7) What is the work of Hydraulic intensifier in WJM?

Ans. It is used to increase the pressure of water to very high pressure. It receives the

water from the pump at 4 bar and increases its pressure up to 3000 to 4000 bar.

8) What is use of mixing chamber in WJM?

Ans. It is a vacuum chamber where the mixing of abrasive particles into water takes place.

9) Nozzle tips are made of which material?

Ans. The tip of the nozzle is made of ruby or diamond to prevent it from erosion.

10) What is the function of abrasive in WJM?

Ans. The function of the abrasive particles is to enhance the cutting ability of the water jet.

11) Why we require the drain and catcher system in WJM?

Ans. The drain and catcher system is used to remove debris and other machined particle form water. It separate metal particle from water and this water is further send to reservoir. It also used to reduce noise associate with WJM

12) Write function of Nozzle.

Ans. The function of is, it is used to convert pressure energy into kinetic energy. This nozzle converts high pressure of water into high velocity jet.

13) What is Stand-Off Distance in WJM?

Ans. The distance from the work surface to the tip of nozzle in water jet machining is called Stand-Off Distance. Its value ranges between 2.5 – 6 mm.

14) Write process parameters of WJM

Ans. process parameters of WJM are

- Stand-Off Distance
- Sapphire size
- Jet velocity
- Jet Diameter

Nozzle feed

15) What are the types of abrasive particle used in WJM?

Ans. Abrasive particles are used in water jet machining for machine hard material. Generally, Garnet or Aluminium oxide, Silicon carbide etc. used as abrasive particles.

16) Explain in short WJM.

Ans. Water jet machining also called as Waterjet cutting is a non –traditional machining process in which high velocity jet of water is used to remove materials from the surface of the workpiece. WJM can be used to cut softer materials like plastic, rubber or wood.

17) What is the function of drain and catcher system in WJM?

Ans. The drain and catcher system is used to remove debris and other machined particle form water. It separate metal particle from water and this water is further send to reservoir. It also used to reduce noise associate with WJM.

18) Mention size and material of nozzle used in WJM.

Ans. The tip of the nozzle used in WJM is made of ruby or diamond material to prevent it from erosion. The size of nozzle is about diameter 0.2 – 0.4 mm.

19) Write the function of Hydraulic intensifier in WJM?

Ans. As the name implies, it is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar. The water pressure at outlet of intensifier is about 3000-4000 bars.

20) What is the work of Hydraulic intensifier in WJM?

Ans. As the name implies, it is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar. The water pressure at outlet of intensifier is about 3000-4000 bars.

ANSWERTHE FOLLOWING: (3M)

1. What is WJM.

Ans. WJM means Water Jet Machiningalso called water jet cutting, is a non-traditional machining process in which high-velocity jet of water is used to remove materials from the surface of the workpiece.

2. Write working principle of WJM.

Ans. It is based on the principle of water erosion. When a high-velocity jet of water strikes the surface, the removal of material takes place. Pure water jet is used to machine softer materials.

3. What is the work of Hydraulic pump in WJM?

Ans. It is used to circulate the water from the storage tank during the machining process. The pump delivers water to the intensifier at low pressure of about 5 bars.

4. Explain Nozzle used in WJM?

Ans. It is a device that is used to convert the pressure energy of water into kinetic energy in water jet machining. Here nozzle converts the pressure of water jet into high-velocity beam of water jet. The tip of the nozzle is made of ruby or diamond to prevent it from erosion.

5. What is the work of drain and catcher system in WJM?

Ans. After the machining, the debris and machined particles from the water are separated out with the help of the drain and catcher system. It removes the metal particle and other unwanted particles from the water and sends it back to the reservoir for further use.

6. What is the work of Hydraulic pump in WJM?

Ans. Hydraulic pump it is used to circulate the water from the storage tank during the machining process. The pump delivers water to the intensifier at low pressure of about 5 bars. A booster is also used which increase the initial pressure of water to 11 bars before delivering it to the intensifier. It is connected by an electric motor of about 100 Horse power.

7. Explain Nozzle used in WJM?

Ans. As we know, nozzles are used to convert pressure energy into kinetic energy. This nozzle converts high pressure of water into high velocity jet. This high speed water jet strikes at work surface which is used for machining. There is possibility of erosion at orifice of the nozzle due to high pressure water jet. Therefor the tip of the nozzle is made of ruby or diamond material to prevent it from erosion. The size of nozzle is about 0.2 – 0.4 mm.

8. What is the work of drain and catcher system in WJM?

Ans. The drain and catcher system is used to remove debris and other machined particle form water. Its separate metal particle from water and this water is further send to reservoir. It also used to reduce noise associate with WJM

9. Write any five parts of WJM.

Ans. The various parts of water jet machine are.

- Hydraulic pump
- Hydraulic intensifier
- Accumulator
- Mixing chamber or tube
- Control valve
- Flow regulator or valve
- Nozzle
- Drain and catcher system.

10. Why we need accumulator in WJM

Ans. Accumulator is needed in WJM because:

Accumulator stores the high pressurized water temporary. It supplies that fluid when a large amount of pressure energy is required. It eliminates pressure fluctuation condition in the machining process.

11. Why we need Hydraulic intensifier in WJM

Ans. Hydraulic intensifier needed in WJM because:

It is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar. The water pressure at outlet of intensifier is about 3000-4000 bars.

12. Write the function of Accumulator in WJM?

Ans. Accumulator

Accumulator stores the high pressurized water temporary. It supplies that fluid when a large amount of pressure energy is required. It eliminates pressure fluctuation condition in the machining process.

13. The hydraulic intensifier used in WJM because?

Ans. Hydraulic intensifier

As the name implies, it is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar. The water pressure at outlet of intensifier is about 3000-4000 bars.

14. Write types of process parameters of WJM.

Ans. Process parameters of WJM are

Stand-Off Distance
Sapphire size
Jet velocity
Jet Diameter
Nozzle feed

15. Write a short note on Nozzle used in WJM?

Ans. As we know, nozzles are used to convert pressure energy into kinetic energy. This nozzle converts high pressure of water into high velocity jet. This high-speed water jet strikes at work surface which is used for machining. There is possibility of erosion at orifice of the nozzle due to high pressure water jet. Therefor the tip of the nozzle is made of ruby or diamond material to prevent it from erosion. The size of nozzle is about 0.2 – 0.4 mm.

16. What is the use of flow regulator valve and control valve in WJM.

Ans. Flow Regulator or valve:

Flow regulators are used to regulate the flow according to cutting requirement. For high cutting load, high pressurized water is supplied at high rate.

Control valve:

It controls the pressure and direction of the water jet.

ANSWERTHE FOLLOWING: (5M)

1) List out advantages of WJM.

Ans. Advantages

- It has the ability to cut materials without disturbing its original structure. And this happens so because there is no heat-affected zone (HAZ).
- It is capable of producing complex and intricate cuts in materials.
- The work area in this machining process remains clean and dust-free.
- It has low operating and maintenance cost because it has no moving parts.
- The thermal damage to the workpiece is negligible due to no heat generation.

2) Explain WJM.

