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CMR INSTITUTE OF TECHNOLOGY, BENGALURU. ACCREDITED WITH A+ GRADE BY NAAC

Internal Assessment Test 2 – June. 2022

Sub:	Nontraditional machining					Sub Code:	18ME641	Branch:	ME
Date:	8.6.22	Duration:	90 min's	Max Marks:	50	Sem / Sec:	VI/A&B		OBE

<u>Answer any FIVE FULL Questions</u>

		MARKS	CO	RBT
1	Explain briefly the electrolyte flow techniques in electro chemical machining process.	[10]	CO3	L2
2	Explain with neat sketch the working of Electro chemical honing machining and electrochemical grinding.	[10]	CO3	L2
3	Explain with neat flow chart the working of Chemical milling process and also mention its advantages and disadvantages.	[10]	CO3	L2
4	Explain with neat sketch the working of Electro chemical machining process and also mention its advantages and disadvantages.	[10]	CO3	L2
5	Explain travelling wire EDM and EDG with neat sketch	[10]	CO4	L2
6.	Explain with neat sketch the working of Electro discharge machining and also mention its advantages and disadvantages	[10]	CO4	L2

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Scheme of Evaluation

Question number	Particulars	Marks distribution
1.	Five flow techniques	2x5 marks
2.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
3.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
4.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
5.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
6.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks

1. Tooling Techniques in ECM

The figure 1 shows a simple round tool. The leading edge is sharp and the shank is not insulated. This type of tool produces a hole with considerable amount of taper because the complete surface area of the hole produced is being constantly machined.

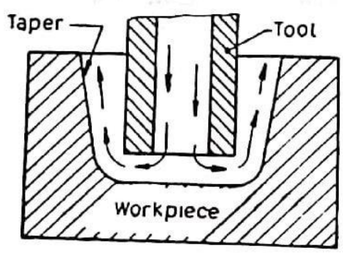


Figure 1

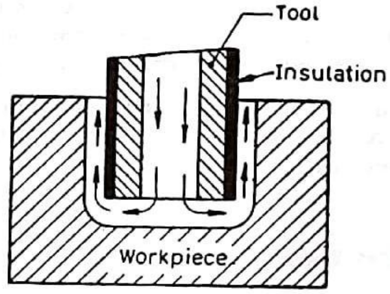


Figure 2

The figure 2 shows the same tool with insulation on the sides. This limits ECM action extending from the tip of the tool to the top of the hole, and no significant taper is produced. This type of tool is still quite apt to produce striations because the electrolyte tends to become turbulent as it passes around the sharp corners. This will have an adverse effect on the ability to hold tolerances and surface finish, as well encourage arcing and possible shorting at the corners of the tool.

The figure 3 shows a tool with its leading edge radiused to encourage uniform electrolyte flow around the corner, also a tip brased on the shank of the tool allows easy replacement and use of materials such as tungsten and copper to prevent damage in the event of arcing.

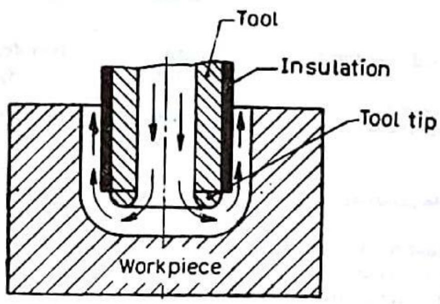


Figure 3

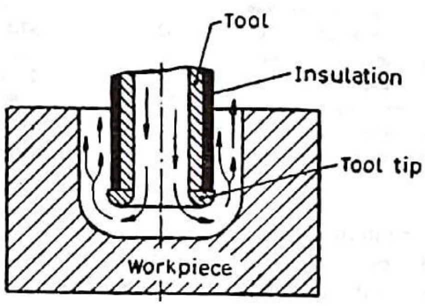
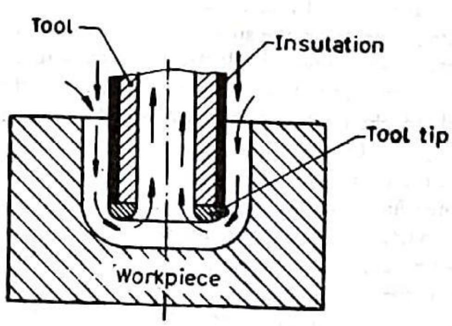


