

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-II

ELECTRICAL ENERGY BASED PROCESSES

2.1 Electric Discharge Machining (EDM)

Definition

EDM is the controlled erosion of electrically conductive materials by the initiation of rapid and repetitive spark discharge between the electrode tool (Cathode) and workpiece (Anode) separated by a small gap of 0.01 to 0.05 mm, kept in a bath of dielectric medium.

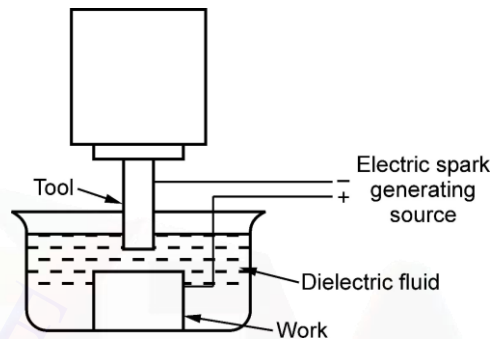


Fig. 2.1 EDM Process

2.1.1 Equipment

The important elements of the EDM process equipment are,

1. **Work-piece** - All the conductive material can be worked by EDM.
2. **Tool electrode** - The EDM electrode is the tool that determines the shape of the cavity to be produced.
3. **Dielectric fluid** - The EDM setup consists of a tank in which the dielectric fluid is filled. The electrode and workpiece are submerged into the dielectric fluid.
4. **Servo system** - The servo system is commanded by signals from a gap voltage sensor system in the power supply and controls the feed of the electrode and workpiece to precisely match the rate of material removal.
5. **Power supply** - The power supply is an important part of any EDM system. It transforms the alternating current from the main utility supply into the pulse direct current (DC) required to produce the spark discharge at the machining gap.
6. **The DC pulse generator** is responsible for supplying pulses at a certain voltage and current for a specific amount of time.

2.1.2 Dielectric Fluid

Functions of Dielectric Fluid

1. It acts as a spark conductor concentrating the energy to a very narrow region
2. It acts as a coolant for the workpiece and the tool
3. It acts as an insulating medium during the charging time of the sparking circuit in order to discharge an effective spark for machining.
4. It acts as a coolant in quenching the spark and helps arching to be prevented.
5. It acts as a flushing medium for the disposal of the product of machining.

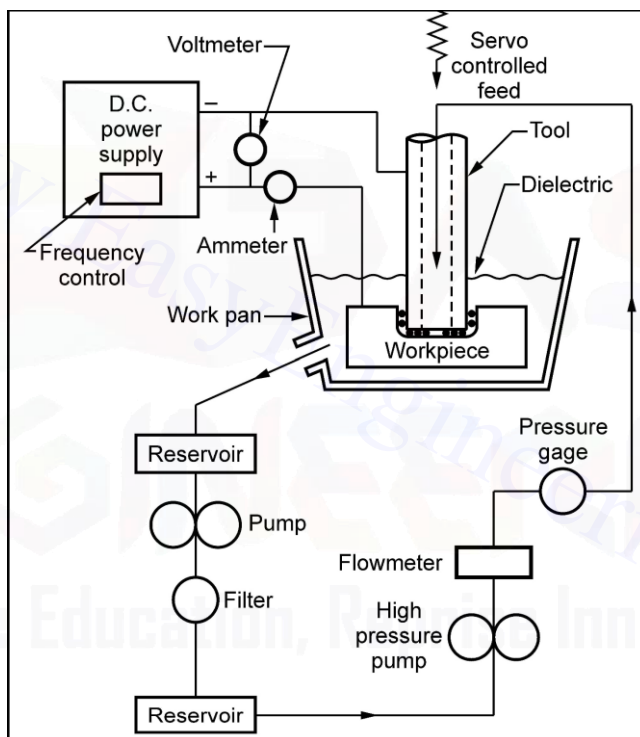


Fig. 2.2

Basic requirement of an ideal dielectric fluid

1. Should have a stable dielectric strength to be electrically nonconductive till the required discharge voltage is built up and should thereafter break down in a very short span of time.
2. It should have an optimum velocity, because a high viscosity of the dielectric results in a poor flow of dielectric in the gap between the tool and workpiece. A low viscosity dielectric is not able to carry the products of machining.

3. It should have high flash point to avoid any fire hazard.
4. It should be chemically stable at high temperatures and neutral, not to attack the electrode, workpiece, the table or the container.
5. It should not emit any toxic vapors or unpleasant odour.
6. It should be cheap and easily available.

Notes : The various dielectric fluids used are hydrocarbon oils such as kerosene, silicon oils, de-ionized water, transformer oil, white spirit, paraffin oil and polar liquids such as aqueous solution of ethylene glycol.

- De-ionized water rarely used because it results in high electrode wear. But it enhances high MRR and better cooling capacity.
- White spirit is used for machining small part with intricate details. Also it is used to machine tungsten carbide.
- Choice of dielectric depends on
 - Size of the workpiece
 - Shape complexity
 - Tolerance surface finish
 - Material removal rate
- The dielectric is pumped and kept in circulation during the machining, so as to avoid non-uniform machining and ensure surface quality which is intended.

2.1.3 Tool

- The purpose of the tool in EDM process is to convert the electrical discharge pulse to the workpiece to allow erosion of the workpiece at the required rate.

Desirable characteristics of the tool material

- High thermal conductivity
- High electrical conductivity
- High melting temperature
- Cheap and easily machinable
- The selection of tool material depends on

1. The wear ratio of the tool

It is the ratio of the loss of tool material in given time to the volume of metal removed from the workpiece in the same time. The less the wear ratio, the better is the tool material.

2. The hardness of the tool

Though material of any hardness may be used as an electrode the softer the tool material the more will be the tool wear.

3. Tolerance of the workpiece

The required tolerance on the workpiece can only be obtained, when the tool wear ratio is low.

4. Ease of shaping the tool electrode.

For precision manufacturing harder materials are selected which imposes difficulties in shaping the tool.