Ans. **Water Jet Machining** (WJM) also called water jet cutting, is a non-traditional machining process in which high-velocity jet of water is used to remove materials from the surface of the workpiece. WJM can be used to cut softer materials like plastic, rubber or wood. In order to cut harder materials like metals or granite, an abrasive material is mixed in the water. When an abrasive material is used in the water for the machining process than it is called Abrasive Water Jet Machining (AWJM).

3) List out dis advantages of WJM.

Ans. Disadvantages

- It is used to cut softer materials. But AWJM can cut harder material of limited thickness.

- Very thick material cannot be machined by this process.
- The initial cost of WJM is high.

4) Write application of WJM.

Ans. Application

- Water jet machining is used in various industries like mining, automotive and aerospace for performing cutting, shaping and reaming operations.
- The materials which are commonly machined by water jet (WJM or AWJM) are rubber, textiles, plastics, foam, leather, composites, tile, stone glass, food, metals/ paper and much more.
- WJM is mostly used to cut soft and easy to machine materials such as thin sheets and foils, wood, non-ferrous metallic alloys, textiles, honeycomb, plastics, polymers, leathers, frozen, etc.
- AWJM is typically used to machine those materials which are hard and difficult to machine.
- Besides the Machining process, the high-pressure water jet is used in paint removal, surgery, cleaning, peening to remove residual stress, etc.

5) List out the parts of water jet machine.

Ans. The various parts of water jet machining are:

- Hydraulic Pump
- Hydraulic Intensifier
- Accumulator
- Mixing chamber or tube
- Control Valve
- Flow Regulator or Valve
- Nozzle

- Drain and Catcher System

6) What is WJM? Write working principal of WJM.

Ans. WJM means Water Jet machining. It is based on the principle of water erosion. When a high-velocity jet of water strikes the surface, the removal of material takes place. Pure water jet is used to machine softer materials. But to cut harder materials, some abrasive particles mixed with the water for machining and it is called as AWJM (Abrasive Water Jet Machining)

7) Explain what is the use of all parts of water jet machine.

Ans. The apparatus of water jet machining consists of the following components:

- Reservoir: It is used for storing water that is to be used in the machining operation.
- Pump: It pumps the water from the reservoir.
- Intensifier: It is connected to the pump. It pressurizes the water acquired from the pump to a desired level.
- Accumulator: It is used for temporarily storing the pressurized water. It is connected to the flow regulator through a control valve.
- Control Valve: It controls the direction and pressure of pressurized water that is to - Flow regulator: It is used to regulate the flow of water.
- Nozzle: It renders the pressurized water as a water jet at high velocity.

8) What is the function of Hydraulic pump and Hydraulic intensifier in WJM?

Ans. Hydraulic pump:

Hydraulic pump it is used to circulate the water from the storage tank during the machining process.

The pump delivers water to the intensifier at low pressure of about 5 bars. A booster is also used which increase the initial pressure of water to 11 bars before delivering it to the intensifier.

It is connected by an electric motor of about 100 Horse power.

Hydraulic intensifier:

As the name implies, it is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar.

The water pressure at outlet of intensifier is about 3000-4000 bars.

9) Explain what is the use of Accumulator and Nozzles in water jet machine.

Accumulator

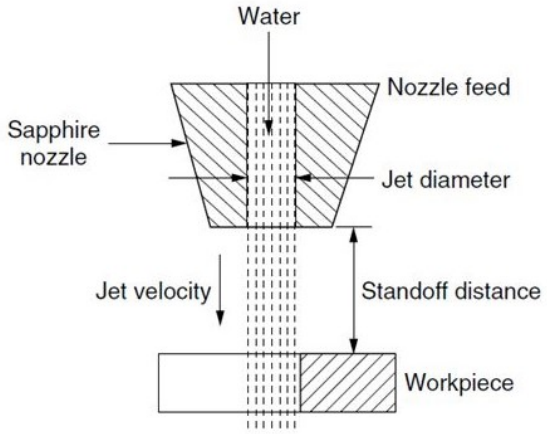
Accumulator stores the high pressurized water temporary. It supplies that fluid when a large amount of pressure energy is required. It eliminates pressure fluctuation condition in the machining process.

Nozzles

As we know, nozzles are used to convert pressure energy into kinetic energy. This nozzle converts high pressure of water into high velocity jet. This high speed water jet strikes at work surface which is used for machining. There is possibility of erosion at orifice of the nozzle due to high pressure water jet. Therefor the tip of the nozzle is made of ruby or diamond material to prevent it from erosion. The size of nozzle is about 0.2 – 0.4 mm.

10) Draw neat sketch of showing parameters of WJM during process.

Ans.



11) Write the work of control valve, flow regulator, and the drain and catcher system in WJM.

Ans. Control valve:

It controls the pressure and direction of the water jet.

Flow Regulator or valve:

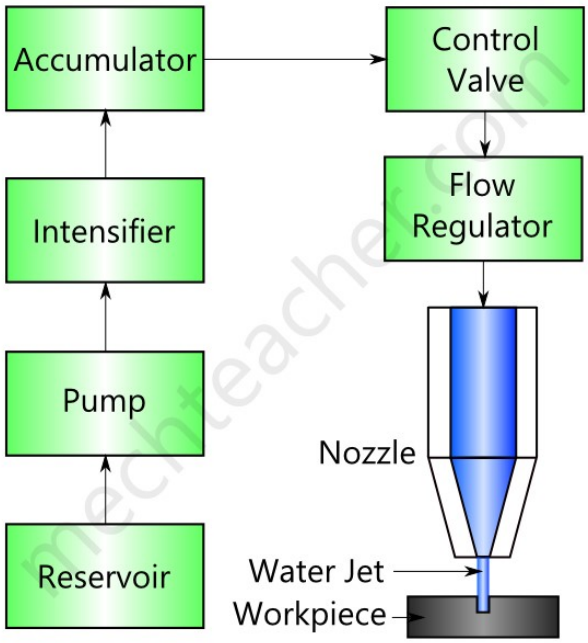
The flow of the water is regulated with the help of flow regulator.

The drain and catcher system:

The drain and catcher system is used to remove debris and other machined particle form water. Its separate metal particle from water and this water is further send to reservoir. It also used to reduce noise associate with WJM

12) Show schematic diagram of WJM.