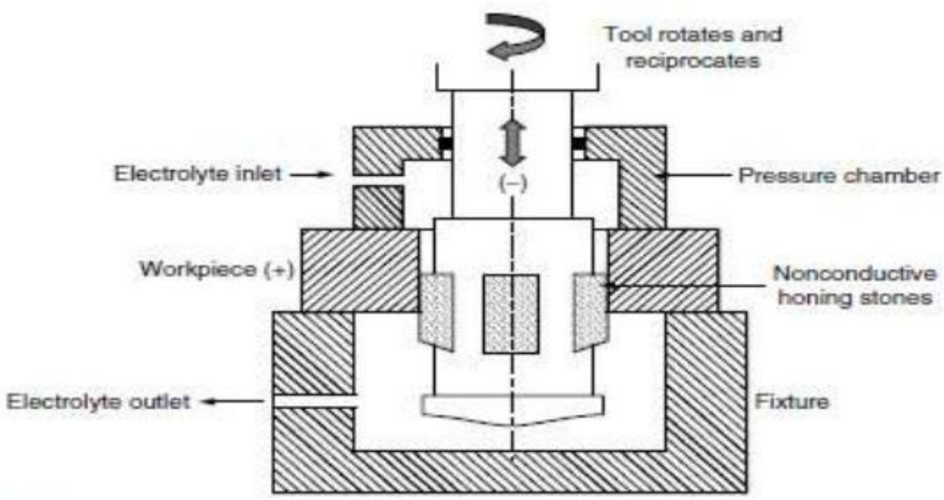
Figure 4

The figure 4 shows yet another improvement that has proved effective in eliminating any significant taper encountered in the previous methods. The overlap of the tip causes the electrolyte flow to break up as is passed around the radiused corner. This minimizes the effect of any stray currents which are likely to cause additional machining over the already finished surfaces.

The figure 5 shows a tool which has its tip flush with the main body and insulation. The electrolyte flow is reversed. This technique produces hole with minimum taper and excellent finish.



2. Electrochemical Honing



It is a process in which it combines the high removal characteristics of Electrochemical Dissolution (ECD) and Mechanical Abrasion (MA) of conventional Honing. It has much higher rates than either of honing & internal cylindrical grinding. Cathodic tool is similar to the conventional honing tool, with several rows of small holes so that electrolyte could enter directly into inter electrode gap. Electrolyte provides electron through the ionization process which acts as coolant and flushes away the chips that are formed off by mechanical abrasion and metal sludge that results from electrochemical dissolution action. Tool is inserted inside the worked hole or a cylinder. • Mechanical abrasion takes place first by the stones/hones. Oxides formed due to working from previous process will be removed by it and clean surface will be achieved. Now the clean surface will be in contact with electrolyte and then Electrochemical Dissolution will remove the desired material. Same procedure is continued till the required cut is made. To control surface roughness Mechanical Abrasion is allowed to continue for a few seconds after the current has been turned off.

