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CMR Institute of Technology, Bangalore
DEPARTMENT OF MECHANICAL ENGINEERING
II - INTERNAL ASSESSMENT

Semester: 6-CBCS 2018 Date: 22 Jun 2021
Subject: NON-TRADITIONAL MACHINING (18ME641)
Faculty: Mr Navaneeth Brahmachari
Time: 01:00 PM - 02:00 PM Max Marks: 50

Instructions to Students:

Answer 5 full questions

ANSWER_ALL_QUESTIONS

Question	Marks	CO	PO	BT/CL
1. Explain Electrochemical Machining with a neat sketch and state its advantages and disadvantages	**[10.0]**	**1**	**[1]**	**[2]**
2. Explain electrochemical grinding and electrochemical honing with a neat sketches	**[10.0]**	**1**	**[1]**	**[2]**
3. Explain Chemical Milling and chemical blanking with suitable block diagrams.	**[10.0]**	**1**	**[1]**	**[2]**
4. Explain Electric discharge machining with a neat sketch and state its advantages and disadvantages.	**[10.0]**	**1**	**[1]**	**[2]**
5. Explain Electric discharge grinding and travelling wire EDM with a neat sketches	**[10.0]**	**1**	**[1]**	**[2]**
6. Explain the flushing techniques used in EDM and also explain characteristics of dielectric medium in EDM	**[10.0]**	**1**	**[1]**	**[2]**

Scheme of Evaluation

Question number	Particulars	Marks distribution
1.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
2.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
3.	Block diagram 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(flushing techniques) Working process (flushing techniques) Characteristics	4 marks 4 marks 2 marks

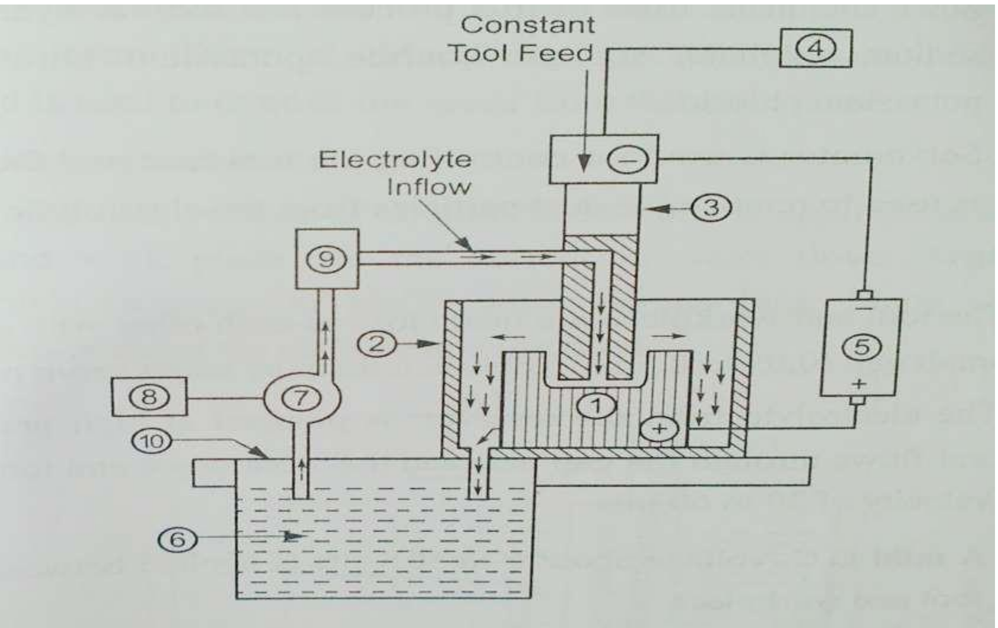
1. Electrochemical Machining

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.

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.