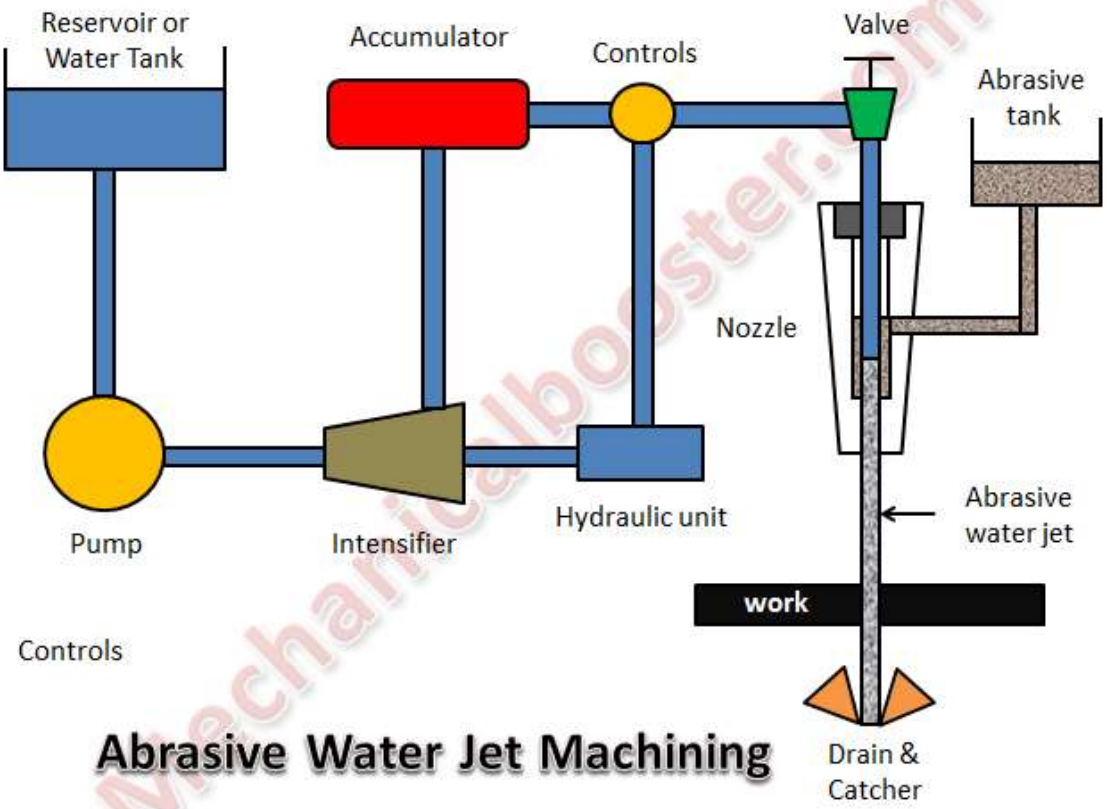
Ans. Schematic diagram of Water Jet Machining:



ANSWERTHE FOLLOWING: (8M)

1) What is WJM? Explain working process of WJM.

Ans. Working of Water Jet Machining

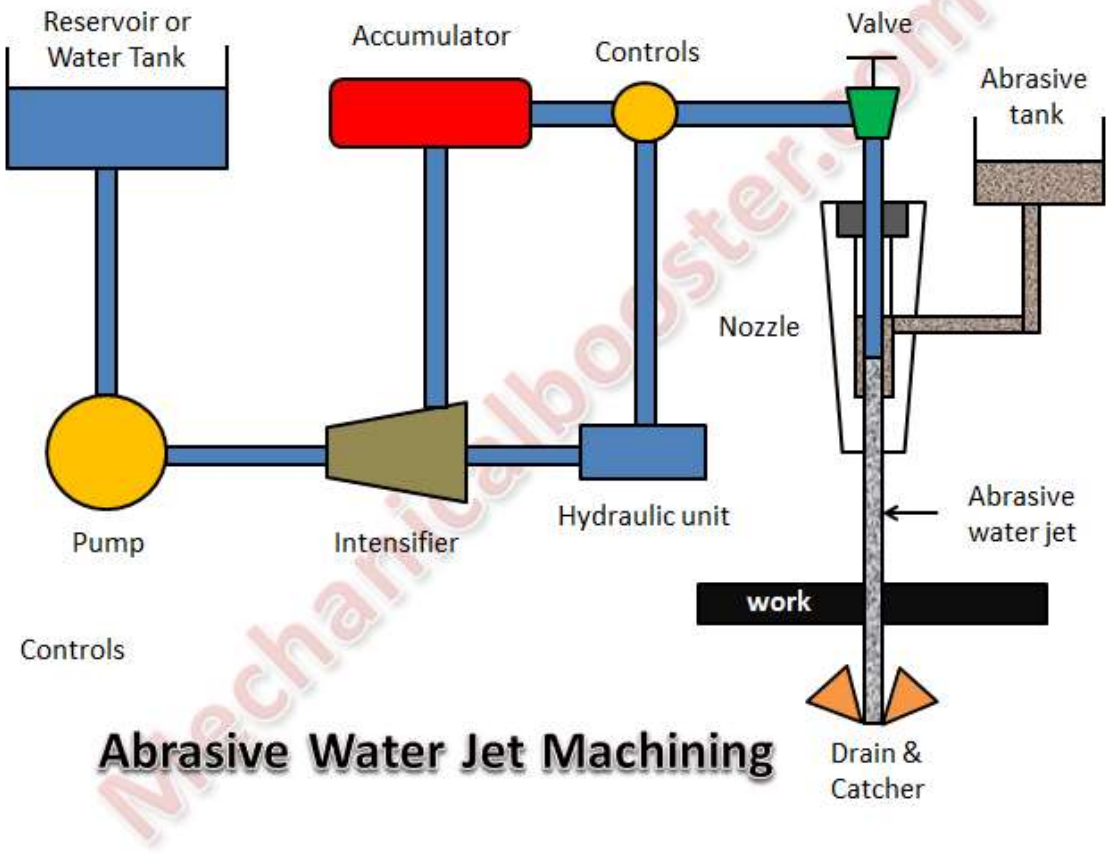


1. The water from the reservoir is pumped to the intensifier with the help of a pump.
2. The intensifier increases the pressure of the water from 5 bars to 3000 to 4000 bar. This high-pressure water from the intensifier is moved to the nozzle as wells as in accumulator.
3. The accumulator stores the high-pressure water and supplies it at any instant when it is required. It is used to eliminate the fluctuation of the high-pressure requirement of machining hard material.
4. The high-pressure water is then passed to the nozzle where the high-pressure energy of the water is converted into kinetic energy. A very high-velocity jet of water (1000 m/s) comes out through the nozzle in the form of a narrow beam.
5. Abrasive such as garnet or aluminium oxide is mixed with water within the nozzle. A mixing chamber is there in the nozzle where the abrasives get mixed with the high-pressure water.
6. This high-velocity jet of water when strikes the surface of the w/p removes the material from it.

7. The water jet after machining it gets collected by the drain and catcher system. Here the debris, metal particles from the water are removed and it is supplied to the reservoir tank.