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

Advantages

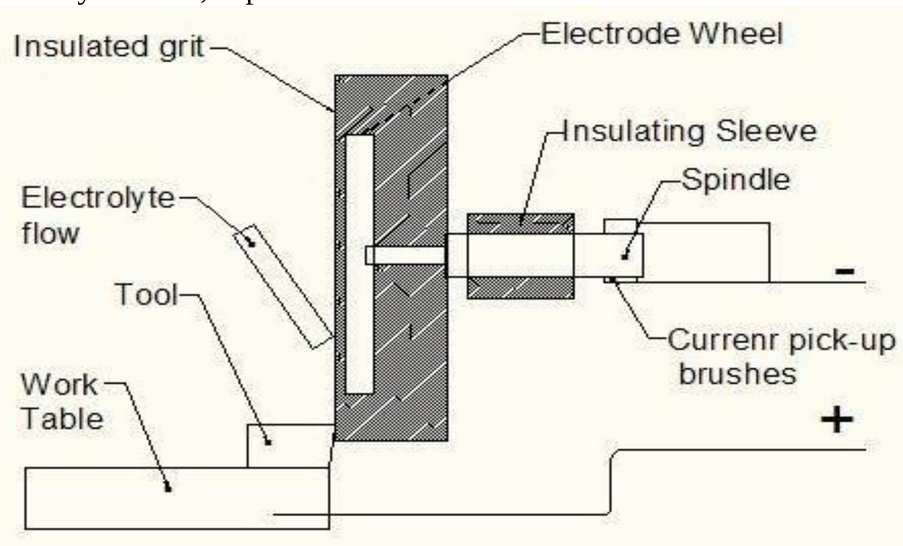
- Low tolerances.
- Good surface finish is achieved.
- Small Correction on work pieces is possible.
- Shaping and surface finishing is done in one process.
- Light stone/hone pressure is used in the process, heat distortion is avoided.

Disadvantages

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

Electrochemical grinding (ECG) -

The process is similar to cathode is a specially constructed grinding wheel instead of a cathodic shaped. The insulating abrasive material (diamond or aluminum oxide) of the grinding wheel is set in conductive bonding, the wheel is a rotating cathodic tool with abrasive particles on its periphery. Electrolyte flow, usually NaNO3, is provided for ECD (Electro chemical dissolution). Similar to ECM except that the cathode is a specially constructed grinding of a cathodic shaped tool. The insulating abrasive material (diamond or the grinding wheel is set in a conductive bonding material. the wheel is a rotating cathodic tool with abrasive particles on its periphery. Electrolyte flow, usually NaNO3, is provided for ECD.



Working Principle

The wheel rotates at a surface m/s, while current ratings when a gap voltage of between the cathodic anodic work piece, a current to 240 A/cm2 is created. The current density depends on the material being machined, the gap width, and the applied voltage surface speed of 20 to 35 ratings are from 50 to 300 A. of 4 to 40 V is applied grinding wheel and the current density of about 120. The current density depends on the material, the gap width, and the applied voltage.

Applications

- Machining parts made from difficult such as sintered carbides, creep-resisting (Inconel titanium alloys, and metallic composites. • Applications similar to milling, grinding, cutting off, sawing, and tool and cutter sharpening.
- Production of tungsten carbide cutting tools, fragile parts, and thin walled tubes.
- Producing specimens for metal fatigue and tensile tests.
- Machining of carbides and a variety of high alloys.

Advantages

- Absence of work hardening
- Elimination of grinding burrs
- Absence of distortion of thin fragile or thermosensitive parts
- Good surface quality • Production of narrow tolerances
- Longer grinding wheel

Disadvantages

- Higher capital cost than conventional machines.