1. Workpiece, 2. Tank, 3. Tool (cathode), 4. Servomotor for controlled tool feed, 5. D.C. Power supply, 6. Electrolyte, 7. Pump, 8. Motor for pump, 9. Filter, 10. Reservoir

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:

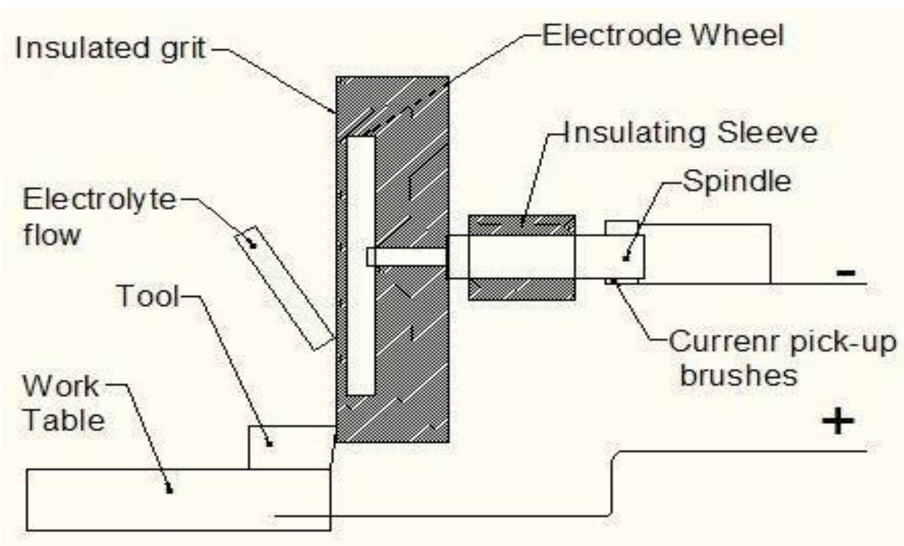
- It can machine very complicated surface.
- A single tool can be used to machining large number of work-piece. Theoretically no tool wear occur.
- Machining of metal is independent on strength and hardness of tool.
- ECM gives very high surface finish.

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.

2. 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
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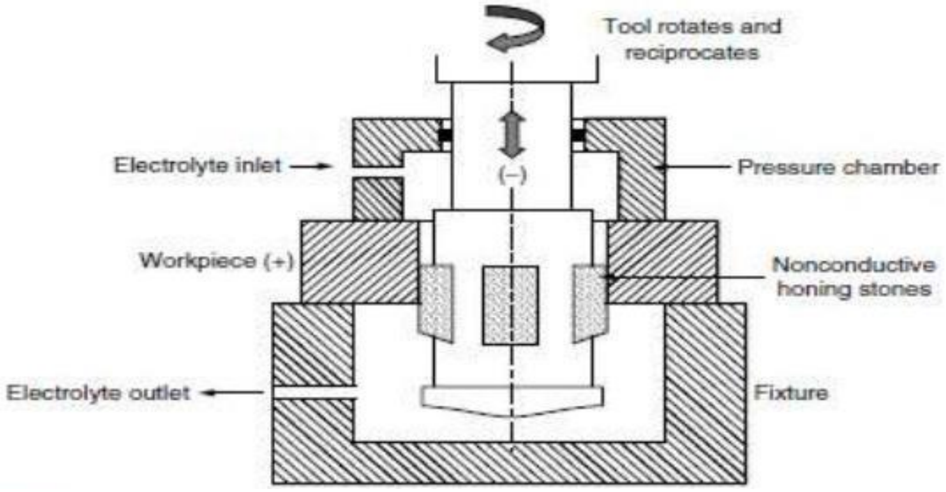
Electrochemical Honing



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.
- Due to Electrochemical Dissolution phase, no stress is accumulated and it automatically deburrs the part.
- It can be used for hard and conductive material that are susceptible to heat and distortion.

