SREENIVASA INSTITUTE OF TECHNOLOGY AND MANAGEMENT STUDIES

(AUTONOMOUS)

DEPARTMENT OF MECHANICAL ENGINEERING

COURSE MATERIAL

Subject Name	**Unconventional Machining Processes**
Subject Code	23MEC364T
Semester	VI Semester
Academic Year	2025-26
Regulation	R23

Unit-III

Chemical and Electro Chemical Energy Based Processes

Unit - III

Chapter - 3

Chemical and Electro-Chemical Energy Based Processes

Syllabus : Chemical machining and Electro-Chemical machining (CHM and ECM)-Etchants - Maskant - techniques of applying maskants - Process Parameters - Surface finish and MRR-Applications. Principles of ECM – equipments - Surface Roughness and MRR Electrical circuit-Process Parameters ECG and ECH - Applications.

3.1 Chemical Machining

- This process is one of the old material removal processes which employ chemicals for the material removal.
- Nearly all metals and even ceramics can be machined.
- The CHM process is employed where metal removal is difficult or impractical by the conventional machining process.
- In this process, is used for the production are protected from chemical attack by masking.
- This process is used for the production of printed circuit boards (PCB's), engraving, machining of air crafts etc.,

Definition

- CHM is a material removal process used for the production of the required shape and dimensions through selective or overall material removal by controlled chemical attack with acid or alkalis.
- CHM process can be classified into two types

  i) Chemical Milling ii) Chemical blanking

i) Chemical Milling

- Chemical milling is defined as the process of chemically eroding material to produce "blind" details like pockets, channels, etc.

ii) Chemical Blanking

- This is the process chiefly used for producing details that penetrate material entirely (Holes, Slots etc.,) or to blank complete parts from sheet material by chemically etching the periphery of the desired shape.
- Processing steps for chemical machining

Preparation of work material	Pre cleaning
Masking	Application of chemically resistant material on the places where machining is not required
Etching	To dip or spray exposing the marked material to the reactive environment or etchant

Removal of mask	The maskant applied on the un machined areas are removed and then the work material is cleaned.
Finish	If further process is required, do it or inspect and post process it.

3.1.1 Equipment

- The equipment consists of a tank or container filled with the etchant.
- The work material is either suspended by a hanger or set on a table inside the tank.
- A stirrer is fitted in the tank to ensure uniform etching.
- A heater is also attached inside the tank to accelerate the etching process.
- To ensure uniform material removal, the etchant continuously sprayed onto the part or the part is submerged in the tank of agitated etchant.
- However, too much agitation should be avoided, since it causes areas of cavitation or stagnation which results in ridges, waviness or grooves in the etched surface.

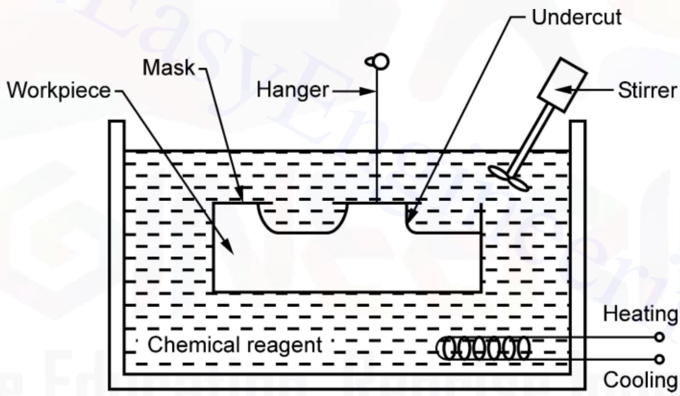

Fig. 3.1

3.1.2 Five Step Process of Chemical Machining

i) Cleaning	ii) Masking	ii) Scribing
iii) Etching	iv) Demasking	

i) Cleaning

- The materials to be machined first cleaned thoroughly to effect uniform adhesion of the maskant and uniform chemical dissolution of the metals.
- Proper cleaning lowers the maskant debonding.

- Depending upon the type of maskant, the required depth of cut and the work piece material the cleaning operation vary from simple solvent to high degree cleaning of operations such as flash etching, vapor degreasing or alkaline etching.
- The porous materials present difficulties for the cleaning process because entrapment of unwanted particles and cleaning solutions.
- When cleaning Aluminium, Magnesium, Steel or titanium alloys the industries adopt the following cleaning process.

  i) Vapour degreasing

  ii) Alkaline cleaning

  iii) Deoxidizing, after cleaning the parts are dried.

ii) Masking

- The chemically resistant mask is applied on the workpiece material by either dip flow coat, airless spray techniques or brushing depends on the part size and configurations.
- Two or more coatings are applied to Aluminium and Magnesium parts while four or more applied to steel, titanium,

iii) Maskants

- Masking material which is called maskant is used to protect workpiece surface from chemical etchant. Polymer or rubber based materials are generally used for masking procedure.
- The selected maskant material should have following properties.
  - Tough enough to withstand handling
  - Well adhering to the workpiece surface
  - Easy scribing
  - Inert to the chemical reagent used
  - Able to withstand the heat used during chemical machining
  - Easy and inexpensive removal after chemical machining etching.
- Multiple maskant coatings are used to provide a higher etchant resistance. Long exposure time is needed when thicker and rougher dip or spray coatings are used.
- Various maskant application methods can be used such as dip, brush, spray, roller, and electro coating as well as adhesive tapes.
- When higher machined part dimensional accuracy is needed, spraying the mask on the workpiece through silk screen would provide a better result.