5. The surface finish of the machined workpiece.

6. Total volume of the material to be removed.

7. Nature of the dielectric fluid.

2.1.4 Tool Materials

1. Metallic Materials

Electrolytic copper, Tellurium or Chromium Copper, Copper Tungsten, Brass, tungsten, Steel, Zinc, Zinc Alloys, Tungsten Carbide and Aluminium.

2. Non-Metallic Materials – Graphite

3. Combination of metallic and non-metallic- Copper Graphite.

Copper and brass are the two commonly used tool materials since it satisfies all the requirements but exhibits high wear rate.

Copper tungsten	Less wear ratio, able to produce good surface finish. Difficulty in machining intricate shapes.
Tungsten carbide	Difficult to machine to the required shape or profile.
Graphite and copper graphite	Easily machined and available in various grades. Drawback – its brittleness.

- The advantages of graphite electrode.
 1. It is not affected by thermal shocks.
 2. It has relatively high melting point and also chemically stable.
 3. Easily machinable by simple conventional methods.
 4. Offers low cost of operation.
- Aluminium is used as an electrode because of its high thermal and electrical conductivity. It also has high machinability which enables it to be shaped to any profile.

2.1.5 Work Materials

- Work materials of any hardness value, which is electrically conductive can be processed by EDM.
- On the reasons of economy, normally hard materials are machined by employing EDM process. Refractory materials, hard carbides and hardenable steels also can be machined.

2.1.6 Servo Mechanism

- EDM machines are equipped with a servo control mechanism that automatically maintains a constant gap of about the thickness of a human hair between the electrode and the workpiece.
- It is important because, that there is no physical contact between the electrode and the workpiece, otherwise arcing could damage the workpiece and break the wire in case of wire EDM.
- The servomechanism advances the electrode into the workpiece as the operation progresses and senses the work-wire spacing and controls it to maintain the proper arc gap which is essential to a successful machining operation.

2.1.7 Electrode Feed Control

- Since, during operation both workpiece and electrode are eroded, the feed control must maintain a movement of the electrode towards the workpiece at such a speed that the working gap, and hence, the sparking voltage remains unaltered.

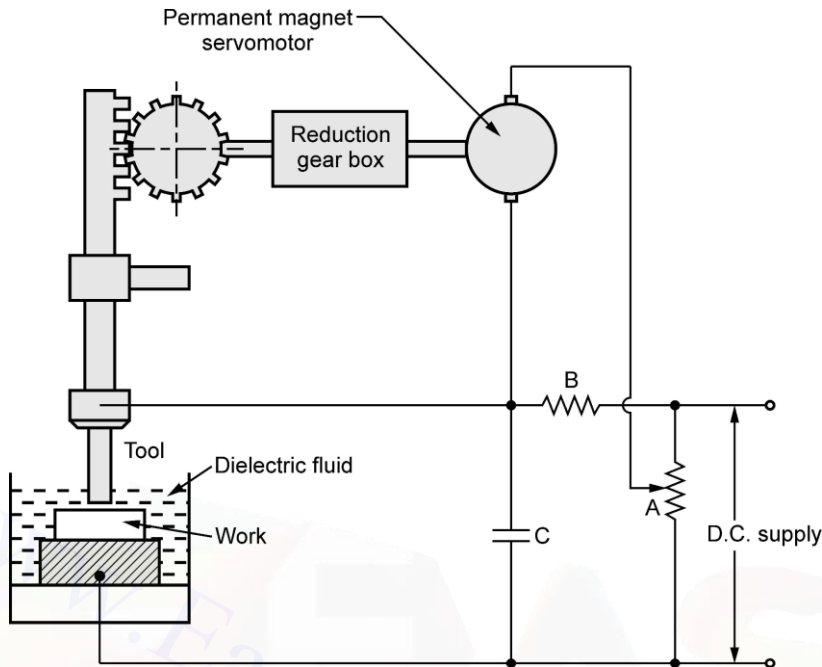
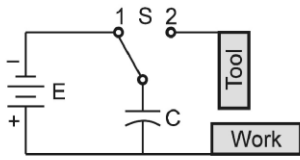


Fig. 2.3

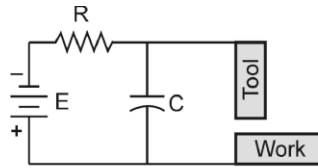
2.1.8 Spark Generator and Electrical Circuitry

- The power supply is an important part of EDM system. It transforms the AC into a pulsed DC which is required to initiate and maintain the unidirectional spark discharges at the machine gap.
- **The functions of a spark generator** in an EDM circuit are,
 1. To supply the required voltage , for the machining discharge
 2. To control the discharge duration
 3. To have a control over the discharge current density
 4. To control the discharge cycle
- Most EDM power supply circuits convert the input AC into DC power by employing conventional solid state rectifier. In all EDM circuits, a capacitor is used for storing the electric charge before the discharge takes place across the gap.
- To achieve the different functions, different power supply circuits are used. They are
 1. Relaxation Circuit (RC) or Resistance Capacitance Circuit or RC circuit.
 2. Rotary impulse generators
 3. Controlled pulse circuit.