Disadvantages

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

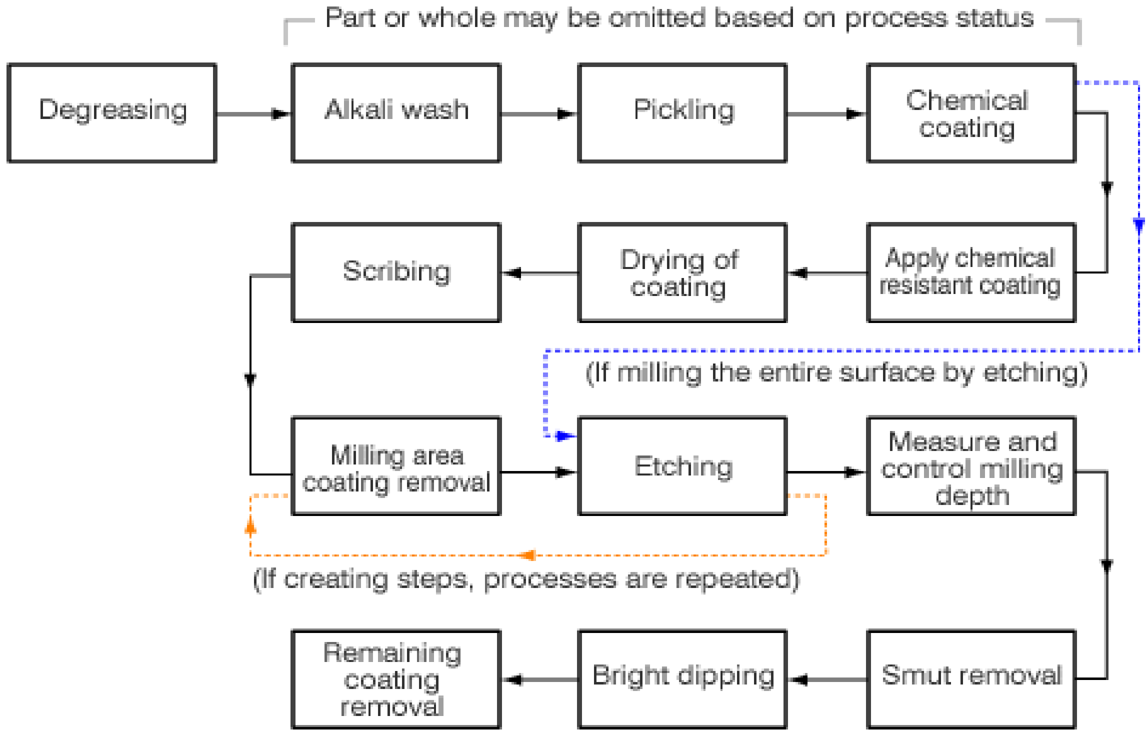
3. Chemical Milling

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.



Advantages

- 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.

Limitations

- 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.
- Material removal from one side of residually stressed material can result in a considerable distortion. Welded areas frequently etch at rates that differ from base metal.

Applications

- CHM applications range from large aluminum alloy airplane wing parts to minute integrates chips.
- CHM is used to thin out walls, webs, and ribs of parts that have been produced by forging, casting, or sheet metal forming
- Shallow cuts in large thin sheets are the most popular application especially for weight reduction of aerospace components

- Removal of sharp burrs from conventionally machined parts of complex shapes.
- Elimination of the decarburized layer from low alloy steel forgings.