- Thin maskant coating would cause severe problems such as notwithstanding rough handling or long exposure times to the etchant.
- The application of photo resist masks which are generally used in photochemical machining operation, produce high accuracy, ease of repetition for multiple part etching, and ease of modification.
- Possible maskant materials for different workpiece materials were given in Table.
- Masking materials for vaious chemical machined materials

Workpiece material	Masking material
Aluminium and alloys	Polymer, Butyl rubber, neoprene
Iron based aloys	Polymer, polyvinyl chloride, polyetilien butyl rubber
Nickel	Neoprene
Magnesium	Polymer
Copper and alloys	Polymer
Titanium	Polymer
Silicon	Polymer

iv) Scribing

- After the application of maskant on the workpiece material the required areas are to be machined are scribed by using knife.
- Patterns and templates are used for obtaining the required shape of the area to be machined chemically.
- Epoxy-impregnated fibre glass, Aluminium, steel are commonly used templates.
- The blank part is scribed with the desired pattern as determined by template.
- After the part is scribed, the maskant in the scribed area is peeled off, leaving the areas for etching.
- Time of immersion of the workpiece in the etchant is determine the depth of cut.

v) Etching

- The etching of the work material done by adopting immersion or spraying technique.
- The etching is done until required depth of cut is obtained.
- Step etching is done by repeated cycles of masking and peeling off.
- Also the pans are rotated during the cycle to ensure uniform etching.

3.1.3 Etchant

- The purpose of etchant is to dissolve the workpiece material by turning it into a metallic salt, which goes into the solution.
- Etchants are the most influential factor in the chemical machining of any material. Various etchant are available due to workpiece material. The best possible etchant should have properties as follows
  - High etch rate
  - Good surface finish
  - Minimum undercut
  - Compatibility with commonly used Maskants
  - High dissolved-material capacity
  - Economic regeneration
  - Easy control of process.
  - Personal safety maintenance

Etchant Selection

Required Surface finish	Some combination of material and etchant result in the formation of surface oxide, which degrade the finish
Removal rate	Faster rates lower the cost, but attack the resist bond, result in poor finish or producing high heat
Material type	Etchant must attack the material without causing embrittlement or corrosion cracking
Etch depth	Some etchants produce surface finishes that worsen with increasing depth
Type of resist	Etchant must destroy resist during the process time.
Cost	Cost of the etchant, maintenance and disposal must be considered

3.1.4 Demasking

- 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.

Method of Masking

Masking can be achieved by any of the following process

- Cut and peel
- Photographic resist
- Screen resist

Cut and Peel

- Apply maskant over entire part by dipping, spraying or painting.
- Maintain the maskant thickness as 0.025 mm to 0.125mm
- After the machining process, maskant can be removed by hand or using knife.
- This type of technique mostly employed in where the accuracy is not important.

Photographic Resist

- In this method photographic technique is used for masking.
- The maskant material contain photo sensitive materials.
- This process is normally applied where small parts are produced in high quantities and close tolerances are required.

Screen Resist

- The maskant is applied by means of silk screening method.
- Maskant is painted on the work parts surface through a silk or steel mesh.
- This method is usually adapted where the accuracy is moderate.
- Tolerance ± 0.075 mm can be achieved with this masking method.

3.1.5 Advantages

The application of chemical machining provides several advantages as follows

- 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
- Requirement of less skilled worker
- Low tooling costs

- The good surface quality
- Using decorative part production
- Low scrap rates (3 %).

3.1.6 Disadvantages

- 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

3.1.7 Environmental Issues in Chemical Machining

Environmental issues in chemical machining operations may be the most important factor affects the machining process should be used or not. Most of the chemicals such as cleaning solutions, etchants, strippers etc. are very hazardous liquids. Therefore handling and disposal of them are very costly. Industrial trend of using these chemicals are to select more environmentally accepted ones for chemical machining process. Moreover, regeneration of waste etchant and etched metal recovery from waste etchants have been studied and there could be a suitable regeneration/recovery systems for some etchants like FeCl3, CuCl2 and alkaline etchants.

3.2 Electrochemical Machining

- Electrochemical Machining (ECM) is a non-traditional machining (NTM) process belonging to Electrochemical category.
- It is a method of removing metal by an electrochemical process. It is best suited for the metals and alloys which are difficult to machine by conventional process.
- It can able to cut intricate shapes even in hard metals like titanium aluminides, Inconel, waspalloy etc., both external and internal surfaces can be machined.
- ECM is a anodic dissolution of atomic level of work piece that is electrically conductive by a shaped tool due to flow of high current through electrolyte.