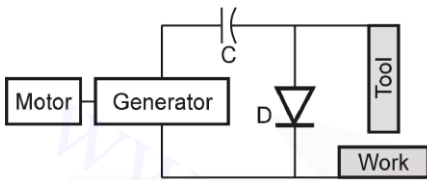
2.1.8.1 Relaxation Circuit or Resistance - Capacitance Circuit



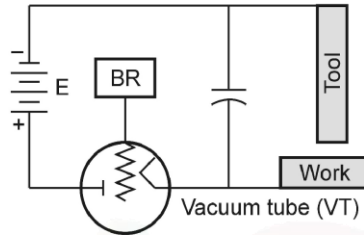
(a) Basic circuit



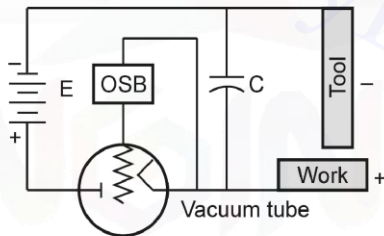
(b) Basic circuit



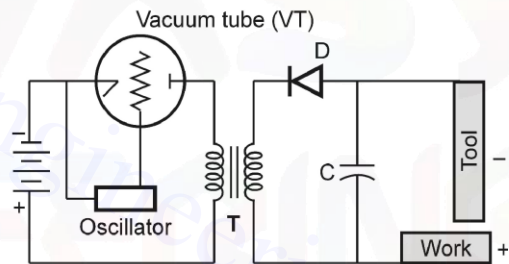
(c) Rotary impulse generator



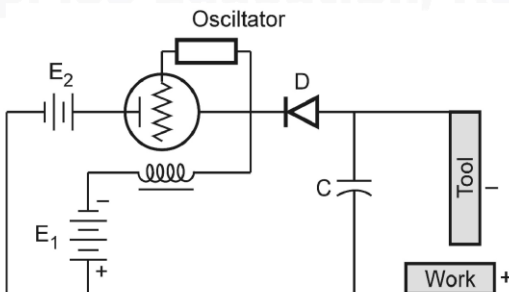
(d) Controlled pulse vacuum tube



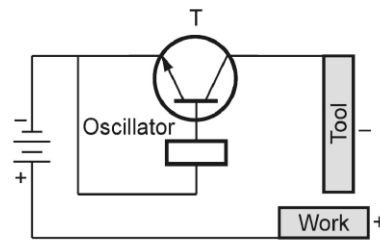
(e) Oscillator controlled pulse vacuum tube



(f) Vacuum tube and transformer circuit



(g) Vacuum tube (two power source)



(h) Transisted pulsed circuit

Fig. 2.4 Types of power supply

- It is one of the oldest and simplest generator to initiate the spark. This generator supplies current to a condenser, the discharge from which produces the spark. The R-C circuit operates on the principle of self-oscillation.
- When the power supply is switched on, the condenser charges through the resistance R. The voltage across the gap V varies with time according to the relation

$$V = V_s (1 - e^{-t/RC})$$

Where,

V_s = The source voltage or supply voltage

T = The time starting at the instant V_s is applied

- First the value of V keeps on rising till it approaches the voltage which is sufficient to breakdown the dielectric medium. The voltage at this point is termed as discharge voltage.
- The discharge time is much smaller than the charging time.
- The spark frequency (γ) is approximately given by the following equation.

$$\gamma = \frac{1}{tC} = \frac{1}{RC \text{ Log } \frac{V_s}{V_s - V_d}}$$

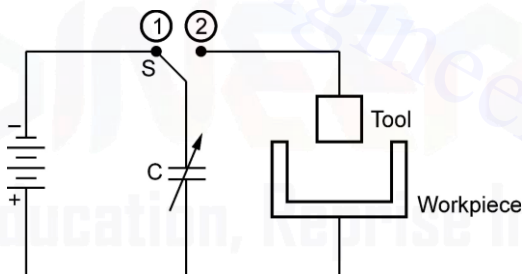


Fig. 2.5 Basic circuit of spark generator

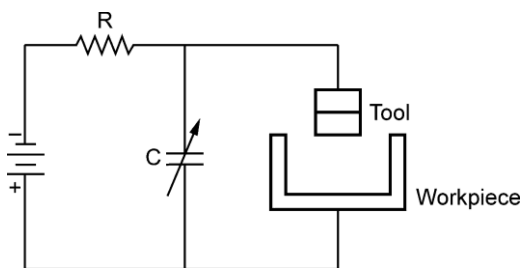


Fig. 2.6 RC circuit

- Where, t_c is the charging time which is the time required for the gap voltage to reach a value V_d .

- The pulse generator circuit can produce high energy sparks whose frequency ranges from 3000 to 10000 per second.
- In this circuit metal removal rate largely depends on high amperage and capacitance.
- An increase in supply voltage means increase in energy liberated per pulse. But this also results in longer charging cycle and lowering of process efficiency.
- The rate of charging of the condenser is influenced by the capacitance (C) and resistance(R).
- This type of circuit is simple, rugged, cheap and reliable in construction. It is best suited for large amount of metal removal rate where critical surface finish is not desired.

2.1.8.2 Rotary Impulse Generator

- It supplies the voltage wave form based on the principles as in the case of DC generators. The rotary impulse generator eliminates the disadvantages of the relaxation circuit. This generator is used for increasing MRR.
- This circuit consists of a rectifier to convert the AC into DC and a pulsar to initiate DC pulses or unipolar pulses.
- The capacitor in this rotary impulse generator is charged through a diode during the first half cycle of the AC input. In the next half cycle, the sum of the voltages generated by the generator and the charged capacitor is applied to the work-tool gap.
- The operating frequency of the generator depends on the motor speed. This generator circuit produces high MRR but poor surface finish.

2.1.8.3 Controlled Pulse Generator

- These generators consists of electronic switching units which allow the current to pass periodically and to effectively control the parameters of the machining.
- This generator circuit also prevents current flow when a short circuit is developed. To achieve this a transistor is used as a switching device.
- A high frequency and a maximum amperage at that frequency results in optimum metal removal rate, with better surface finish. But a high frequency and low amperage setting results in excellent surface finish. Roughing application can employ low frequency discharges.

Notes : High frequency and maximum amperage gives better surface finish, whereas high frequency and low amperage gives poor surface finish.

- In the controlled pulse generator circuit, current flows through the gap from the capacitor during sparking.

- The transistor attached in the circuit behaves as an infinite resistance, by getting biased. When the current in the gap ceases, the conductivity of the tube increases, allowing the flow of current to charge the capacitor for the next cycle.
- An oscillator if employed in the circuit will help to control the biasing and allow the current to flow cyclically with an imposed frequency and increased stability.