Chemical Blanking

- Chemical blanking is used to etch entirely through a metal part.
- In chemical blanking, holes and slots that penetrate entirely through the material are produced, usually in thin sheet materials.
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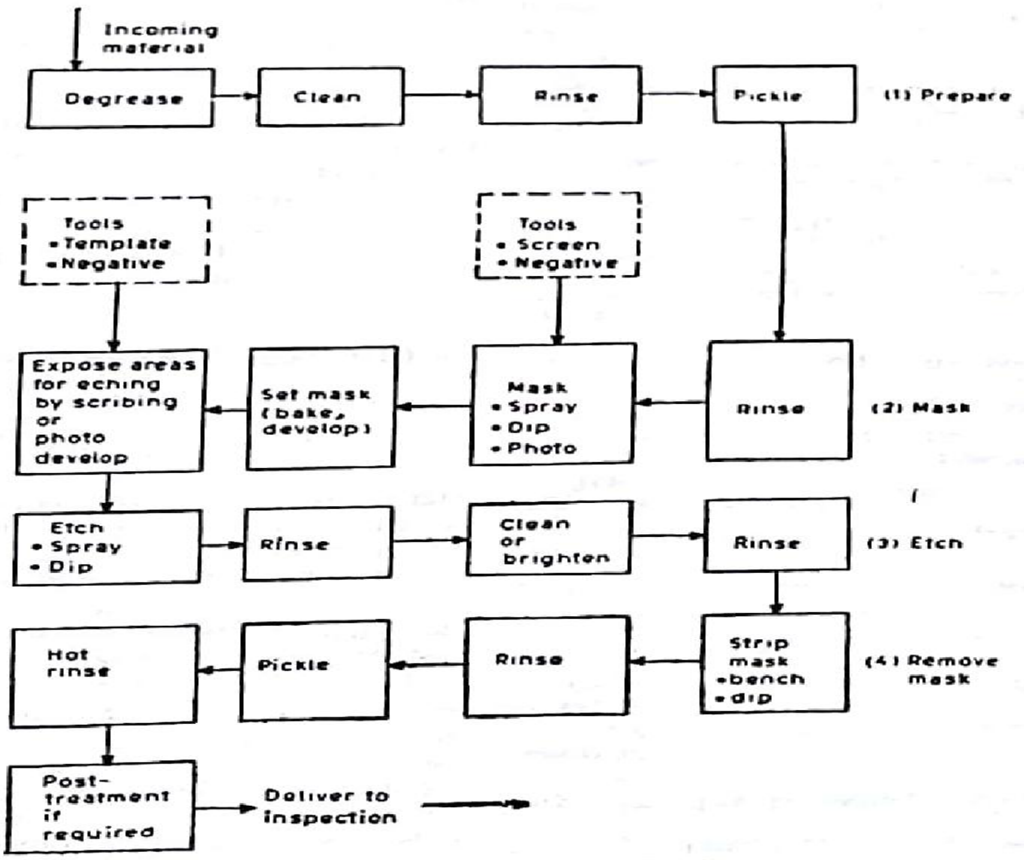
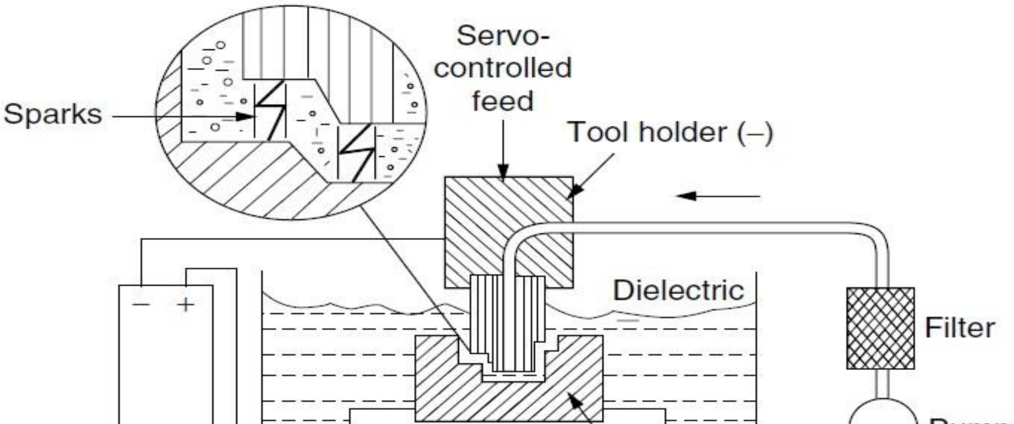
- Used to produce fine screens, flat springs, etc.
- Very cheap but efficient.