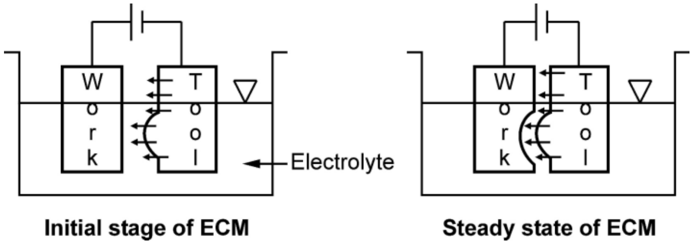

Fig. 3.2 Schematic principle of Electro Chemical Machining (ECM)

3.2.1 Principle

This process based on Faraday's Law of electrolysis

1. First law states that the amount of any material dissolve or deposited is proportional to the quantity of electricity passed.
2. Second law states that, the amount of change produced in the materials is proportional to its electrochemical equivalent of the materials.

- ECM is the reverse electroplating method.

ECM	Electroplating
Material removed from the work piece	Metal deposited on the work piece
Workpiece connected to positive terminal and the tool is connected to negative terminal.	Work piece is connected to negative terminal and the tool is connected to positive terminal.
When the current passed the work piece loses metal and the dissolved metal is carried out by circulating an electrolyte between work and tool	Tool loses material and the metal deposited on the work piece.

3.2.2 Construction and the Working of ECM Process

- Electrochemical machining (ECM) is a machining process in which electrochemical process is used to remove materials from the workpiece. In the process, workpiece is taken as anode and tool is taken as cathode.
- The two electrodes workpiece and tool is immersed in an electrolyte (such as NaCl).
- When the voltage is applied across the two electrodes, the material removal from the workpiece starts.
- The workpiece and tool is placed very close to each other without touching.

- 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.
- During electrochemical machining process, the reactions take place at the electrodes i.e. at the anode (workpiece) and cathode (tool) and within the electrolyte.
- Let's take an example of machining low carbon steel which is mainly composed of ferrous alloys (Fe).
- We generally use neutral salt solution of sodium chloride (NaCl) as the electrolyte to machine ferrous alloys.
- The ionic dissociation of NaCl and water takes place in the electrolyte as shown below.

$$NaCl \rightarrow Na^{+} + Cl^{-}$$

$$H_2O \rightarrow H^{+} + OH^{-}$$

- As the potential difference is applied across the electrode, the movement of ions starts in between the tool and w/p. The positive ions moves towards the tool (cathode) and negative ions move towards the workpiece.
- At cathode the hydrogen ions takes electrons and gets converted into hydrogen gas.

$$2H^{+} + 2e^{-} \rightarrow H_2 \uparrow$$

- In the same way the iron atoms comes out from the anode (w/p) as Fe++ ions.

$$Fe \rightarrow Fe^{++} + 2e^{-}$$

- Within the electrolyte, the sodium ions combines with Hydroxyl ions and form sodium hydroxide and ferrous ion combine with Chloride ions and forms ferrous chloride. Also iron ions combine with hydroxyl ions and forms Iron hydroxide.

$$Na^{+} + OH^{-} \rightarrow NaOH$$

$$Fe^{2+} + 2Cl^{-} \rightarrow FeCl_2 \downarrow$$

- In the electrolyte the $FeCl_2$ and $Fe(OH)_2$ produced and gets precipitated in the form of sludge and settle down. In this way material is removed from the workpiece as sludge.
- The various reactions taking place in the Electrochemical machining process are in the figure given below

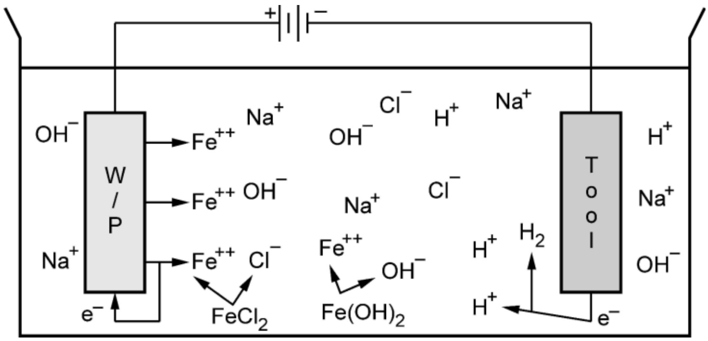

Fig. 3.3 Chemical reaction of ECM

3.2.3 Main Equipment of ECM

- The ECM system has the following modules
  - Power supply
  - Electrolyte filtration and delivery system
  - Tool feed system
  - Working tank