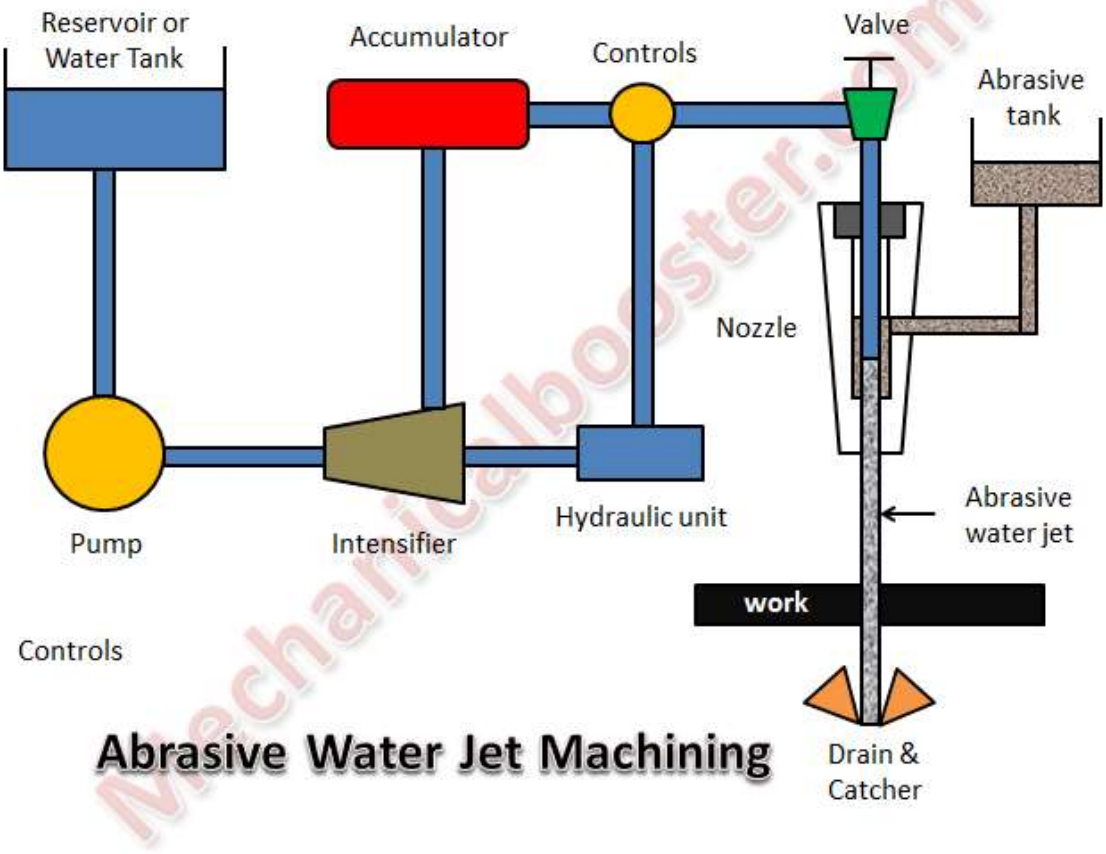
2) Draw neat sketch of water jet machine and show its parts.

Ans.



3) Explain parts of water jet machine.

Ans. Main Parts of Water Jet Machining



The various parts of water jet machining are

1. Hydraulic Pump

It is used to circulate the water from the storage tank during the machining process. The pump delivers water to the intensifier at low pressure of about 5 bars. A booster is also used which increases the initial pressure of water to 11 bar before delivering it to the intensifier.

2. Hydraulic Intensifier

It is used to increase the pressure of water to very high pressure. It receives the water from the pump at 4 bar and increases its pressure up to 3000 to 4000 bar.

3. Accumulator

It stores the high pressurized water temporary. It supplies that fluid when a large amount of pressure energy is required. It eliminates pressure fluctuation conditions in the machining process.

4. Mixing chamber or tube

It is a vacuum chamber where the mixing of abrasive particles into water takes place.

5. Control Valve:

It controls the pressure and direction of the water jet.

6. Flow Regulator or Valve

The flow of the water is regulated with the help of the flow regulator.

7. Nozzle

It is a device that is used to convert the pressure energy of water into kinetic energy in water jet machining. Here nozzle converts the pressure of water jet into high-velocity beam of water jet. The tip of the nozzle is made of ruby or diamond to prevent it from erosion.

8. Drain and Catcher System

After the machining, the debris and machined particles from the water are separated out with the help of the drain and catcher system. It removes the metal particle and other unwanted particles from the water and sends it back to the reservoir for further use.

4) Write advantages and dis-advantages of WJM.

Ans. Advantages

- It has the ability to cut materials without disturbing its original structure. And this happens so because there is no heat-affected zone (HAZ).
- It is capable of producing complex and intricate cuts in materials.
- The work area in this machining process remains clean and dust-free.
- It has low operating and maintenance cost because it has no moving parts.
- The thermal damage to the workpiece is negligible due to no heat generation.
- It is capable of cutting softer materials (WJM) like rubber, plastics or wood as well as harder material (AWJM) like granite.
- It is environment-friendly as it does not create any pollution or toxic products.

- It has a greater precision of the machining. The tolerances of an order of ± 0.005 inch can be achieved easily.

Disadvantages

- It is used to cut softer materials. But AWJM can cut harder material of limited thickness.
- Very thick material cannot be machined by this process.
- The initial cost of WJM is high.

5) Write application and advantages of WJM.

Ans. Advantages:

- It has the ability to cut materials without disturbing its original structure. And this happens so because there is no heat-affected zone (HAZ).
- It is capable of producing complex and intricate cuts in materials.
- The work area in this machining process remains clean and dust-free.
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- It has a greater precision of the machining. The tolerances of an order of ± 0.005 inch can be achieved easily.

Applications:

- Water jet machining is used in various industries like mining, automotive and aerospace for performing cutting, shaping and reaming operations.
- The materials which are commonly machined by water jet (WJM or AWJM) are rubber, textiles, plastics, foam, leather, composites, tile, stone glass, food, metals/ paper and much more.
- WJM is mostly used to cut soft and easy to machine materials such as thin sheets and foils, wood, non-ferrous metallic alloys, textiles, honeycomb, plastics, polymers, leathers, frozen, etc.

- AWJM is typically used to machine those materials which are hard and difficult to machine. It is used to machine thick plates of steel, Al and other commercial materials, reinforced plastics, metal matrix, and ceramic matrix composites, layered composites, stones, glass, etc.
- Besides the Machining process, the high-pressure water jet is used in paint removal, surgery, cleaning, peening to remove residual stress, etc.
- AWJM can also be used to perform drilling, pocket milling, turning and reaming.

6) Write application of WJM.

Ans. **Application**

- Water jet machining is used in various industries like mining, automotive and aerospace for performing cutting, shaping and reaming operations.
- The materials which are commonly machined by water jet (WJM or AWJM) are rubber, textiles, plastics, foam, leather, composites, tile, stone glass, food, metals/ paper and much more.
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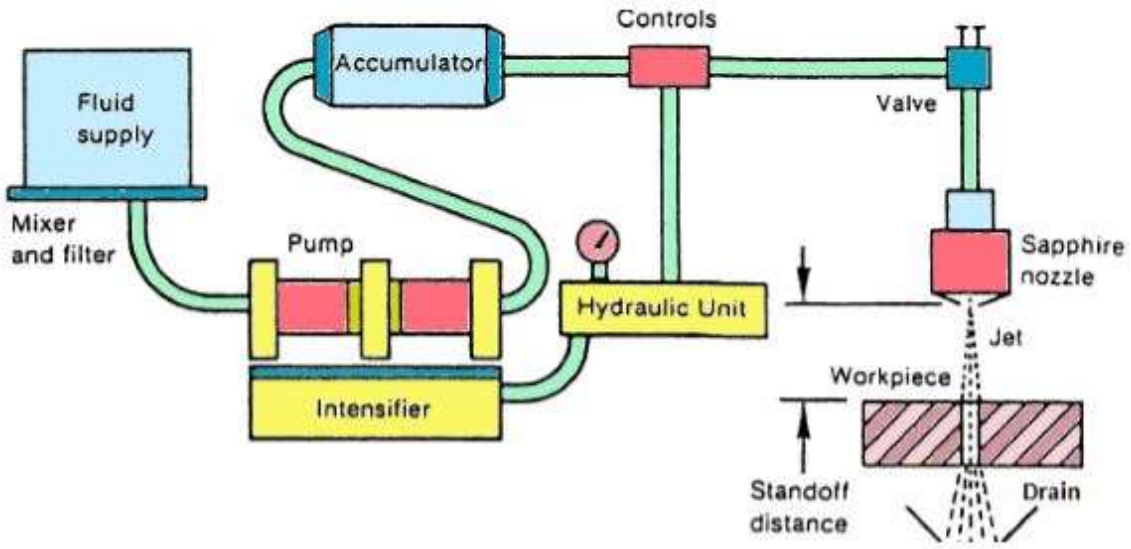
- AWJM is typically used to machine those materials which are hard and difficult to machine. It is used to machine thick plates of steel, Al and other commercial materials, reinforced plastics, metal matrix, and ceramic matrix composites, layered composites, stones, glass, etc.
- Besides the Machining process, the high-pressure water jet is used in paint removal, surgery, cleaning, peening to remove residual stress, etc.
- AWJM can also be used to perform drilling, pocket milling, turning and reaming.