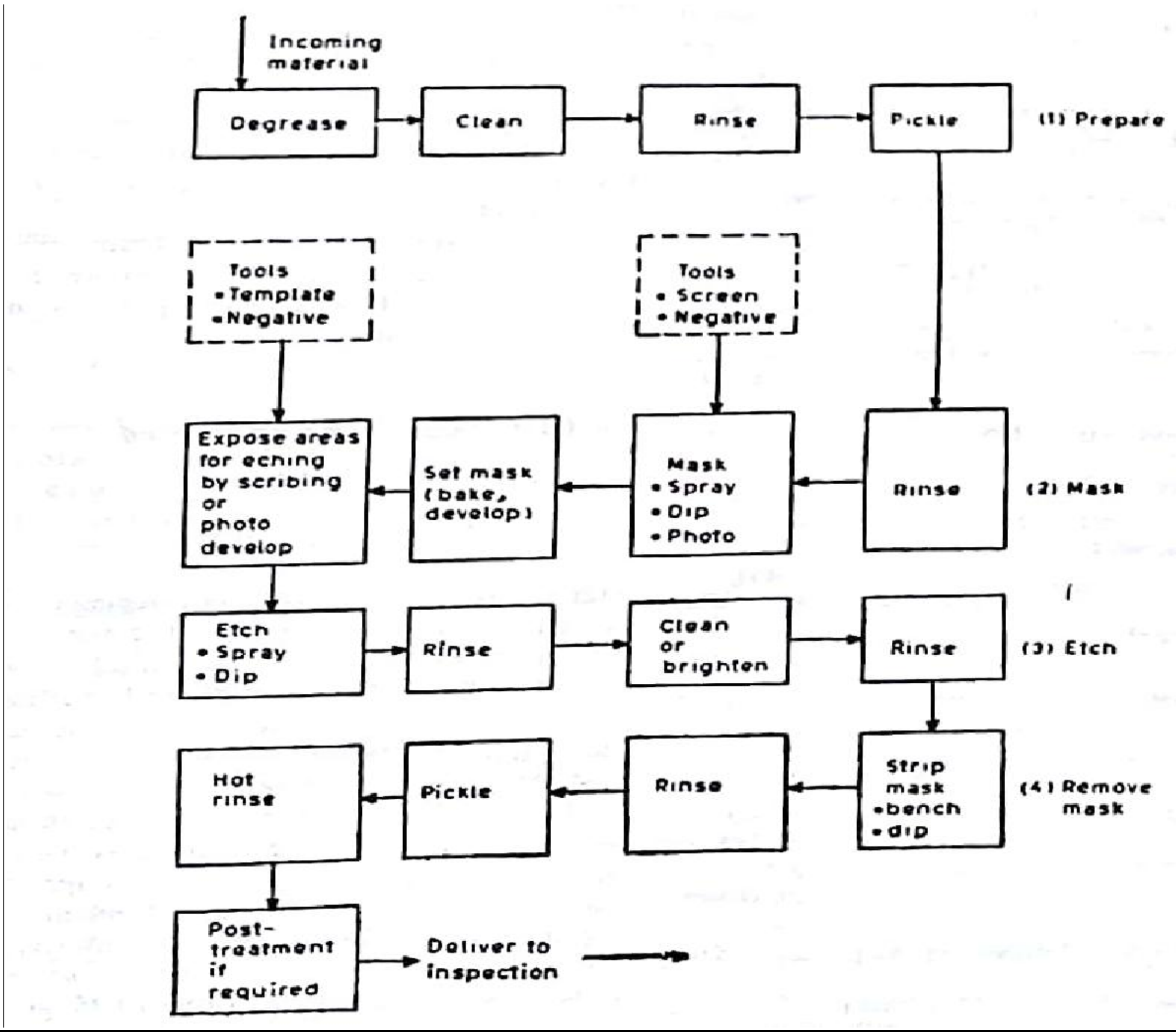
- Process limited to electrically conductive materials.
- Corrosive nature of electrolyte.
- Requires disposal and filtering of electrolyte
- Higher capital cost than conventional
- Process limited to electrically conductive
- Corrosive nature of electrolyte
- Requires disposal and filtering of electrolyte

3. Chemical Milling (CHM) is the controlled chemical dissolution(CD) of the work piece material by contact with a strong reagent Used to produce pockets & contours.

CHM consists of following steps-

- Preparing and pre cleaning the work piece surface.
- Masking using readily strippable mask
- Scribing of the mask, guided by templates
- The work piece Is then etched and rinsed

Etchants are acid or alkaline solutions maintained within a controlled range of chemical composition and temperature. Main technical goals of etchants are- Good surface finish, Uniformity of metal removal, Maintenance of air quality and avoid the environmental problems and ability to regenerate the etchant solution.



<u>Advantages</u>

- Weight reduction is possible on complex contours that are difficult to machine using conventional methods.
- No burrs are found.
- Design changes can be implemented quickly.
- A less skilled operator is needed.
- Simultaneous material removal, from all surfaces, improves productivity and reduces wrapping.