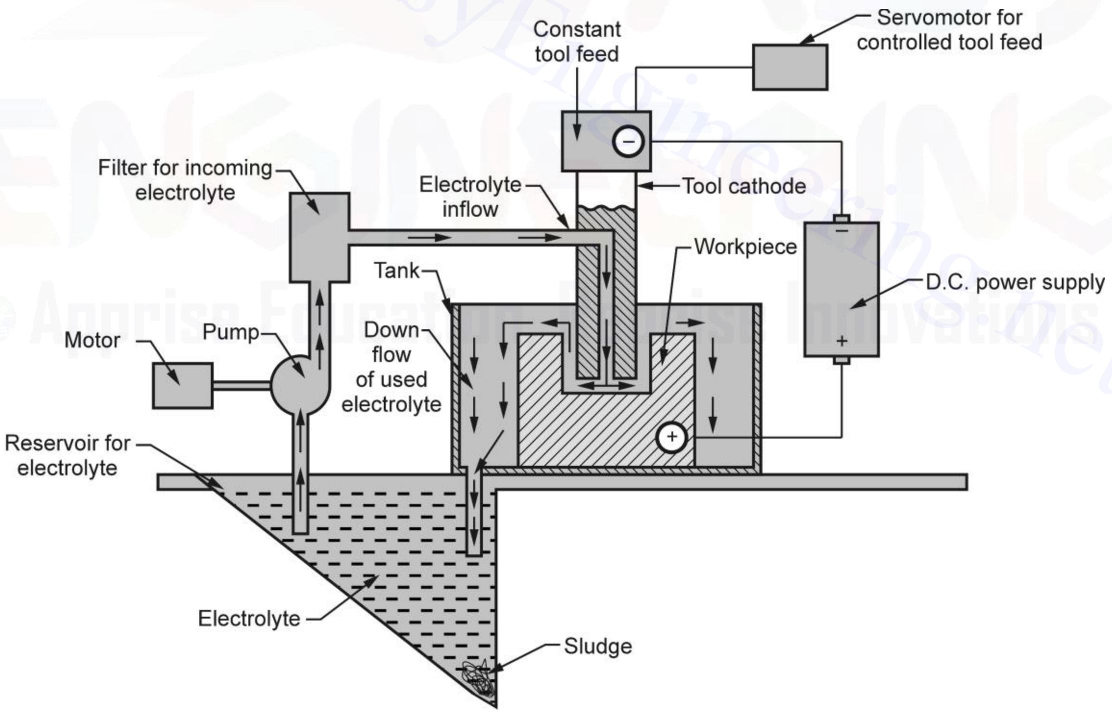

Fig. 3.4 Schematic diagram of ECM

3.2.4 Working Process of Electrochemical Machining

- First the workpiece is assembled in the fixture and tool is brought close to the workpiece. The tool and workpiece is immersed in a suitable electrolyte.
- After that, potential difference is applied across the w/p (anode) and tool (cathode). The removal of material starts. The material is removed as 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 is comes out as positive ions and combine with the ions present in the electrolyte and precipitates as sludge. Hydrogen gas is liberated at 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.

3.2.5 Parameters in ECM

1) Metal Removal Rate (MRR) - It depends on the following factors :

(a) Current density

(b) Conductance of electrolyte

(c) Voltage applied

(d) Shape of electrodes

(e) Gap between the tool and workpiece.

2) Electrolyte used - Following are the types of electrolyte used in the ECM process :

(a) Sodium chloride

(b) Sodium chromate

(c) Sodium hydroxide

(d) Potassium nitrate

(e) Sodium sulphate

(f) Potassium chloride

(g) Sodium fluoride

The electrolyte is used in the process for following purposes :

(a) It carries current between the tool and workpiece.

(b) It flushes away the sludge and other contaminants from the machining area.

(c) It minimizes heat generated in the cutting zone due to current and chemical reaction.

3) Tool for ECM -

- The shape of the tool is reproduced on the workpiece, hence the tool face should be well polished to obtain good surface finish on the workpiece. The tool used in the process should have following properties :

(a) It should be good conductor of electricity.

(b) It should be easily machinable.

(c) It should have high chemical resistance.

(d) It should be easily available and cheap.

Most commonly used materials for ECM process are :

(a) Copper

(b) Brass

(c) Stainless steel

(d) Titanium

3.2.6 Applications

- 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.

3.2.7 Advantages

- Negligible tool wear.
- Complex and concave curvature parts can be produced easily by the use of convex and concave tools.
- No forces and residual stress are produced, because there is no direct contact between tool and workpiece.
- Excellent surface finish is produced.
- Less heat is generated.

3.2.8 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.
- High power consumption.
- High initial investment cost.

3.2.9 Process Capabilities

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/mm^2 to 5 A/mm^2
2.	Electrolyte	
	Material	$NaCl$ and $NaNO_3$
	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 2 mm
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

3.3 Electro Chemical Grinding (ECG)

- ECG is the material removal process in which the material is removed by the combination of Electro-chemical deposition as in ECM process and abrasion due to grinding.

Process :

- ECG is a combination of ECM and the grinding process. The metal is removed by both anodic dissolution as in ECM and abrasion by the grinding wheel.
- Conventional grinding of carbides, high strength temperature resistant alloys and hard to machine alloys become very costly because of employing the high cost abrasives and diamond wheels.
- The possibility of cracking in the grinding wheels due to the abrasion of hard materials is eliminated in the ECG process.
- Hard and difficult to machine, fragile, and electrically conductive materials can be easily machined by ECG process. In this process, 10 % of the work material is removed by abrasive cutting and 90% by electrolytic action.