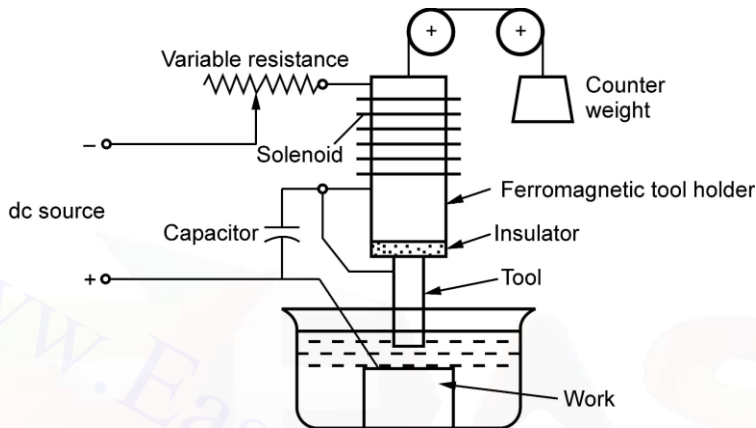


Fig. 2.7 Solenoid controlled EDM

- Advantages of pulse controlled generators.
 1. Tool wear is greatly reduced.
 2. Better surface finish
 3. No. of spark per second produced is high which reduces the machining time.

2.1.9 Working Principle of EDM

- The EDM process involves the removal of work material by finite discrete periodic sparks between tool and the conductive work material separated by a thin film of dielectric medium.
- When two electrodes connected to a DC power source are separated by a very small gap, spark occurs between the two electrodes at the point of closest contact.
- Workpiece is connected to a positive terminal of the DC power supply and negative is connected to a tool.
- In EDM tool shaped to the mirror image of the cavity to be produced.
- The tool and the work are kept immersed in a dielectric medium to promote the effectiveness of the process.

- When the voltage across the gap becomes sufficiently larger (more than 250 V) the high power spark is produced. So, the dielectric breaks down and electrons are emitted from the cathode (Tool) and the gap is ionized.
- This spark occurs in an interval of 10 to 30 micro seconds and with a current density of 15 - 500 A per mm² approximately. So thousands of spark discharge occur per second across the gap between the tool and the work. Which results in increasing temperature of about 10000° C
- At this high temperature, work piece metal is melted, eroded and some of it is vaporized. In this way the metal is removed from the work piece.
- The removed fine material particles are carried away by dielectric fluid circulated around it.
- Particles eroded from the electrodes are known as Debris.
- When the two electrodes are of the same material, the positive terminal is eroded at a faster rate than the negative one.

2.1.10 Mechanism of Metal Removal

- When a suitable voltage is applied between the work and the tool, an electrostatic field of sufficient strength is established and due to this cold emission of electrons starts from the cathode.
- These electrons from the cathode accelerate towards the anode. These electrons while travelling towards the anode collide with the molecules of the dielectric fluid breaking them into electrons and positive ions.
- The electrons so produced also accelerate towards the anode and also dislodge other electrons from the dielectric medium during their travel.
- This process leads to the formation of a narrow column of ionized dielectric molecules between the tool and workpiece.
- This ionized column of ions, have high conductivity, is the spark. This spark occurs at the place of closest contact between the tool and workpiece surface, producing very high temperature on the electrodes.
- This high temperature melts and vaporizes the positive electrode at the spot of spark formation and the compression shock wave generated evacuate the molten metal by mechanical blast, thus removing material.
- When the material is thus removed the spark gap at that particular spot increases and the cycle is repeated at the place of next shortest gap.

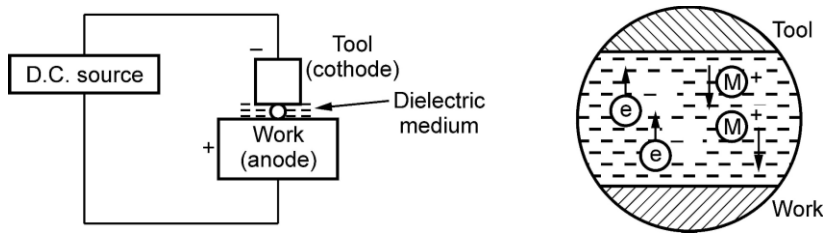


Fig. 2.8

- When the above process is taking place in the equipment, yet another phenomenon occurs in the electrical circuit.
- When the supply voltage is given to the circuit, since the dielectric as it is, is a non-conductor does not allow the current to flow through the gap. So a major part of the applied voltage is stored in the condenser for further recharge.
- A minor portion of the applied voltage causes the cold emission of electrons from the cathode.
- When dielectric medium is fully ionized it becomes a conductor and the entire stored voltage in the capacitor is discharged from the cathode to anode which removes the material.

2.1.11 Material Removal Rate

- The amount of material removed in a single discharge can be determined by considering the diameter of the crater and the depth to which melting temperature is reached.
- Assumptions considered for the theoretical calculation of MRR are
 - The properties of the electrode material do not change with the increase of temperature.
 - The rate of heat input is a constant throughout the discharge period.
 - The vaporization of the electrode material is neglected.
 - The spark is a uniform circular column heat source and the diameter of the column is also a constant.
 - The regions other than the heat source is insulated.
- MRR increases with an increase in discharge duration for different spark energies, but up to a certain limit and then drops to zero. It is also observed that the MRR is maximum when the pressure is below atmospheric.
- The MRR is also strongly influenced by the circulation of dielectric fluid, without a forced circulation, the wear particles melt and reunite with the electrode.