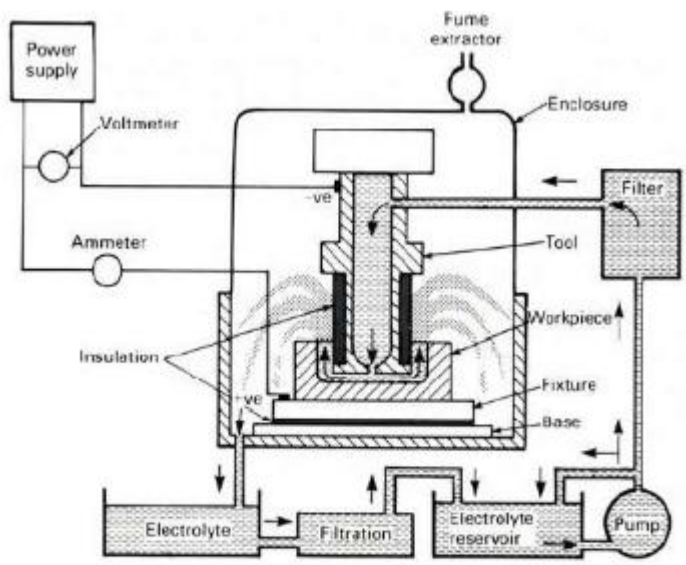
<u>Limitations</u>

- Handling and disposal of chemicals can be troublesome.
- Surface imperfections are reproduced in the machined parts.
- Deep narrow cuts are difficult to produce.
- Porous castings yield uneven etched surfaces.

4. Electrochemical Machining

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.

ECM



Working of Electrochemical Machining:

Electrochemical machining works inverse as electroplating process. Metal is removed from 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 work piece 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.
- 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, ferrous ions created at the work piece (anode) which gives equal amount of electron in mixture.
- These Ferrous ions react with opposite chlorine ions or hydroxyl ions and get precipitate in form of sludge.
- 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.

Application:

- ECM is used to machining disk or turbine rotor blade.
- It can be used for slotting very thin walled collets.
- ECM can be used to generate internal profile of internal cam.
- Production of satellite rings and connecting rod, machining of gears and long profile etc.

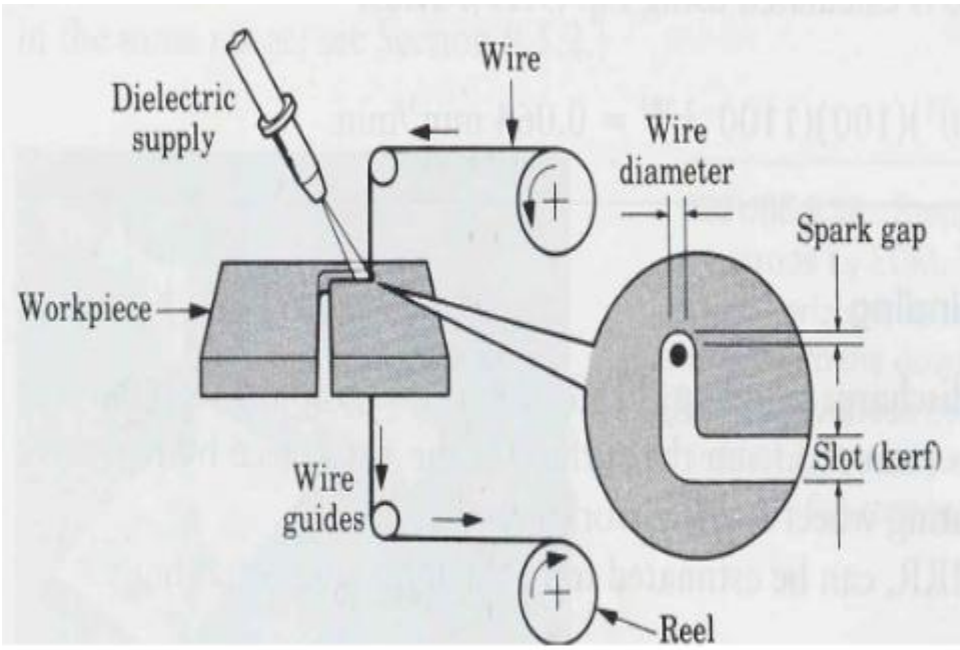
Advantages:

- It can machine very complicated surface.
- A single tool can be used to machining large number of work-piece. Theoretically no tool wear occur.
- Machining of metal is independent on strength and hardness of tool.
- ECM gives very high surface finish.