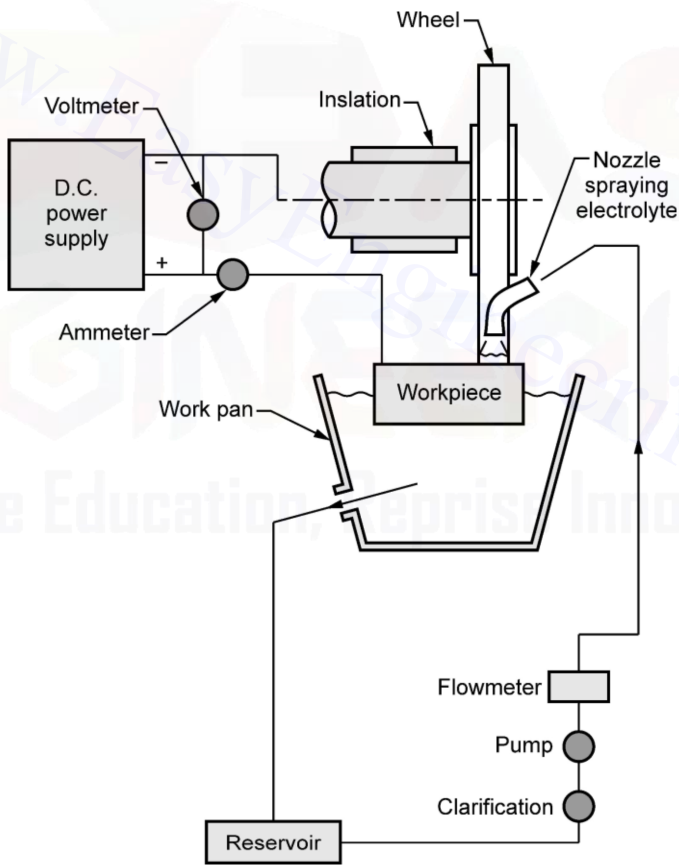

Fig. 3.5 ECG process

3.3.1 Equipment

- The equipment consists of a conductive grinding wheel rotated by an insulated spindle, an electrolyte spraying and circulating unit and a work table for achieving desired shape and size of machining.
- Also a DC power supply unit is employed for the supply of electrical energy. At the outset, the ECG equipment is similar to a conventional grinder.
- The grinding wheels used in ECG process are conductive ones. It consists of abrasive particles in an electrically conductive bonding agent.
- **Copper, Brass, Nickel are the most commonly used materials for metal-bond wheels.** Soft, copper-impregnated resins are used when wheels are fabricated for form-Grinding applications.
- The most common abrasive used is Aluminium oxide. In special applications, a solid metal disk with a layer of diamond particles, in a nickel matrix is used.
- The abrasive particles of the grinding wheel are non-conductor of electricity. The abrasive grits on the grinding wheel are made to protect from 0.0125 mm to 0.0375 mm from the surface of the grinding wheel.
- The grinding wheels are dressed in the conventional way using a diamond dresser. Several techniques are employed to maintain the proper gap between the wheel and workpiece during machining.
- The grinding wheel and the spindle are insulated from the rest of the machine. The short circuit between the wheel and the work piece is prevented due to point contact made by the fine diamond points.
- Two methods are currently employed to carry power through the spindle, the brushes and mercury couplings.
- Most of the ECG machines use heavy metal brushes to provide sliding electrical connection. But the use of brushes is limited because of its inability to carry high current. The mercury couplings are used to carry high current and ensure for higher material removal.
- The electrolyte system consists of pump, filter, Relief valve etc., the electrolyte is pumped in the gap between the work and the grinding wheel.
- The used electrolyte contacting the removed material and sludges are collected in the reservoir from which it passes through the filter and is pumped to the machining area through flow control and relief valve.

- The feeding mechanism is attached to the machine table provides the feed to the workpiece.

3.3.2 Working Principle

- The workpiece is made as anode which is connected to the positive terminal of the DC power supply and the grinding wheel tool is made as the cathode.
- A small gap of approximately 0.025m is maintained between the work surface and grinding wheel.
- A suitable electrolyte is fed into the gap through nozzle. When a low voltage of 4 to 15 volts and current of 100 amps is applied between the tool and the workpiece.
- A high density current (77 to 620 amp/cm^2) passes through them.
- The whole system forms an electrolytic cell and hence machining occurs by,
  - a) Anodic dissolution of the workpiece.
  - b) Abrasive action of the grits of the wheel.

When voltage is applied, the work material gets dissolved in the electrolyte and as the wheel rotates, the abrasive particle remove the material by abrasive action.

Material Removal Rate

The material removal rate in electrochemical Grinding can be calculated from the equation,

$$MRR = \frac{MI}{\rho F}$$

M is equivalent weight in grams

I is the current in ampere

ρ is density g/mm^3

F faradays constant in coulomb

3.3.3 Advantages

1. No thermal damage to the work piece.
2. About 80% faster material removal rate than conventional grinding
3. Long lasting wheels because 10% grinding action by grits.
4. Wheel wear is negligible.
5. No distortion of the workpiece.
6. No micro-crack and no structural changes occur in the workpiece.
7. Cutting force is very small compared to conventional grinding.

8. Higher accuracy is achieved. (about 0.01mm)
9. Single pass grinding.
10. More economical for grinding harder material than conventional grinding.