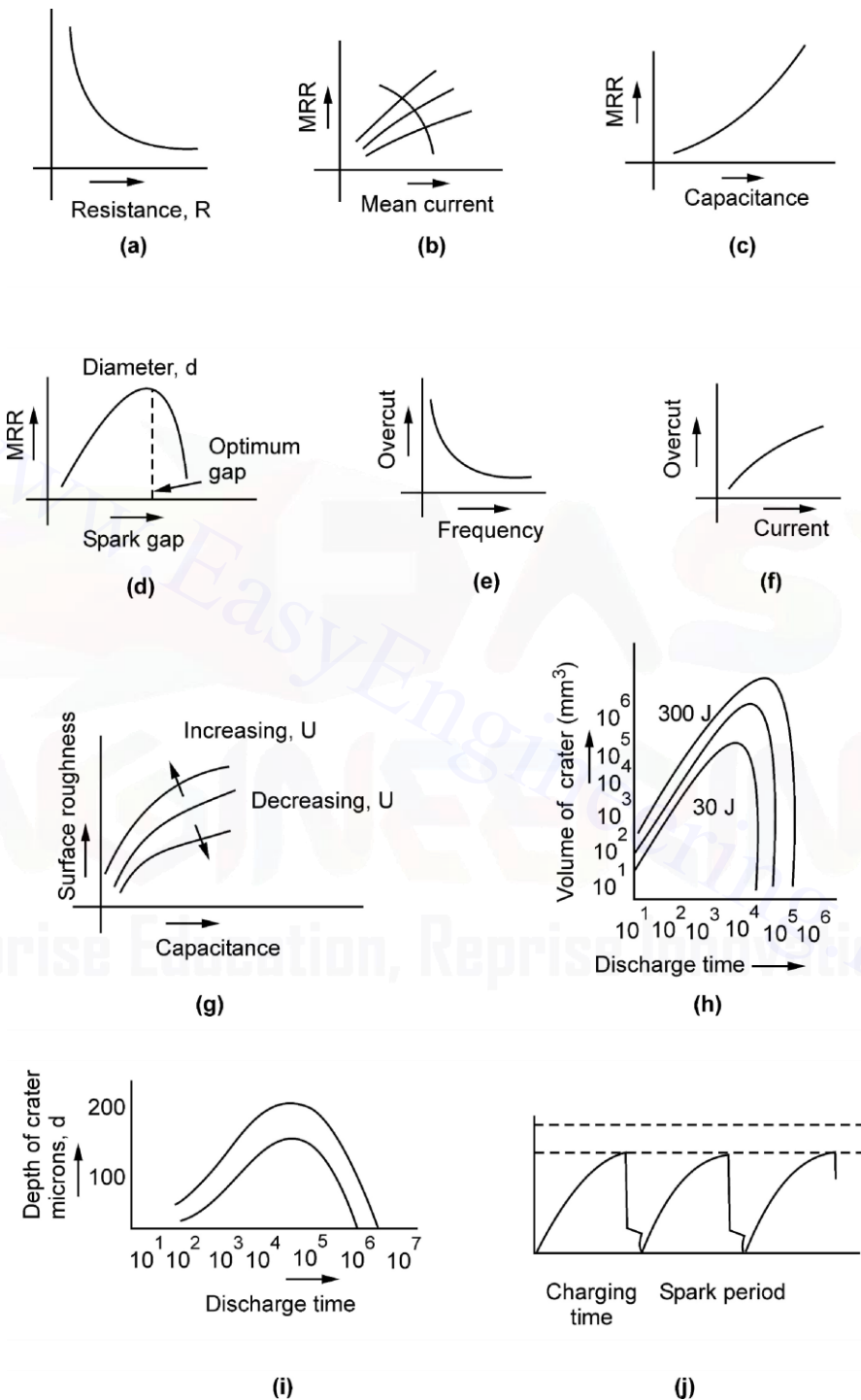


Fig. 2.9 Graphical representation of various process parameters

- The MRR is proportional to the working current. (Working current is the volume of metal removed per unit time per ampere). As the current increases, the energy of spark increases and hence the MRR.
- A higher pulse energy increases MRR but results in a bigger size of broken off or machined particles.
- For a particular electrical parameter, there is an optimum machining at which the MRR is high, lower the electrical conductivity of a work material, lower will be the MRR.
- The viscosity of the dielectric medium also influences the MRR. Lower is the viscosity of the dielectric, lesser will be the amount of eroded particle carried away which would affect the MRR.
- The metal removal rate increases with the decrease in the resistance for a particular value of capacitance. However, the resistance is decreased below a particular value would in arching and damage the work.

2.1.12 Expression for Material Removal Rate (MRR)

- The MRR in EDM is basically a function of the current and the melting point of the workpiece material, although other process variables also have an effect. The following approximate empirical relationship can be used as a guide to estimate the MRR in EDM.

$$\text{MRR} = 4 \times 10^{-1.23} I T_w^3 \text{ mm}$$

I = Current in ampere

T_w = Melting point of the workpiece in °C

2.1.13 Tool Electrode Wear

- During the EDM operation not only the work material (Anode) is eroded but also the cathode due to sparking.
- **The wear ratio is the ratio of the materials removed from the work materials to material removed from the tool**

$$\text{Wear ratio} = \frac{\text{Materials removed from the work materials}}{\text{Material removed from the tool}}$$

- Normally electrode wear at the end of corner or at all the sides. The electrode wear is basically function of polarity, thermal conductivity, melting point of electrode, duration and intensity of spark discharges and the type of work material used in connection with the tool material.
- The knowledge of the tool wear is important while designing the tool electrode and the selection of tool for a particular application.

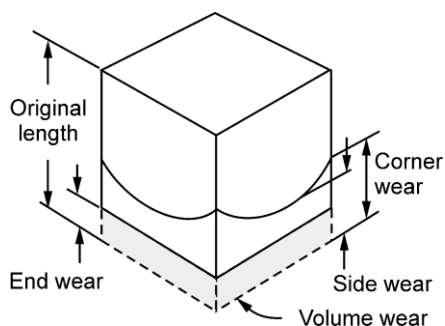


Fig. 2.10

- The wear rate of the electrode w_t can be estimated from the empirical equation:

$$w_t = 1.1 \times 10^{11} I.Tt^{-2.38} \text{ mm}^3 / \text{min.}$$

where, T_t is the melting point of electrode material

The wear ratio of the workpiece to electrode, R can be estimated from the expression

$$R = 2.25 T_r^{-2.38}$$

where, T_r is the ratio of workpiece to electrode melting point.