Disadvantages:

- High initial cost of machine.
- Design and tooling system is complex.
- Fatigue property of machined surface may reduce.
- Nonconductive material cannot be machined.
- Blind hole cannot be machined form ECM.
- Space and floor area requirement is high compare to conventional machining.

5. Travelling wire EDM



Wire electrical discharge machining (EDM) is a non-traditional machining process that uses electricity to cut any conductive material precisely and accurately with a thin, electrically charged copper or brass wire as an electrode.During the wire EDM process, the wire carries one side of an electrical charge and the workpiece carries the other side of the charge. When the wire gets close

to the part, the attraction of electrical charges creates a controlled spark, melting and vaporizing microscopic particles of material. The spark also removes a miniscule chunk of the wire, so after the wire travels through the workpiece one time, the machine discards the used wire and automatically advances new wire. The process takes place quickly—hundreds of thousands of sparks per second—but the wire never touches the workpiece. The spark erosion occurs along the entire length of the wire adjacent to the workpiece, so the result is a part with an excellent surface finish and no burrs regardless of how large or small the cut.Wire EDM machines use a dielectric solution of deionized water to continuously cool and flush the machining area while EDM is taking place. In many cases the entire part is submerged in the dielectric fluid, while high-pressure upper and lower flushing nozzles clear out microscopic debris from the surrounding area of the wire during the cutting process. The fluid also acts as a non-conductive barrier, preventing the formation of electrically conductive channels in the machining area. When the wire gets close to the part, the intensity of the electric field overcomes the barrier and dielectric breakdown occurs, allowing current to flow between the wire and the workpiece, resulting in an electrical spark.
On most wire EDM machines, the path of the wire is controlled by computer numerically-controlled (CNC) diamond guides, which can move independently of each other on multiple axes for tapered cuts and complex shapes such as small-radius inside corners and narrow slots. Additionally, wire sizes vary from 0.012” diameter down to 0.004” for high-precision work. Wire EDM is capable of holding tolerances as tight as +/-0.0001”.Wire EDM provides a solution to the problems encountered when trying to machine materials that are normally difficult to work with, such as hardened steel, aerospace-grade titanium, high-alloy steel, tungsten carbide, Inconel, and even certain conductive ceramics.
One requirement of the wire EDM process is a start hole for threading the wire if the part’s features do not allow you to cut an edge. Wire EDM can only machine through features; however, we can quickly drill a hole in any conductive material using another type of EDM, small hole drilling or “hole pop” EDM.