3.3.4 Disadvantages

1. High capital costs, Because of the special tool and insulation arrangements.
2. Power consumption is quite high.
3. Electrolyte is corrosive.
4. The electrolyte and the bonding material should have high electrical conductivity.
5. High Preventive maintenance costs.

3.3.5 Limitations

1. The work material must be conductive.
2. Not suitable for machining soft materials.
3. Require dressing tools for preparing the wheels.

3.3.6 Applications

1. Precision grinding of hard metals economically.
2. Grinding carbide cutting tool inserts.
3. To Re-profile motor gears, gear teeth and re-establish new teeth contour.
4. Burr-free sharpening of hypodermic needles, grinding of super alloy turbine blades and form grinding of fragile honeycomb metals.
5. To grind end mill cutters more precisely.
6. Thin walled components of hard steels can be easily and accurately ground by this process.

3.4 Electro Chemical Honing (ECH)

- Electro Chemical Honing process comes under the process of Electro Chemical Machining process. It is the usage of combined power of electricity and chemical energy for the material removal from the work piece is known as Electro Chemical Machining process.
- Electro Chemical Honing process is mostly employed for better surface finish, accuracy and economic aspects too.

- Honing is an abrasive machining process that produces a precision surface on a metal workpiece by scrubbing an abrasive stone against it along a controlled path.
- Honing is primarily used to improve the geometric form of a surface, but may also improve the surface texture.
- A special tool, called a honing stone or a hone, is used to achieve a precision surface.
- The hone is composed of abrasive grains that are bound together with an adhesive.
- Generally, honing grains are irregularly shaped and about 10 to 50 micrometers in diameter (300 to 1,500 mesh grit).
- Smaller grain sizes produce a smoother surface on the workpiece.
- Hone tool has a combined motion of rotation and translation
- A honing stone is similar to a grinding wheel in many ways, but honing stones are usually more easily crumbled so that they conform to the shape of the workpiece as they wear in.
- To counteract their friability, honing stones may be treated with wax or sulfur to improve life; wax is usually preferred for environmental reasons.
- Any abrasive material may be used to create a honing stone, but the most commonly used are corundum, silicon carbide, cubic boron nitride, or diamond.

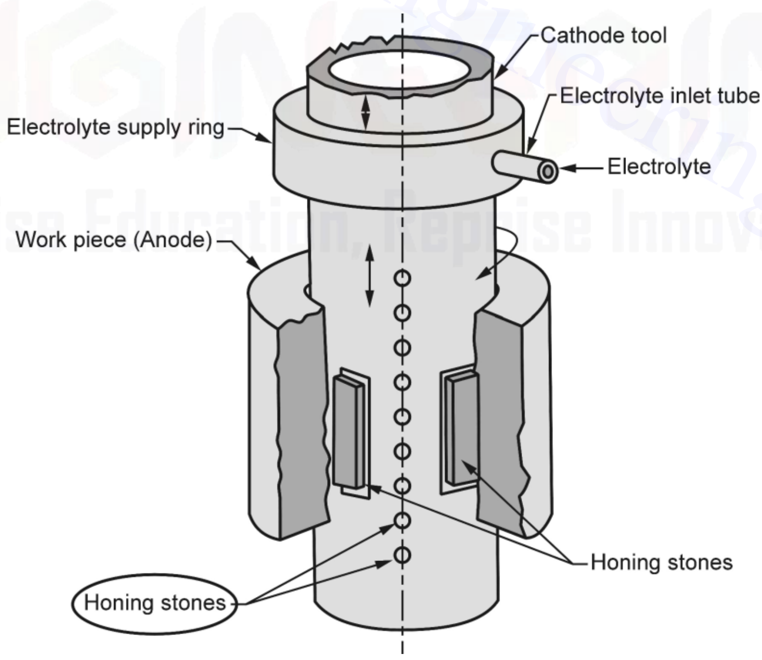

Fig. 3.6 Structure of hone tool

- In an electrochemical honing process, in order to obtain better accuracy, the size of the tolerance on the diameter can be provided at 0.01 mm and roundness can be maintained at lesser than 0.05 mm.
- It provides the surface roughness in the range of 0.1 microns to 0.5 microns. To attain a specified roughness on the work surface, the abrasive honing stones are required to keep on the work for a few seconds after the power is cut off.
- The surface finish of the electrochemical honing process obtained is mostly based up on the following terms.
  1. Size of the abrasive grains.
  2. Speed of the rotation and reciprocation.
  3. Duration of the run out period.