7) Explain construction & working of WJM

Ans.

- Water Jet Machining (WJM) is a mechanical energy based non-traditional machining process used to cut and machine soft and non-metallic materials.

- It involves the use of high velocity water jet to smoothly cut a soft workpiece. It is similar to Abrasive Jet Machining (AJM).
- In water jet machining, high velocity water jet is allowed to strike a given workpiece. During this process, its kinetic energy is converted to pressure energy. This induces a stress on the workpiece. When this induced stress is high enough, unwanted particles of the workpiece are automatically removed.



Construction of Water Jet Machining (WJM):

The apparatus of water jet machining consists of the following components:

- Reservoir: It is used for storing water that is to be used in the machining operation.
- Pump: It pumps the water from the reservoir.
- Intensifier: It is connected to the pump. It pressurizes the water acquired from the pump to a desired level.
- Accumulator: It is used for temporarily storing the pressurized water. It is connected to the flow regulator through a control valve.
- Control Valve: It controls the direction and pressure of pressurized water that is to - Flow regulator: It is used to regulate the flow of water.
- Nozzle: It renders the pressurized water as a water jet at high velocity.

Working of Water Jet Machining (WJM):

- Water from the reservoir is pumped to the intensifier using a hydraulic pump.
- The intensifier increases the pressure of the water to the required level. Usually, the water is pressurized to 200 to 400 MPa.
- Pressurized water is then sent to the accumulator. The accumulator temporarily stores the pressurized water.
- Pressurized water then enters the nozzle by passing through the control valve and flow regulator.
- Control valve controls the direction of water and limits the pressure of water under permissible limits.
- Flow regulator regulates and controls the flow rate of water.
- Pressurized water finally enters the nozzle. Here, it expands with a tremendous increase in its kinetic energy. High velocity water jet is produced by the nozzle.
- When this water jet strikes the workpiece, stresses are induced. These stresses are used to remove material from the workpiece.
- The water used in water jet machining may or may not be used with stabilizers. Stabilizers are substances that improve the quality of water jet by preventing its fragmentation.
- For a good understanding of water jet machining, refer the schematic diagram above.

8) Write advantages, disadvantages& applications of WJM.

Ans. Advantages of Water Jet Machining (WJM):

- Water jet machining is a relatively fast process.
- It prevents the formation of heat affected zones on the workpiece.
- It automatically cleans the surface of the workpiece.
- WJM has excellent precision. Tolerances of the order of ±0.005” can be obtained.
- It does not produce any hazardous gas.
- It is eco-friendly.

Disadvantages of Water Jet Machining:

- Only soft materials can be machined.
- Very thick materials cannot be easily machined.

- Initial investment is high.

Applications of Water Jet Machining:

- Water jet machining is used to cut thin non-metallic sheets.
- It is used to cut rubber, wood, ceramics and many other soft materials.
- It is used for machining circuit boards.
- It is used in food industry.

9) Elaborate WJM? Explain construction of water jet machine.

Ans. WJM: Water Jet Machining

Construction of Water Jet Machining (WJM):

The apparatus of water jet machining consists of the following components:

- Reservoir: It is used for storing water that is to be used in the machining operation.
- Pump: It pumps the water from the reservoir.
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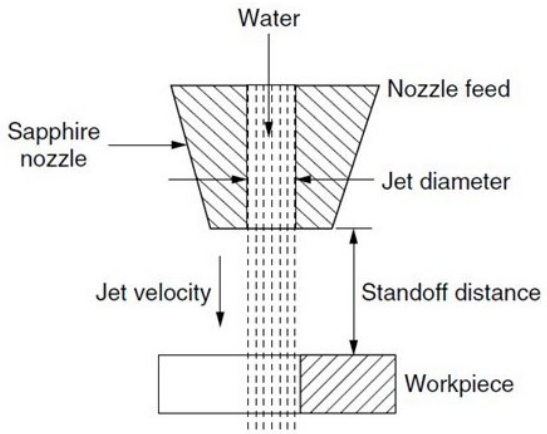
- Flow regulator: It is used to regulate the flow of water.
- Nozzle: It renders the pressurized water as a water jet at high velocity.

10) Explain working principal and Show the sketch of showing parameters of WJM during process.

Ans. Water jet machining is based on the principal of water erosion. When a high velocity jet of water strikes the surface, the removal of material takes place. Pure water jet is used to machine softer material. But to cut harder materials, some abrasive particles mixed with the water for machining and it is called as AWJM.



11) What is the need of WJM?

Ans. The need of WJM.

- It is used in aerospace industries.
- Abrasive jet machining is used to cut hard metal like stainless steel, titanium, Inconel etc.
- It is used to machining or cutting reinforced plastic.
- Use to cut stone which reduce dust in environment.
- Used to machining PCB.
- Trimming of carbon resistors, sheet metal and plastic parts.
- Drilling small holes in hard materials like tungsten and ceramics.
- Cutting complex profile on thin and hard materials viz, thin films for making ICs.
- Cutting or engraving patterns on thin films.
- Dynamic balancing of precision rotating components, such as of watches.
- It is used to cut rubber, wood, ceramics and many other soft materials.

12) Mention parts of water jet machine. And explain any two

Ans. The various parts of water jet machine are.

- Hydraulic pump
- Hydraulic intensifier
- Accumulator
- Mixing chamber or tube

- Control valve
- Flow regulator or valve
- Nozzle
- Drain and catcher system.

Hydraulic pump

Hydraulic pump it is used to circulate the water from the storage tank during the machining process. The pump delivers water to the intensifier at low pressure of about 5 bars. A booster is also used which increase the initial pressure of water to 11 bars before delivering it to the intensifier. It is connected by an electric motor of about 100 Horse power.

Hydraulic intensifier

As the name implies, it is used to increase the water pressure for further process. Hydraulic intensifier accept water from pump at a small pressure about 4 bar. The water pressure at outlet of intensifier is about 3000-4000 bars.

13) List out the parts of water jet machine. And explain nozzle

Ans. The various parts of water jet machine are.

- Hydraulic pump
- Hydraulic intensifier
- Accumulator
- Mixing chamber or tube
- Control valve
- Flow regulator or valve
- Nozzle
- Drain and catcher system.