EDG

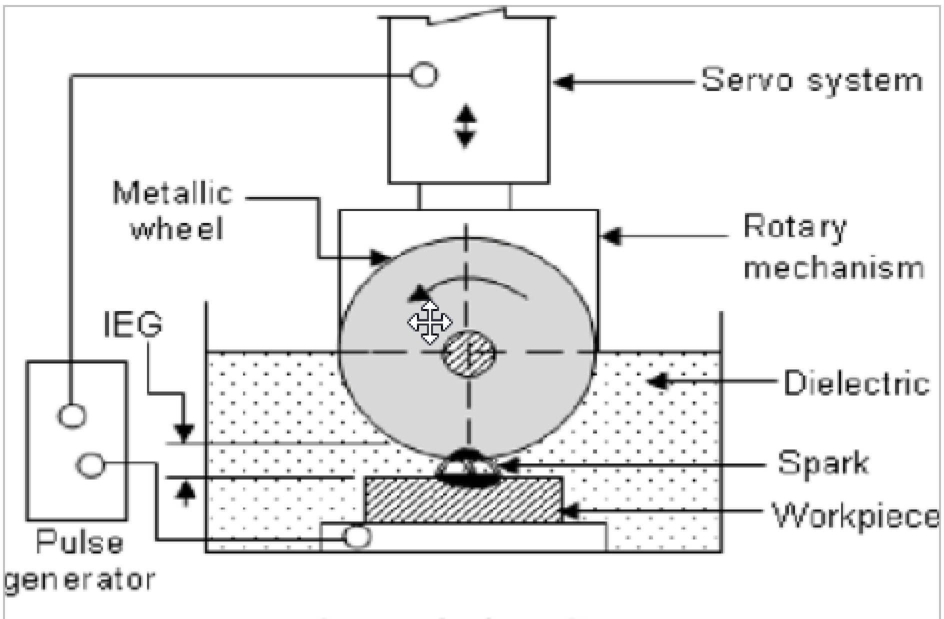


Fig. 1 Detail of EDG process

Electrical discharge grinding is similar to electric discharge machining, but with the tool in the form of a rotating conductive wheel and with lower currents.
The tool consists of a disc, which rotates around its horizontal axis.

Connection via power supply makes the disc act as the cathode and workpiece as the anode. When the disc is brought close to the workpiece, intermittent spark discharges occur, which means that the workpiece is melted and vaporized.

The discharge is supported by a dielectric liquid , which in combination with the rotation of the disc helps to cool the process and carry away the removed material while the disc is moved over the workpiece. The spark gap makes the machined surface is slightly below the disc's outer diameter.

It is important that the electrode, i.e., the rotating wheel is electrically conductive so it’s normally made of metal or graphite.

Electro discharge grinding is a mass reducing process that uses a rotating grinding wheel to remove the electrically conductive material by means of a controlled repetitive spark discharges. A dielectric fluid is used to flush away the chips, regulate the discharges and cools the wheel and the workpiece. We know that in normal EDM operation so there is a very problem of the dielectric flushing system. So dielectric flushing system should be as good as possible so that whatever debris are there that should not clog the inter-electrode gap and because very small gap is maintained if some debris actually clogs there will be a short circuiting. After short circuiting it will damage both the tool and the workpiece. So effective flushing is required. So in case of electro discharge grinding a graphite grinding wheel is used. This graphite grinding wheel like normal grinding operation, this grinding wheel actually rotates with a very high RPM so because of this rotational motion of this grinding wheel and this graphite grinding wheel which is metallic, metallic graphite grinding wheel and the workpiece both are actually this part of the grinding wheel and the workpiece both are actually immersed into the dielectric medium and as the grinding wheel rotates at a high RPM so effectively this inter-electrode gap it flushes away by the dielectric fluid. So whatever this debris materials are there it can be removed very easily by using this electro discharge grinding operation. So these process characteristics, a rotating wheel electrically conductive material, usually graphite so this graphite is taken because it is inexpensive and easy to this grinding wheel easy to fabricate by using a soft grinding graphite material. So there is no abrasive particles are used like in conventional grinding operation.