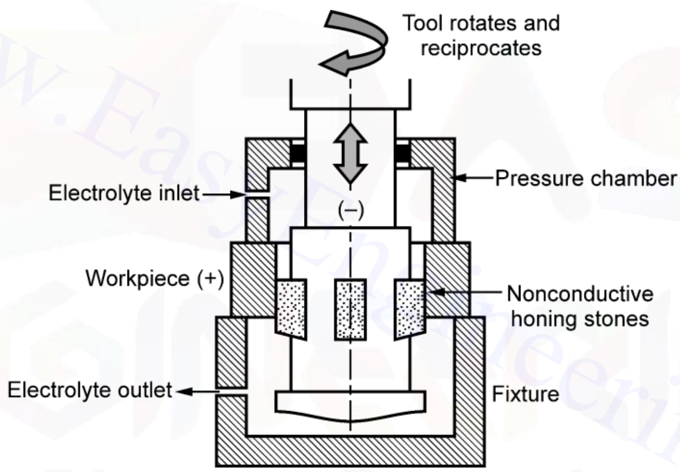

Fig. 3.7

3.4.1 Process Characteristics

- Abrasive stones are used to maintain the gap size of 0.075 to 0.250 mm.
- Surface finish ranges from: 0.2 to 0.8 μm.
- Electrolyte temperature is nearly maintained at 38-40 °C.
- Pressure of 1000 kPa.
- Flow Rate : 95 L/min.
- DC current is used.
- Voltage gap of 6 to 30 V is kept accordingly.
- Current density of 465 A/cm^2 .
- Cross-hatched cut surface is obtained after machining which is most desired after any load bearing surface.

- Tolerance can be achieved is as low as ±0.003 mm.
- Material removal rate is 3 to 5 times faster than conventional honing and 4 times faster than that of internal cylindrical grinding.

3.4.2 Advantages of Electorchemical Honing Process

1. Electrochemical honing process enhances the material removal rate specifically for harder materials.
2. There is no presence of burrs on the finished surfaces.
3. Electrochemical honing process requires minimum amount of work pressure on the tool and the work piece.
4. Electrochemical honing process reduces the noise level and distortion while honing thin walled tubes.
5. Electrochemical honing process increases the accuracy without damaging the materials due to the provision of cooling medium.

3.4.3 Disadvantages

- Machinery cost is high
- Machining cost per piece increases as it is an addition process.

3.4.4 Applications

- Due to rotating and reciprocating honing motion, the process reduces the errors in roundness through the rotary motion.
- Taper and waviness errors can also be reduced

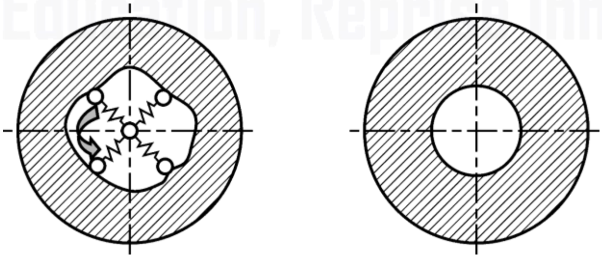

Fig. 3.8 Removing roundness error

- Typical applications are the finishing of cylinders for internal combustion engines, air bearing spindles and gears.

3.5 Two Marks Questions with Answers (Part - A)

Q.1 *What are the advantages of chemical machining ?* **(Section 3.1.5)**

Q.2 *What are the factors influencing the selection of maskants in chemical machining process ?* **(Section 3.1.2 (iii))**

Q.3 *What are maskants in chemical machining process ?* **(Section 3.1.2 (iii)Table)**

Q.4 *Write the principle of Electro Chemical Machining (ECM) ?* **(Section 3.2.1)**

Q.5 *Name any two electrolytes used in ECM.* **(Section 3.2.5 (2))**

Q.6 *What are the materials used for tools in ECM ?* **(Section 3.2.5 (3))**

Q.7 *What are the process parameters of ECM ?* **(Section 3.2.5 (1))**

Q.8 *What is the function of electrolyte in ECM ?* **(Section 3.2.5 (2))**

Q.9 *Mention the applications of ECM.* **(Section 3.2.6)**

Q.10 *Mention a few advantages of ECM process.* **(Section 3.2.7)**

Q.11 *What is the basic difference between electro plating and ECM ?* **(Section 3.2.1 (Table))**

Q.12 *State the working principle of ECG.* **(Section 3.3.2)**

Q.13 *State the advantages of ECG.* **(Section 3.3.3)**

Q.14 *Give the applications of Electro Chemical Honing (ECH) process.* **(Section 3.4.4)**

Q.15 *Write any two process characteristics of ECH ?* **(Section 3.4.1)**

3.5 Long Answered Questions (Part - B)

Q.1 *Describe the working principle and elements of chemical machining.* **(Section 3.1.1)**

Q.2 *Briefly explain the following with respect to chemical machining.* **(Section 3.1.2)**

a. Characteristics of cut and peel maskants

b. Selection of maskants

c. Advantages of photoresist maskant

d. Limitations of chemical machining.