Nozzles

As we know, nozzles are used to convert pressure energy into kinetic energy. This nozzle converts high pressure of water into high velocity jet. This high speed water jet strikes at work surface which is used for machining. There is possibility of erosion at orifice of the nozzle due to high pressure water jet.

Therefor the tip of the nozzle is made of ruby or diamond material to prevent it from erosion. The size of nozzle is about 0.2 – 0.4 mm.

14) Elaborate WJM? Explain process of water jet machining.

Ans. WJM: - Water Jet Machining

Process of Water Jet Machining (WJM):

- Water from the reservoir is pumped to the intensifier using a hydraulic pump.
- The intensifier increases the pressure of the water to the required level. Usually, the water is pressurized to 200 to 400 MPa. (5bars to 3000 to 4000 bars).
- Pressurized water is then sent to the accumulator. The accumulator temporarily stores the pressurized water.
- Pressurized water then enters the nozzle by passing through the control valve and flow regulator.
- Control valve controls the direction of water and limits the pressure of water under permissible limits.
- Flow regulator regulates and controls the flow rate of water.
- Pressurized water finally enters the nozzle. Here, it expands with a tremendous increase in its kinetic energy. A very high velocity water jet comes out through the nozzle at speed of 1000m/s in the form of narrow beam.
- When this water jet beam strikes the workpiece, stresses are induced. These stresses are used to remove material from the workpiece.
- The water jet after machining is get collected by the drain and catcher system. Here the debris, metal particles from the water is removed and it is supplied to the reservoir tank.

15) Write a short note on:

a. Application of WJM
b. Hydraulic pump

a.) Application:

- It is used in aerospace industries.
- Abrasive jet machining is used to cut hard metal like stainless steel, titanium, Inconel etc.

- It is used to machining or cutting reinforced plastic.
- Use to cut stone which reduce dust in environment.
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- Dynamic balancing of precision rotating components, such as of watches.
- It is used to cut rubber, wood, ceramics and many other soft materials.

b.) Hydraulic pump

Hydraulic pump it is used to circulate the water from the storage tank during the machining process. The pump delivers water to the intensifier at low pressure of about 5 bars. A booster is also used which increase the initial pressure of water to 11 bars before delivering it to the intensifier. It is connected by an electric motor of about 100 Horse power.

CHAPTER-8 LASER BEAM MACHINING.

PART-A

FILL IN THE BLANKS:

1. Laser stands for Light Amplification by Stimulated Emission of Radiation
2. Types of lasers used in LBM are Gas laser and Ruby laser.
3. Expand LBM Laser Beam Machining
4. Laser is an Electromagneticradiation.
5. Laser is produces monochromaticlight.
6. Laser provides intense and Uni-directionalbeams of light.
7. In LBM the most important part of the laser apparatus is the Laser crystal.
8. Focusing a laser beam on a spot1/100of a square mm in size.

9. The laser in short pulses has a power output of nearly 10kw/cm^2 of the beam cross section.
10. solid statelasers are generally used in material processing.
11. lasing medium lasers are classified as solid state and gas laser
12. Nd-YAG laser is pumped usingFlash tube.
13. Lasing materialis at the focal plane of the flash tube in LBM.
14. CO_2acts as the main lasing medium whereas Nitrogen helps in sustaining the gas plasma.
15. Mechanism of material removal in Laser Beam Machining is due to Melting and vaporization
16. Nd-yag stands for Neodymium doped Yttrium Aluminium Garnet

MULTIPLE CHOICE QUESTIONS:

1. The Nd & Nd-yag used in the process
    a. LBM
    b. ECM
    c. CHM
    d. WAJM

2. LBM stands for
    a. Plasma arc machining
    b. Laser beam machining
    c. Light amplification by stimulated emission
    d. None of the above

3. In LBM, the most important part of the laser apparatus is the ____.
    a. Electrolyte
    b. Dielectric
    c. Laser crystal
    d. Anode.

4. What is the full form of LBM in advanced machining processes?

a. Laser Beam Manufacturing
b. Laser Beam Machining
c. Light Blast Manufacturing
d. Light Beam Machining

5. LBM offers a good solution for which material properties below?
   a. Thermal conductivity
   b. Specific heat
   c. Boiling temperature
   d. All of the mentioned

6. What is the abbreviation of Laser?
   a. Light allowed simple emission of radiation
   b. Light amplification by stimulated emission of radiation
   c. Light amplified simultaneous emission of rays
   d. Light amplified stimulated emanation of rays

7. Which of the following are the properties of a laser?
   a. Highly collimated
   b. Monochromatic
   c. Coherent light beam
   d. All of the mentioned

8. Laser beam machining uses which type of power sources for machining?
   a. Very low power
   b. Low power
   c. Medium power
   d. High power

9. Which of the following are different types of lasers used in Laser beam machining?
   a. Solid-state ion

b. Neutral gas
c. Semiconductor
d. All of the mentioned

10. Which types of lasers are used in Laser beam machining?
a. Continuous wave
b. Pulsed mode
c. All of the mentioned
d. None of the mentioned

11. What is the wavelength value of Ruby laser used in Laser beam machining?
a. 633 nm
b. 694 nm
c. 856 nm
d. 1064 nm

12. What is the wavelength value of Nd-YAG and Nd-glass lasers used in LBM?
a. 633 nm
b. 694 nm
c. 856 nm
d. 1064 nm

13. What is the wavelength value of neutral gas laser used in LBM?
a. 633 nm
b. 694 nm
c. 856 nm
d. 1064 nm

14. What is the wavelength value of CO2 laser used in Laser beam machining?
a. 0.16 µm
b. 1.6 µm
c. 10.6 µm

d. 106 µm

15. What are the values of wavelengths of GaAs laser used in LBM?

a. 100 – 200 nm
b. 200 – 400 nm
c. 600 – 700 nm
d. 800 – 900 nm

16. What are the values of wavelengths of Excimer laser used in LBM?

a. 100 – 200 nm
b. 200 – 500 nm
c. 600 – 700 nm
d. 800 – 900 nm

17. What are the values of wavelengths of Argon laser used in LBM?

a. 120 – 230 nm
b. 220 – 310 nm
c. 330 – 530 nm
d. 760 – 940 nm

18. . The Laser Beam Machining process can be carried out, when the media forenergy transfer between tool and workpiece is

a. Air
b. Liquid
c. Vacuum
d. Any of the above medium

19. **Types of lasers used in LBM.**

a. Gas lasers
b. Solid state lasers
c. Ruby lasers
d. All of the above.

20. Accuracy of profile cutting in LBM is

a. ±0.1mm
b. ±0.05mm
c. ±0.2mm
d. ±0.3mm

ANSWERTHE FOLLOWING: (2M)

1. Name any two-laser beam?
   - YAG
   - Nd YAG

2. List the types of lasers?
   - Gas lasers
   - Solid state lasers
   - Ruby lasers

3. What is LASER stands for?

Ans. LASER stands for Light Stimulated Emission of Radiation.

4. Why is Laser Machining used?

Ans. Laser Machining is used for very micro-operation.

5. What are the advantages of Laser Machining? (any 2)

Ans. - Any material can be machined including non-metal.

There is no tool wear.

- Soft materials like rubber, plastic can be machined.

