USN | | | | | | | | | |

CMR INSTITUTE OF TECHNOLOGY, BENGALURU.

Internal Assessment Test 3 – NOV. 2019

Sub:	Nontraditional machining					Sub Code:	17ME554	Branch:	ME	
Date:	18.11.19	Duration:	90 min’s	Max Marks:	50	Sem / Sec:	V/A&B		OBE	

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Explain with neat sketch the principle and working of Electric discharge machining process and also mention its advantages and disadvantages.	[10]	CO4	L2
2	Explain with neat sketch the working of travelling wire EDM and Electric discharge grinding process.	[10]	CO4	L2
3	Explain with neat sketch the working of Plasma arc machining and also mention its advantages and disadvantages	[10]	CO4	L2
4	Explain briefly the flushing techniques in electric discharge machining process.	[10]	CO4	L2
5	Explain with neat sketch the working of Laser beam machining and also mention its advantages and disadvantages.	[10]	CO5	L2
6.	Explain with neat sketch the working of Electron beam machining process and also mention its advantages and disadvantages.	[10]	CO5	L2

CI CCI HOD

USN | | | | | | | | | |

CMR INSTITUTE OF TECHNOLOGY, BENGALURU.

Internal Assessment Test 3 – NOV. 2019

Sub:	Nontraditional machining					Sub Code:	17ME554	Branch:	ME	
Date:	18.11.19	Duration:	90 min’s	Max Marks:	50	Sem / Sec:	V/A&B		OBE	

Answer any FIVE FULL Questions

		MARKS	CO	RBT
1	Explain with neat sketch the principle and working of Electric discharge machining process and also mention its advantages and disadvantages.	[10]	CO4	L2
2	Explain with neat sketch the working of travelling wire EDM and Electric discharge grinding process.	[10]	CO4	L2
3	Explain with neat sketch the working of Plasma arc machining and also mention its advantages and disadvantages	[10]	CO4	L2
4	Explain briefly the flushing techniques in Electric discharge machining process.	[10]	CO4	L2
5	Explain with neat sketch the working of Laser beam machining and also mention its advantages and disadvantages.	[10]	CO5	L2
6.	Explain with neat sketch the working of Electron beam machining process and also mention its advantages and disadvantages.	[10]	CO5	L2

CI CCI HOD

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	2 marks each 3 marks each
3.	Sketch Working process Advantages and disadvantages	4 marks 4 marks 2 marks
4	3 flushing techniques Diagram (5) Explanation (5)	10 marks 1 mark each 1 mark each
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