2.1.14 Accuracy and Surface Finish

- The accuracy and the surface finish in EDM is depends on the diameter and depth of the crater formed due to the spark. If the size of the crater is large, then the surface finish obtained is rough.
- The greatest factor responsible for inaccuracy in the EDM process is the formation of side sparks between the tool surface and the machined work piece. The side sparks remove extra material from the machined surface and enlarges the cavity or hole.
- Higher value of capacitance leads to greater pulse energy and hence bigger particles of material removal.
- If the machining area is more, larger is the inaccuracy.
- Lesser the tool wear ratio greater will be the inaccuracy.
- Increase of pulse energy increase in the working voltage and leads to poor or rough surface finish.
- Forced circulation of the dielectric fluid results in improved surface finish than without forced circulation.

2.1.15 Flushing

- The circulation of dielectric fluid between the electrode and the workpiece is called flushing. Flushing is a vital for process efficiency and product quality.

- The effective flushing removes wastes products from the gap and increases MRR whereas the bad flushing results in low MRR and poor surface finish.
- The good flushing system is one that shoots the dielectric to the place where the sparking occurs. It is observed that flushing in blind cavities is difficult.
- So, flushing does not perform well in blind cavities.
- Various methods of flushing are,
 - Suction through electrode
 - Suction through workpiece
 - Pressure through electrode
 - Pressure through workpiece
 - Jet flushing
 - Periodic cycling of electrode

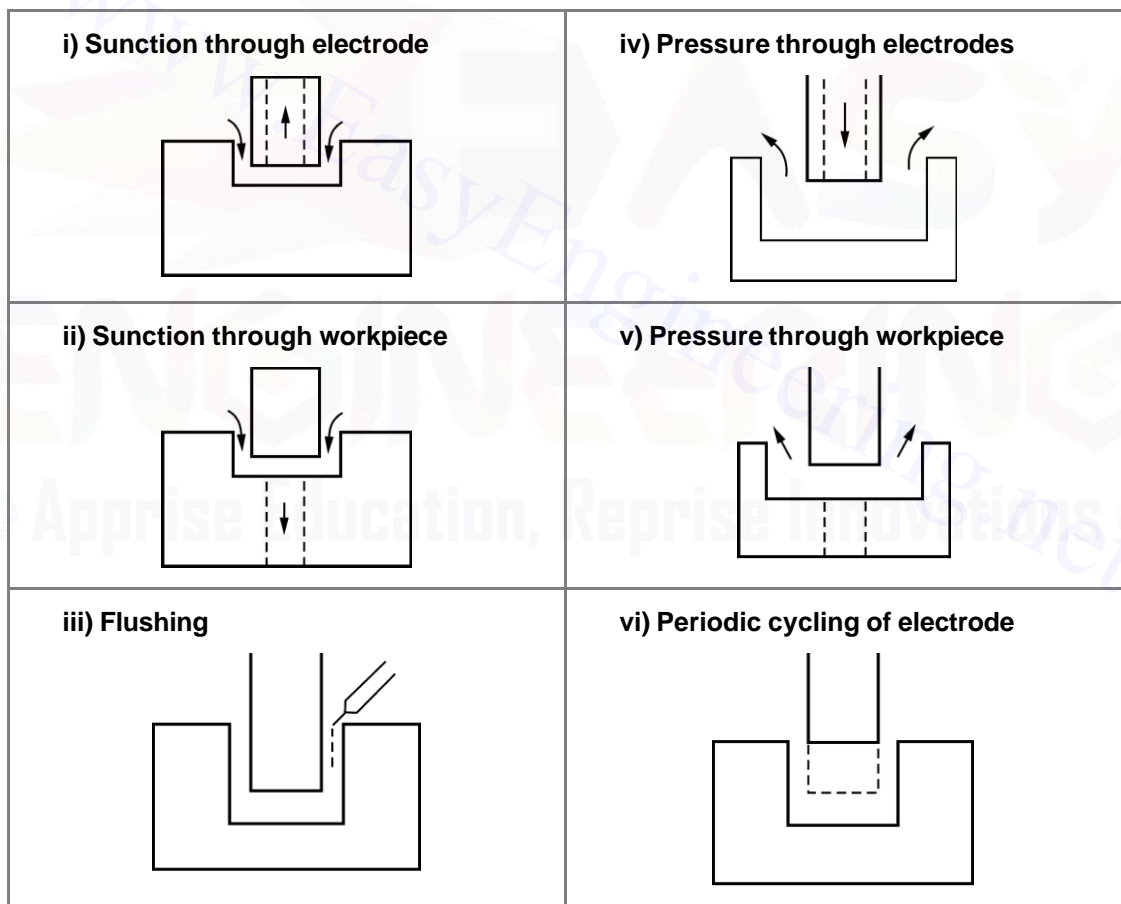


Fig. 2.11

2.1.16 Advantages

1. Any conductive materials of any hardness, toughness or brittleness can be machined.
2. Tool material property is not a constraint to restrict the machining.
3. No cutting forces is encountered since there is no contact between tool and workpiece.
4. Thin sections also can be machined.
5. Complicated geometrical forms can be easily reproduced.
6. High accuracy is possible.
7. It is a burrless process.
8. Materials can be machined even in the heat treated condition.
9. Surface finish obtained is good.
10. More suitable for producing surfaces that are to be used for wear resistance which can contain lubricant.

2.1.17 Disadvantages

1. Low material removal rate (MRR)
2. Thermal stress may develop due to intense heat.
3. Power required is very high.
4. Possibility of surface cracking is encountered in some materials
5. Difficult to produce soft corners.

2.1.18 Limitations

1. Only electrically conductive material can be machined.
2. Tool wear affect the accuracy and surface finish.
3. Produces heat affected zone(HAZ) in the work material.
4. High specific energy consumption.