6. What is laser cutting?

Ans. Laser cutting is a technology that uses a laser to cut materials, and is typically used for industrial manufacturing applications

ANSWERTHE FOLLOWING: (3M)

1. What is laser?

Ans. Laser is an electromagnetic radiation. It produces monochromic light which is in the form of an almost collimated beam that can be focused optically on to very small spots of less than 0.002 mm dia.

2. Name the parts of basic laser circuit?

Ans. A basic laser circuit, consist of three parts,

- A pair of mirrors
- Source of energy
- Optical amplifier.

3. Define accuracy in LBM?

Ans.The laser is best used for cutting as well as for drilling. In order to achieve the best possible results in drillings, it is imperative that the material be located within a tolerance of +0.2 mm or -0.2 mm of focal point. Accuracy in profile cutting in numerical control or photoelectric laser is about +0.1 mm or -0.1 mm.

4. Define LBM.

Ans. Laser Beam Machining Definition:

A laser beam is a non-conventional machining method in which the operation performed by the laser. The laser stand for Light stimulated emission of radiation. The process used thermal energy to remove material from a metallic surface.

5. Write the type of laser material.

Ans. Laser Material:

There are many different types of laser material available but in later machining mostly CO2 (Pulsed or continuous waves) and Nd: YAG is Used. Carbon die oxide is a laser material that emits light in infrared region. It can provide up to 25 KW power in continuous wave mode. The other one is called Neodymium doped Yttrium Aluminium Garnet is a solid-state laser which can delivery light through optical fibre. It can generate about 50 KW power in pulsed mode and 1 KW power in continuous mode.

ANSWER THE FOLLOWING: (5M)

1. Mention advantages and disadvantages of lasers?

   Advantages:

   It is free from electro-magnetic interference. This phenomenon is used in optical wireless communication through free space for telecommunication as well as computer networking.

   ➡It has very minimum signal leakage.

   ➡Laser based fibre optic cables are very light in weight and hence are used in fibre optic communication system.

   Disadvantages:

   ➡It is free from electro-magnetic interference. This phenomenon is used in optical wireless communication through free space for telecommunication as well as computer networking.

   ➡It has very minimum signal leakage.

   ➡Laser based fibre optic cables are very light in weight and hence are used in fibre optic communication system.

2. How do lasers cut?

Ans. Laser beams cut through things by vaporizing the material in the beam's path. That's what makes the reputed "clean cut" of a laser. If the laser does not generate enough heat to vaporize, the material melts and/or catches fire. This results in an uneven or uncompleted cut.

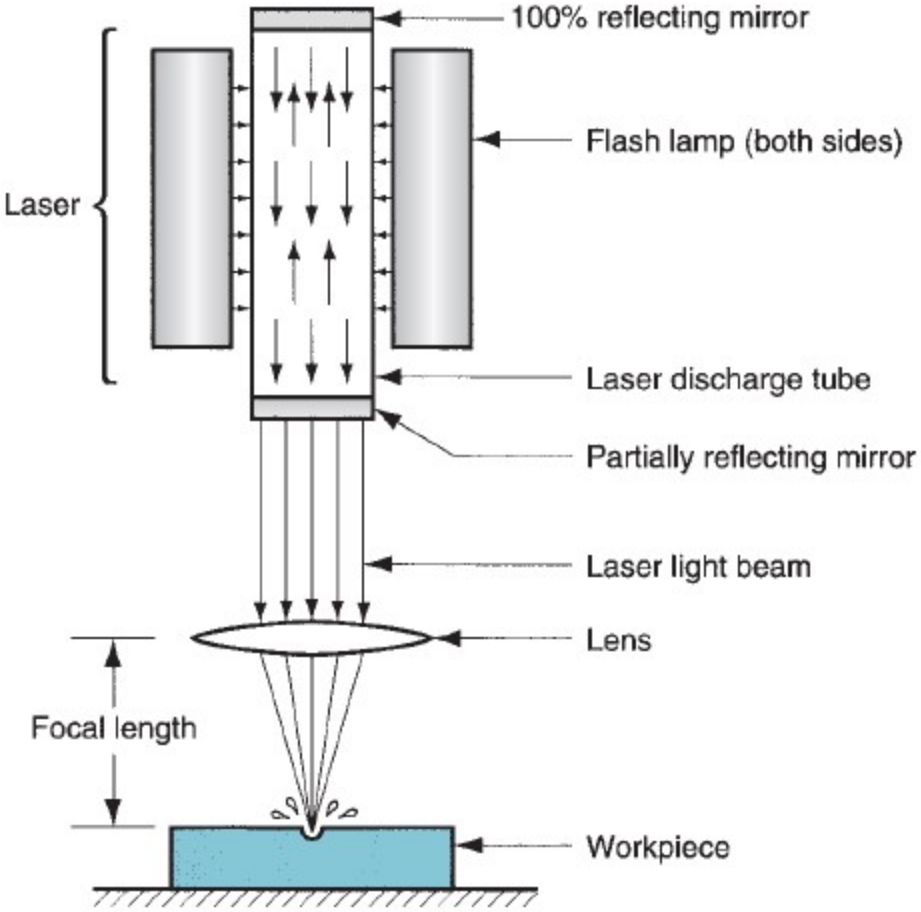
3. Write the limitation of the laser?
   - Its overall efficiency is extremely low.
   - The process is limited to thin sheets
   - It has very low material removal rate.

- The machined holes are not round and straight.
- Cost is high.
- Output energy from LASER is difficult to control precisely.

ANSWER THE FOLLOWING: (8M)

1. Explain LBM process with neat sketch?

Laser Beam Machining (LBM) is a form of machining process in which laser beam is used for the machining of metallic and non-metallic materials. In this process, a laser beam of high energy is made to strike on the work piece; the thermal energy of the laser gets transferred to the surface of the w/p (work piece). The heat so produced at the surface heats, melts and vaporizes the materials from the w/p. Light amplification by stimulated emission of radiation is called LASER.



- Write the advantages and disadvantages of LBM?

Advantages:

- There is no direct contact between the tool and the work piece
- Machining of any material including non metal is possible
- Extremely small holes can be machined
- There is no tool wear

Disadvantages:

- The process is limited to thin sheets
- It has very low material removal rate
- The machined holes are not round and straight
- Cost is high

2. Write application of LBM.

Ans. Laser Beam Machining Application:

The following application of Laser beam machining is:

- Laser beam machining process is used for making very small holes.
- Complicated welding of non-conductive and refractory materials.
- Mass macro machining production.
- Selective heat treating of materials.
- This is used in surgery.
- Micro-drilling operation.
- Photography in medical science.
- Spectroscopic Science.

3. List out advantages & disadvantages of LBM.

Ans. The following advantages of laser beam machining are:

- Any material can be machined including non-metal.
- There is no direct contact between the tool and the work.
- There is no tool wear.
- Soft materials like rubber, plastic can be machined.
- Extremely small holes can be machined.

- No mechanical force on the work.
- The heat-affected zone is very small.
- Heat treated and magnetic materials can be welded, without losing their properties.