Q.3 *List the advantages of chemical machining process.* (**Section 3.1.5)**

Q.4 *Why maskants are required in chemical machining process ? Explain.* **(Section 3.1.2 (iii))**

Q.5 *During the machining of Iron (Fe) using aqueous solution of Nacl, what are the possible reactions at electrodes ?* (**Section 3.2.2)**

Q.6 *Explain the ECM process. Explain how a replica of the tool is obtained.* (**Section 3.2)**

Q.7 *Explain in detail ECM process with sketch and also mention the advantages and application.* (**Sections 3.2.4 , 3.2.6 and 3.2.7)**

Q.8 *Explain the process of electro chemical machining with a neat sketch and discuss about influences of process parameters in machining output.* (**Section 3.2.5)**

Q.9 *Describe the principle of ECG and ECH. Discuss about the process parameters that influences the ECM.* (**Sections 3.3 and 3.4)**

Q.10 *Explain the working principle of Electro Chemical Grinding (ECG) and discuss the process capabilities and application.* (**Section 3.3)**

Q.11 *Explain the principle of ECG with sketch.* (**Sections 3.3.1 and 3.3.2)**

Q.12 *Describe the Electro Chemical Honing (ECH) process with a neat sketch.* (**Section 3.4)**

3.7 Multiple Choice Questions with Answers

Chemical Machining

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

a Chemical machining — b Chemical manufacturing

c Chemical machining — d None of the mentioned **[Ans. : a]**

Q.2 Of the following, which mechanism is used for the removal of material using chemical machining process ?

a Material vaporization — b Chemical dissolution

c Mechanical erosion — d Mechanical abrasion **[Ans. : b]**

Q.3 Which of the following solutions cannot be used as chemical reactive solution in CHM ?

a Acidic solution — b Alkaline solution

c Neutral solution — d None of the mentioned **[Ans. : c]**

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

a Pockets — b Contours

c Slots — d All of the mentioned **[Ans. : d]**

Q.5 Pre cleaning is done on the work piece surface in order to achieve, which of the following factors ?

a To provide good adhesion — b To provide clean surface

c To assure the absence of contaminants — d All of the mentioned **[Ans. : d]**

Q.6 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 **[Ans. : a]**

Q.7 Type of mask depends on which of the factor/s, given below ?

a Size of work piece
b Number of parts
c Desired resolution
d All of the mentioned **[Ans. : d]**

Q.8 During chemical machining, depth of etch is controlled by which factor of immersion ?

a Time
b Mask method
c Mask area
d None of the mentioned **[Ans. : a]**

Q.9 What is the range of reagent temperatures used for chemical dissolution in CHM ?

a 12 °C to 35 °C
b 37 °C to 85 °C
c 90 °C to 101 °C
d 121°C to 142 °C **[Ans. : b]**

Q.10 In chemical machining, excessive flow of chemical reagent results in which of the following defects ?

a Channellings
b Grooves
c Ridges
d All of the mentioned **[Ans. : d]**

Q.11 State whether the following statement about chemical machining is true or false.

"At higher temperatures, faster etching rates occur in chemical machining."

a True
b False **[Ans. : a]**

Q.12 Of the following, which ratio defines the etch factor ?

a Etching depth to undercut
b Undercut to etching depth
c Undercut to mask area
d Mask area to undercut **[Ans. : b]**

Q.13 CHM cannot eliminate which of the following defects ?

a Irregularities and dents
b Surface scratches
c Waviness
d All of the mentioned **[Ans. : d]**

Q.14 Which of the following are the tools required for chemical machining ?

a Maskants
b Etchants
c Scribing plates
d All of the mentioned **[Ans. : d]**

Q.15 State which of the following statement is true or false regarding chemical machining.

"Maskants are generally used in CHM, to protect the work piece from the etching chemical agent."

a True
b False **[Ans. : a]**

Q.16 Which of the following are the materials used for making maskants ?

a Synthetic materials
b Rubber materials
c Polymeric materials
d All of the mentioned **[Ans. : d]**

Q.17 What are the properties that a maskant used in chemical machining should possess ?

a Be tough and adhere well
b Scribe easily
c Be inert to chemical reagent
d All of the mentioned

[Ans. : d]

Q.18 Which of the following can be used to apply the maskants on work piece in chemical machining ?

a Dipping or spraying
b Rolling or electro coating
c Adhesive tapes
d All of the mentioned

[Ans. : d]

Q.19 State whether the following statement is true or false regarding maskants.

"After etching, maskants should be removed easily and inexpensively."

a True
b False

[Ans. : a]

Q.20 In maskant application, photo-resist masks ensure which of the following advantages ?

a High accuracy
b Ease of repetition
c Ease of modification
d All of the mentioned

[Ans. : d]

Q.21 Which of the tolerance values are obtained, when we use cut and peel mask method for maskant ?

a ± 0.013 mm
b ± 0.045 mm
c ± 0.077 mm
d ± 0.179 mm

[Ans. : d]

Q.22 Which of the tolerance values are obtained, when we use silk-screen resist method for maskant ?

a ± 0.013 mm
b ± 0.045 mm
c ± 0.077 mm
d ± 0.179 mm

[Ans. : c]

Q.23 Which of the tolerance values are obtained, when we use photo resist method for maskant application ?

a ± 0.013 mm
b ± 0.045 mm
c ± 0.077 mm
d ± 0.179 mm

[Ans. : a]

Q.24 Which of the following, are the main uses of etchants applied in chemical machining ?

a Good surface finish
b Uniform material removal
c Control intergranular attack
d All of the mentioned

[Ans. : d]

Q.25 State whether the following statement is true or false about etchants.

"Etchants are used for controlling H_2 absorption in case of Ti alloys."

a True
b False

[Ans. : a