2.1.19 Applications

1. Chiefly employed for the manufacture and reconditioning of press tools, forging dies, extrusion dies and moulds for the injection moulding.
2. Any intricate shapes or profiles on alloy steel, tungsten carbide dies can be produced with fine details.
3. Blind complex cavities micro holes for nozzles and fuel injectors through cutting of non-circular holes and narrow slots can be produced.
4. Used for machining fragile work pieces.

5. Fine slits can be made by using a wire electrode.
6. Fine cutting can be obtained using thread shaped electrode.
7. Hole as small as 0.1 mm in diameter can be drilled.
8. Embossing and engraving operations is also possible using this process.
9. Stamping and wire drawing dies can be produced by this process.
10. Punches and forming dies are manufactured by this process.
11. Internal threads and internal helical gears can be cut in hardened materials by employing rotary spindle and suitable attachments.
12. Curved hole drilling and deep trepan drilling can also be done by this EDM process.
13. Die-sinking, cutting, slicing using a rotary disc or ribbon, external and internal form grinding are some more operations that can be performed using EDM process.

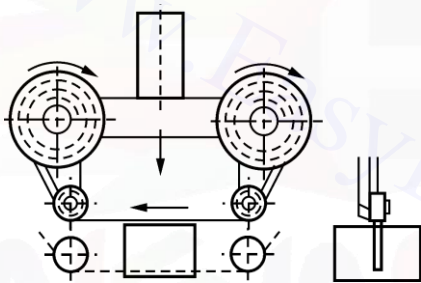


Fig. 2.12 Fine cutting with thread shaped electrode

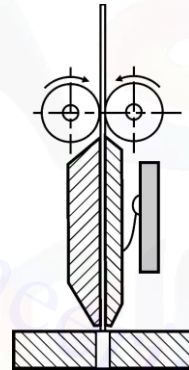


Fig. 2.13 Drilling of micro holes

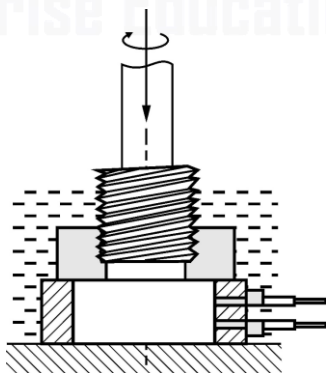


Fig. 2.14 Thread cutting

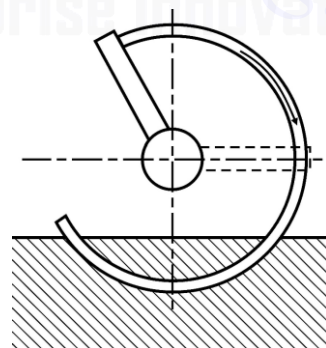


Fig. 2.15 Curved hole drilling

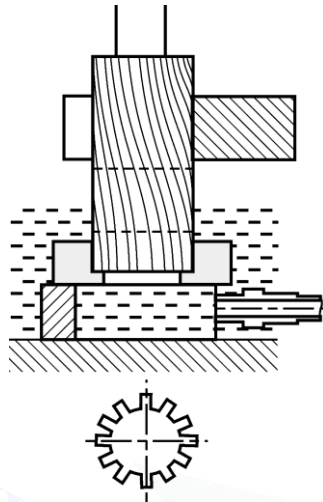


Fig. 2.16 Helical profile drilling

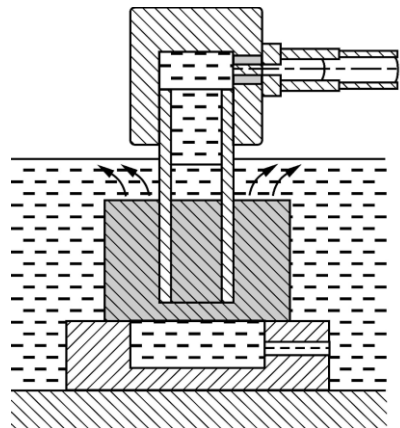


Fig. 2.17 Deep trepan drilling with injection of dielectric but without electrode rotation

- **Factors to be considered while selecting EDM machine tool** are tolerance and surface finish, power requirement, material removal rate, cost, efficiency, tooling and fixtures, tool consumption, safety, work material, and shape feature.

2.2 Electrical Discharge Wire Cutting (EDWC) or Wire EDM

- The EDWC process uses the same principle of EDM process for material removal.
- The EDWC process differs from the EDM process in the sense that it uses a thin wire to spark erode the workpiece in a complex 2D or 3D profile.
- The prominent feature of a moving wire is that, any complicated profile can be easily machined without using a forming electrode.
- This EDWC process can also be called as travelling wire EDM or Wire EDM.

Definition

- The EDWC is a material removing process in which a thin wire is used along with a stream of dielectric fluid for facilitating spark erosion.

2.2.1 Equipment

This process consists of the following elements,

- | | |
|------------------------|-----------------------|
| 1. Wire driving system | 2. Positioning system |
| 3. Power supply system | 4. Dielectric system |

2.2.1.1 Wire Driving System

- The EDWC removes material by using a wire electrode which is moved along the required profile or shape. The function of wire driving system is to continuously feed the wire under constant tension to the work area.
- The tensioning of the wire avoids problems that occur during machining such as taper, machining streaks, wire breaks, vibration markings.
- The wire in this process is fed from a spool, through several stages of preparation system which ensures wire straightness.
- Before the wire is passed through the workpiece, it is guided by set of rollers made of sapphire or diamond. But before being collected by the take up spool, it passes through a series of tensioning rollers.
- Some machine uses devices for wire drawing and annealing to enable direct use of the available commercial grade wires.
- When the wire passes through the workpiece, a major portion of the spark discharges occur at the leading surface of the wire, which results in the deformation of the wire cross section and so the wires is discarded after single use.

Notes : Copper, brass, tungsten and molybdenum are the materials used as wire electrode.