4. Electric Discharge Machining



The main components in EDM

1. Electric power supply
2. Dielectric medium
3. Work piece & tool
4. Servo control unit.

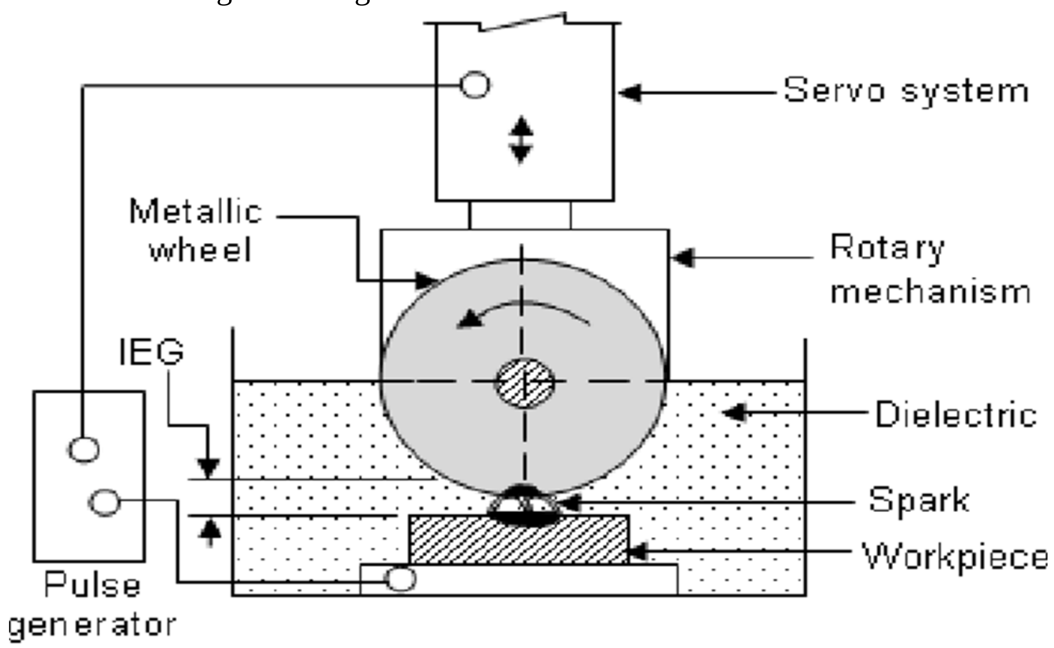
- The work piece and tool are electrically connected to a DC power supply.
- The current density in the discharge of the channel is of the order of 10000 A/cm2 and power density is nearly 500 MW/cm2.
- A gap, known as SPARK GAP in the range, from 0.005 mm to 0.05 mm is maintained between the work piece and the tool.
- Dielectric slurry is forced through this gap at a pressure of 2 kgf/cm2 or lesser

Working

- It is a process of metal removal based on the principle of material removal by an interrupted electric spark discharge between the electrode tool and the work piece.
- In EDM, a potential difference is applied between the tool and work piece. Essential - Both tool and work material are to be conductors.
- The tool and work material are immersed in a dielectric medium. Generally kerosene or deionized water is used as the dielectric medium. A gap is maintained between the tool and the work piece.
- Depending upon the applied potential difference (50 to 450 V) and the gap between the tool and work piece, an electric field would be established.
- Generally the tool is connected to the negative terminal (cathode) of the generator and the work piece is connected to positive terminal (anode).
- As the electric field is established between the tool and the job, the free electrons on the tool are subjected to electrostatic forces.
- If the bonding energy of the electrons is less, electrons would be emitted from the tool.Such emission of electrons are called or termed as '**<u>cold emission'</u>**.
- The "cold emitted" electrons are then accelerated towards the job through the dielectric medium.
- As they gain velocity and energy, and start moving towards the job, there would be collisions between the electrons and dielectric molecules.
- Such collision may result in ionization of the dielectric molecule.
- Ionization depends on the ionization energy of the dielectric molecule and the energy of the electron.
- As the electrons get accelerated, more positive ions and electrons would get generated due to collisions.
- This cyclic process would increase the concentration of electrons and ions in the dielectric medium between the tool and the job at the spark gap.
- The concentration would be so high that the matter existing in that channel could be characterized as "plasma".
- The electrical resistance of such plasma channel would be very less.
- Thus all of a sudden, a large number of electrons will flow from tool to job and ions from job to tool.