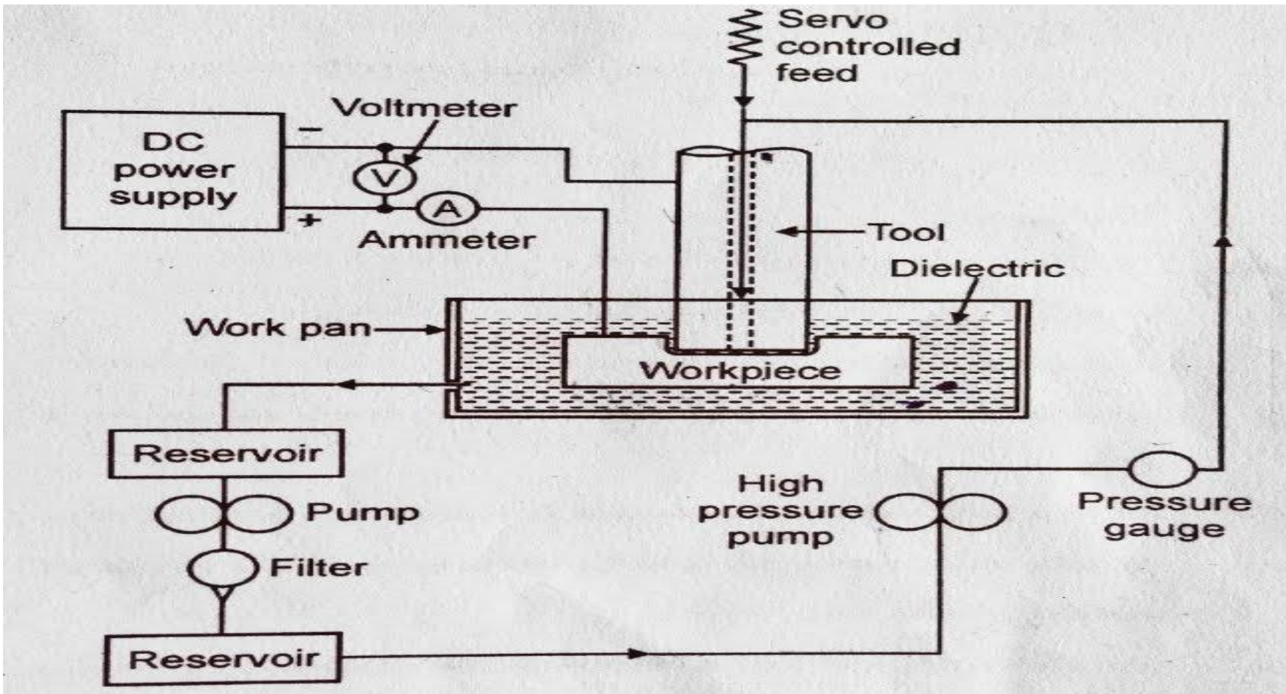
6. Working principle of EDM

The principle behind this process is the ability of controlled electric sparks to erode material. The workpiece and electrode do not touch during this process. In between is a gap that is roughly as thick as a human hair. The amount of removed material with a single spark is small, yet the discharge occurs roughly several 100,000 times a second.

While the electrode is moved closer to the workpiece, the electric field in the gap, also known as **spark gap**, increases until it reaches the breakdown volume. For this process, it is necessary that the fluid in which this discharge occurs is not conductive, or dielectric. The discharge causes strong heating of the material, melting away small amounts of material. This excess material is removed with the steady flow of the dielectric fluid. The liquid is also useful for cooling during the machining. Moreover, it is necessary for controlling the sparks.

At the beginning of EDM operation, a high voltage is applied across the narrow gap between the electrode and the workpiece. This high voltage induces an electric field in the insulating dielectric that is present in narrow gap between electrode and workpiece. This cause conducting particles suspended in the dielectric to concentrate at the points of strongest electrical field. When the potential difference between the electrode and the workpiece is sufficiently high, the dielectric breaks down and a transient spark discharges through the dielectric fluid, removing small amount of material from the workpiece surface. The volume of the material removed per spark discharge is typically in the range of 10^{-6} to 10^{-6} mm^3.

EDM removes material by discharging an electrical current, normally stored in a capacitor bank, across a small gap between the tool (cathode) and the workpiece (anode) typically in the order of 50 volts/10amps.



Advantages of EDM

- By this process, materials of any hardness can be machined;
- No burrs are left in machined surface
- One of the main advantages of this process is that thin and fragile/brittle components can be machined without distortion.
- Complex internal shapes can be machined.

Limitations of EDM

- The main limitations of this process are:
- This process can only be employed in electrically conductive materials.
- Material removal rate is low and the process overall is slow compared to conventional machining processes.
- Unwanted erosion and over cutting of material can occur.