- The diameter of the wire electrode ranges from 0.076 mm to 0.3 mm. The normally used size of the electrode wire is 0.2 mm. The size is decided on the basis of the desired kerf width.
- **Kerf width** is one of the important performance measures in WEDM. Kerf width is the measure of the amount of the material that is wasted during machining. It determines the dimensional accuracy of the finishing part.

2.2.1.2 Positioning System

- The EDWC positioning system consists of a CNC table which may be two axis or multi axis, depending on the shape of the profile.
- **The spark gap is maintained at the required value between the workpiece and the wire electrode by connecting the positioning system to adaptive control mode.**
- This mode enables the positioning system to avoid short circuiting, if in case any machined material comes between wire electrode and the workpiece.

2.2.1.3 Power Supply System

- There are differences between the conventional EDM and the EDWC power supply system. The most differences are the frequency of the pulse and the current.
- To obtain a smooth surface finish, high frequency pulses are used in EDWC.
- Since the diameter of the wire used is small, current rating less than 20 Amps is only supplied.

2.2.1.4 Dielectric System

- Deionized water is normally used as the dielectric fluid because of its low viscosity to enter into the smaller gap, high cooling rate, high MRR and no fire hazard.
- The dielectric fluid is delivered through a nozzle to the machining area coaxial with the wire. The de-ionized water is used once is filtered with filter paper and reused again.

2.2.2 Working Principle of EWDC

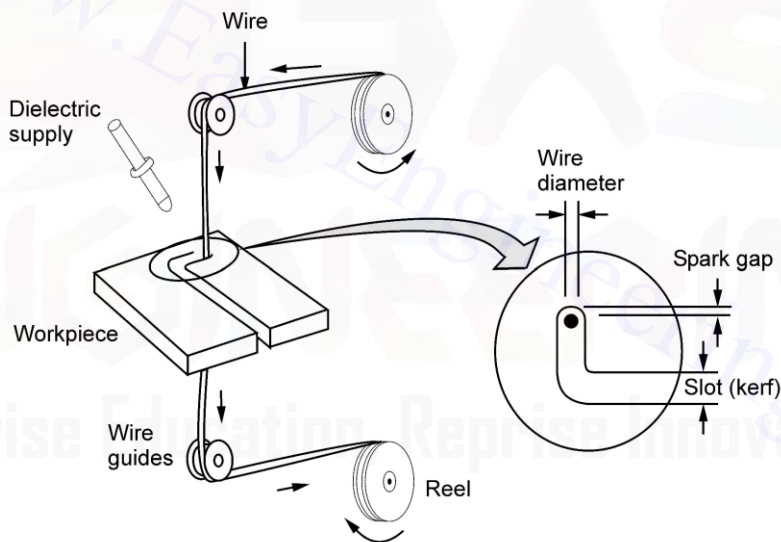


Fig. 2.18

- **EDWC** uses the thermal energy produced by the spark for removing the material. The work material is connected to the positive terminal and the wire electrode to the negative terminal of the high frequency pulses of DC power supply, which are separated by the spark gap.
- The spark gap is fed with the supply of dielectric fluid.
- When the power supply is switched on spark appears in the gap and the work material is machined by the intense heat which melts and vaporizes it.

- The wire is continuously fed from spool through the guiding rolls and taken up by the take up rolls.
- The machine table is moved along with the workpiece along the profile in which it need to be machined.

2.2.3 Material Removal Rate

- The MRR for wire EDM can be obtained from the following expression,

$$\text{MRR} = V_f h b$$

V_f = Feed rate of the wire into workpiece in mm/min.

h = Workpiece thickness or height in mm. and, the kerf is denoted as $d_w + 2s$

d_w = Wire diameter in mm.

s = Gap between wire and workpiece during machining in mm.

2.2.4 Advantages

1. No fabrication of electrode is required.
2. No cutting force are encountered.
3. Can machine any hard material.
4. Automation is possible.
5. Electrode wear is negligible.
6. Machined surfaces are smooth.
7. Extremely high tolerances can be achieved.
8. Any profile or shape can be obtained through this process.

2.2.5 Disadvantages

1. High capital cost.
2. Formation of thin recast layer
3. Slow cutting rate
4. Applicable only in small parts.
5. Wire electrode cannot be reused which calls for high cost of electrode.

2.2.6 Applications

1. Best suited for the production of extrusion dies, Blanking dies and punches. Press tools and sintered compacting dies.

2. Can be used for shallow cutting, finishing operations and micro-drilling of non-conducting materials.
3. Thick sections of 200mm can be used machined.
4. The machining of hard press-stamping dies can be easily done.
5. Even heat treated materials can also be processed by this process.
6. Stator, core-stamping dies are machined by wire-EDM.
7. The powder compaction dies which are more thicker than normal dies, with high aspect ratios can be machined easily.
8. Even EDM electrodes can be made by this EDWC process.
9. Fabrication of grinding wheel form tools, profile gauges and templates are possible.
10. Large quantities of parts can be cut simultaneously by arranging them into a stack.

2.2.7 Difference between EDM and Wire Cut EDM

S. No	Wire cut EDM	EDM (Die sinking)
1.	Thin wire is used as a tool	Shaped tool is used. (Mirror image of the workpiece)
2.	Very thin wire made of brass or molybdenum is used as the electrode (tool).	Expensive alloy of silver and tungsten are used as the electrode (tool) which are traditionally made by cutting and grinding.
3.	The whole workpiece is not submerged in dielectric medium. Instead, the working zone alone is supplied with a co-axial jet of dielectric medium	The whole workpiece is submerged in dielectric medium
4.	It is easy to machine complex two dimensional profiles.	It is difficult to cut complex two dimensional profiles.

2.3 Laser Beam Machining (LBM)

Laser is the term applied for phenomenon of amplification of light by stimulated radiation emission.

2.3.1 Construction

- Fig. 2.19 shows the setup of laser beam machining, which consists of a stimulating light source (Xenon flash lamp) and a laser rod.