- This is called avalanche motion of electrons.
- Such movement of electrons and ions can be visually seen as a spark. Thus the electrical energy is dissipated as the thermal energy of the spark.
- The high speed electrons then impinge on the job and ions on the tool.
- The kinetic energy of the electrons and ions on impact with the surface of the job and tool respectively would be converted into thermal energy or heat flux.
- Such intense localized heat flux leads to extreme instantaneous confined rise in temperature which would be in excess of 10,000^{o}C.
- Such localized extreme rise in temperature leads to material removal.
- Material removal occurs due to instant vaporization of the material as well as due to melting.
- The molten metal is not removed completely but only partially.

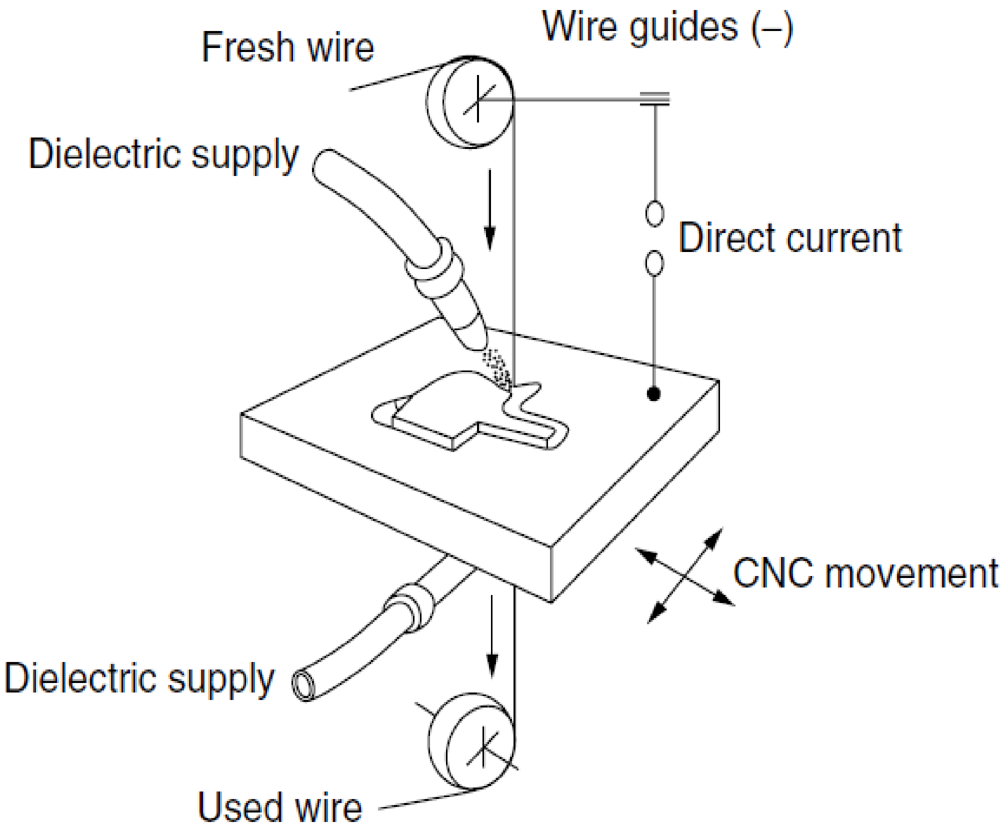
5. Electric Discharge Grinding



- Electric Discharge Grinding (EDG) is one thermal energy based non-traditional machining process that has apparent similarity in construction with the conventional grinding process.
- In EDG, a disc type metallic wheel is rotated about a fixed axis maintaining a small gap with the work piece.
- The conductive wheel is given negative polarity, while the conductive work piece is given positive polarity.
- The gap between wheel and work piece is immersed with a suitable dielectric fluid.
- When sufficient potential difference is applied across two electrodes, the dielectric breaks down leading to the formation of a narrow conductive channel.
- Thus avalanche of electrons pass via this channel in the form of a spark.
- This spark, when strikes the work surface, elevates the localized temperature as high as 10,000°C that ultimately leads to melting and vaporization of a tiny volume of work piece material.
- Repeated formation of spark leads to palpable material removal. The principle of EDG process is similar to the Electric Discharge Machining (EDM) process, except the form of tool electrode.