Laser Beam Machining Disadvantage:

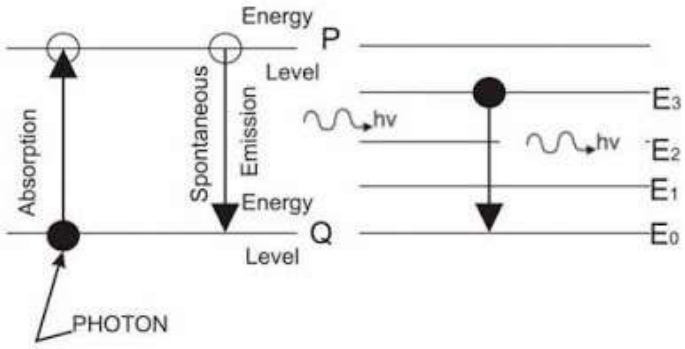
The following disadvantages of laser machining are:

- The overall efficiency of the machining is very low.
- It is limited to thin sheets.
- It's having a high cost.
- A very low rate of metal-removing.
- The life of the flash lamp is short.
- It is not possible to remove a large number of metals.
- The machined holes are not round and straight.
- Not able to drill too deep holes.

4. Explain working principle of LBM.

Ans. Principle:

The word laser stands for Light amplification by Stimulated Emission of Radiation. When an electron of atom absorbed energy form an external source, the electron which are in its original energy level, jump to a higher energy level. This is not a stable condition of atom so this electron emits the absorbed energy in form of photons and come back to its original state. If an atom which is already at higher energy level absorbs energy, it will emit double energy to return at its original state. The energy emitted by the atom has same frequency and wavelength as the stimulating energy. This is fundamental of laser. When the laser material placed in presence of some other energy source, it absorb energy at some extant and release it when reaches its absorbing limit. This high amplified light beam is called laser.

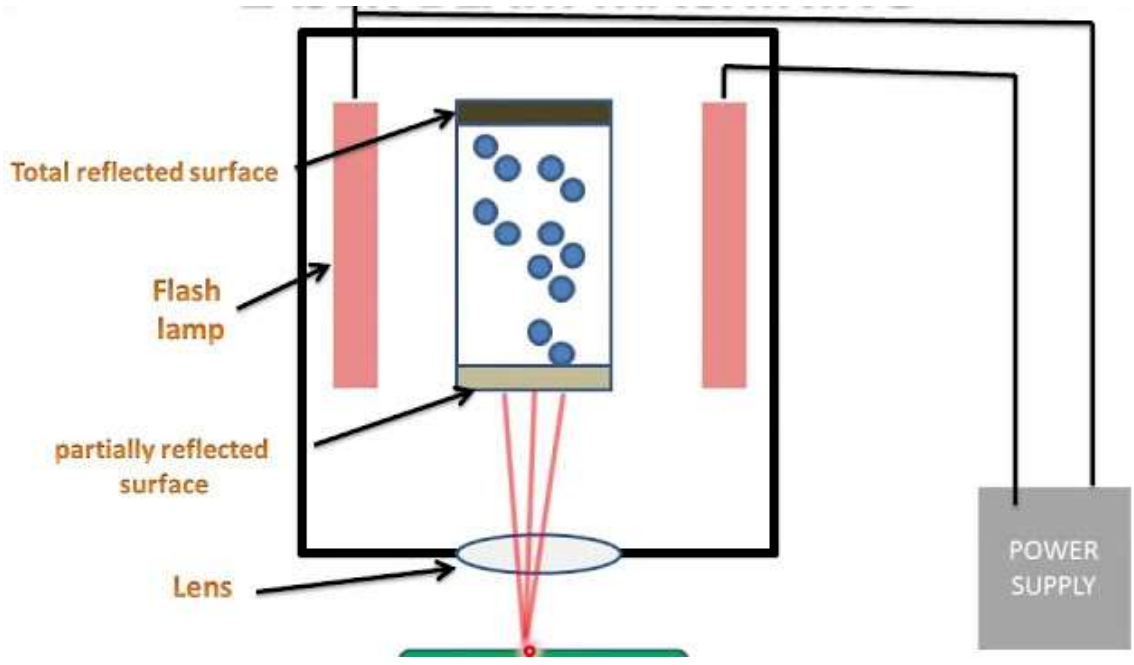


Principle of Laser Beam Welding

This machining process works on basic property of laser. It uses a laser beam, which is a narrow, monochromatic high intense light which can cut or machine any metal and non-metal. It can use to cut any material irrespective to hardness of work piece. It can also use to cut diamond which is hardest known material on earth.

5. Explain main equipment's & working principle of LBM.

Ans. Equipment's:



Laser Beam Machining

Power Supply:

It provides the energy for excitation of electron from lower energy level to higher energy level. This gives power to xenon flash lamps, which produce light energy. The laser material is exposed in light energy to keep storing energy.

Laser Discharge Tube:

The laser material filled in lased discharge tube. The excitation of electron and come back to its original state process takes place in it. It's one side is partially transparent for laser opening and other side is 100% reflected. It is situated between flash lamp.

Laser Material:

There are many different types of laser material available but in later machining mostly CO2 (Pulsed or continuous waves) and Nd: YAG is Used. Carbon die oxide is a laser material that emits light in infrared region. It can provide up to 25 KW power in continuous wave mode. The other one is called Neodymium doped Yttrium Aluminium Garnet is a solid-state laser which can delivery light through optical fibre. It can generate about 50 KW power in pulsed mode and 1 KW power in continuous mode.

Focusing Lens:

A focusing lens is used in laser machining operation. It is a convex lens which focus is at work piece.

Working:

As we know in laser energy is used to remove metal from workpiece. Its process can be summarized as follow.

- First laser material CO2 or other gases filled into laser discharge tube.
- Now switch on the power supplied which is connected by flash lamp. This lampproduces light energy which used to excite electrons of atom.
- The atoms of laser material absorb energy from the light energy produced by flash lamp. It leads jump of orbital electron of atom form low energy level to high energy level. This is unstable condition of atom.
- This energy initially blind up in laser material. When the atoms absorb sufficient energy, it starts emit energy continuously. This is high amplified same frequency and same wavelength coherent light.

- This laser light collected by the focus lens and directed toward the work piece.
- Now the laser impinging on work piece start machining process by melting or vaporize material from contact surface.

6. List out advantages, disadvantages & applications of LBM.

Ans. Application:

- Used to drill small hole of diameter about 0.005 mm in refectory and ceramic materials.
- It is used in drilling and cutting for both metals and non-metals.
- It is extensively used in electronic and automotive industries.
- It is mostly used in aerospace industries.
- Used to machine complex profile where machining by tool is not possible.

Advantages:

- It can cut all material.
- No tooling cost because no physical tool is required.
- It produces finish part or high surface finish.
- No tool wear because no physical tool is used.
- Micro holes can be drilled accurately.
- Complex shape can be machined easily because laser can be move in any path.
- Very hard material can be cut through laser beam machining.
- High accuracy can be achieved.
- It can be easily automated and flexible.

Disadvantages:

- It is uneconomical when high volume of same shape to be cut compare to stamping.
- High capital and maintenance cost.
- It cannot use to produce blind hole.
- Laser can lead to safety hazards.

7. Explain working of Laser.

Ans. Working:

- First laser material CO_2 or other gases filled into laser discharge tube.

- Now switch on the power supplied which is connected by flash lamp. This lampproduces light energy which used to excite electrons of atom.
- The atoms of laser material absorb energy from the light energy produced by flash lamp. It leads jump of orbital electron of atom form low energy level to high energy level. This is unstable condition of atom.
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