• Moreover, the rotating EDG wheel inherently sucks fresh dielectric into the inter-electrode gap and thereby eliminates the requirement of additional flushing arrangement as it is needed in EDM.

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 work piece 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 work piece 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 work piece.
- The spark erosion occurs along the entire length of the wire adjacent to the work piece, 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 work piece, resulting in an electrical spark.

6. Flushing Techniques

- One of the important factors in a successful EDM operation is the removal of debris (chips) from the working gap.
- Flushing these particles out of the working gap is very important, to prevent them from forming bridges that cause short circuits.
- EDMs have a built-in power adaptive control system that increases the pulse spacing as soon as this happens and reduces or shuts off the power supply.
- Flushing – process of introducing clean filtered dielectric fluid into spark gap.
- If flushing is applied incorrectly, it can result in erratic cutting and poor machining conditions.
- Flushing of dielectric plays a major role in the maintenance of stable machining and the achievement of close tolerance and high surface quality.
- Inadequate flushing can result in arcing, decreased electrode life, and increased production time.

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.

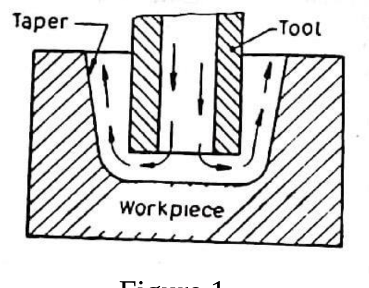


Figure 1

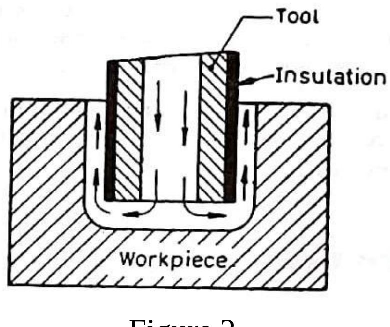


Figure 2

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.

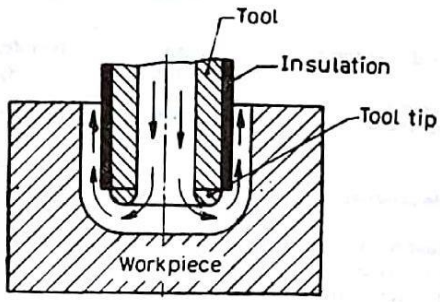


Figure 3

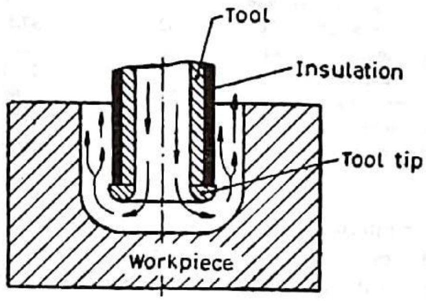


Figure 4

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.

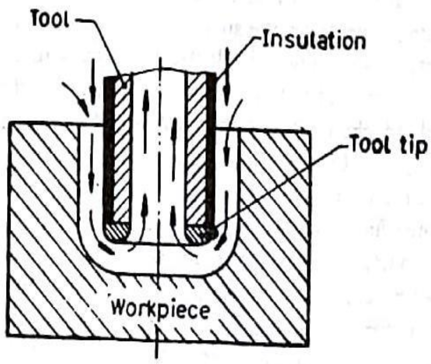


Figure 5

Dielectric Characteristics

- The main requirements of the EDM dielectric fluids are adequate viscosity, high flash point, good oxidation stability, minimum odor, low cost, and good electrical discharge efficiency.
- For most EDM operations kerosene is used with certain additives that prevent gas bubbles and de-odoring.
- Silicon fluids and a mixture of these fluids with petroleum oils have given excellent results.
- Other dielectric fluids with a varying degree of success include aqueous solutions of ethylene glycol, water in emulsions, and distilled water.