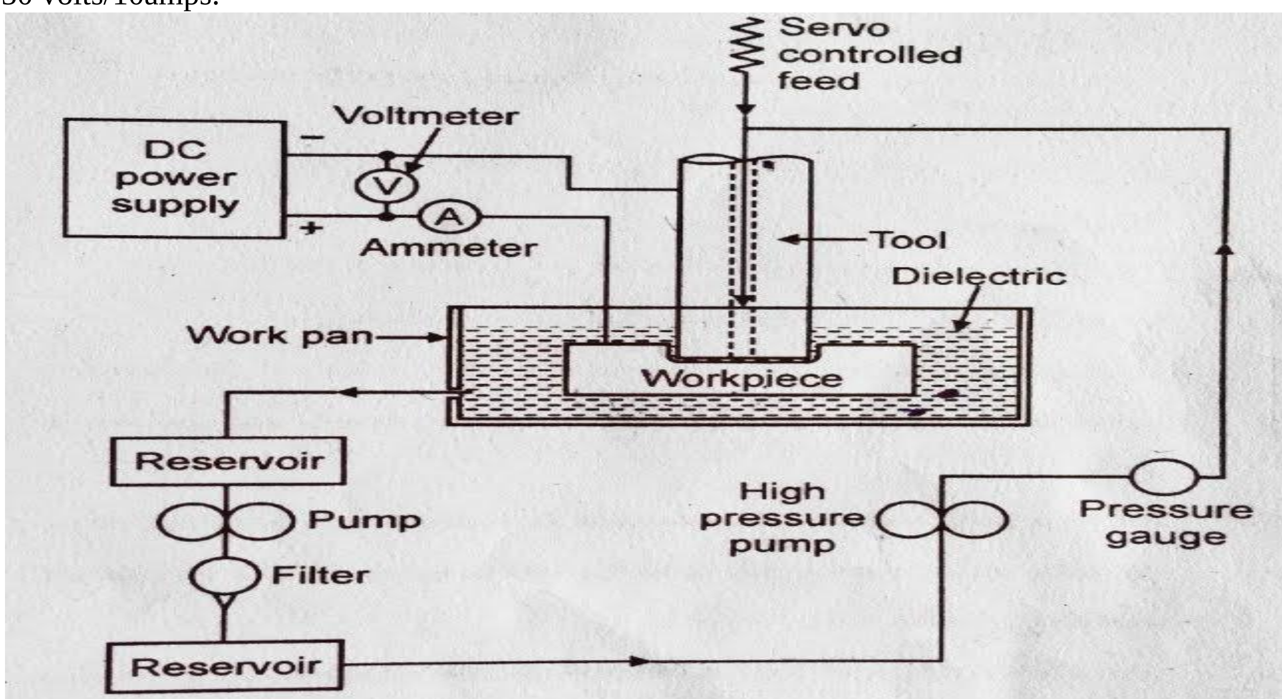
1. Working principle of EDM

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.

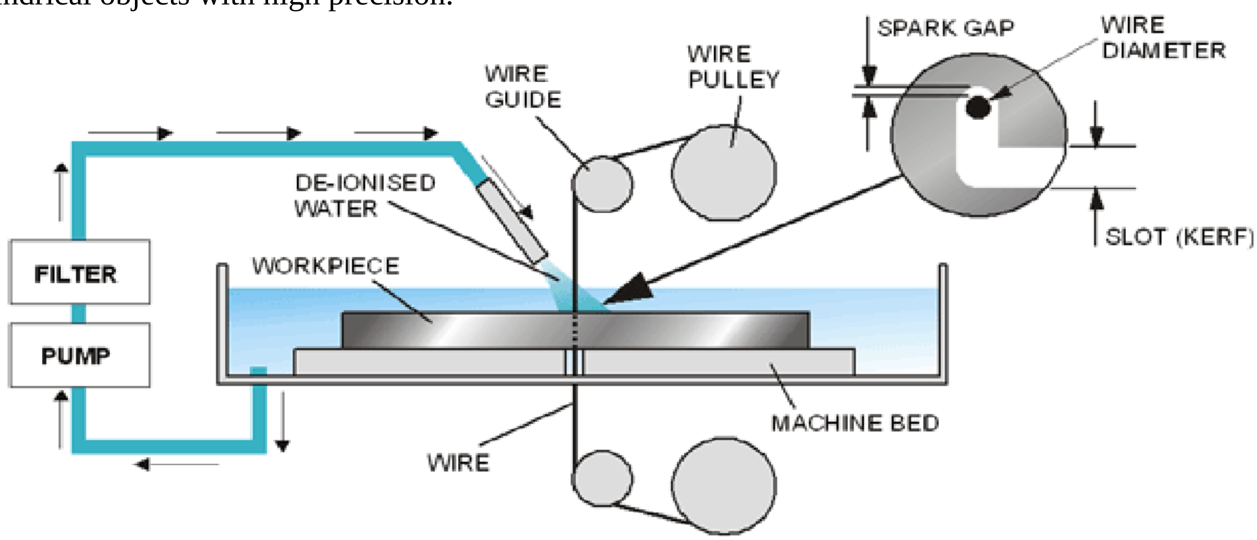
Limitations of EDM

- 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.
- Rough surface finish when at high rates of material removal.

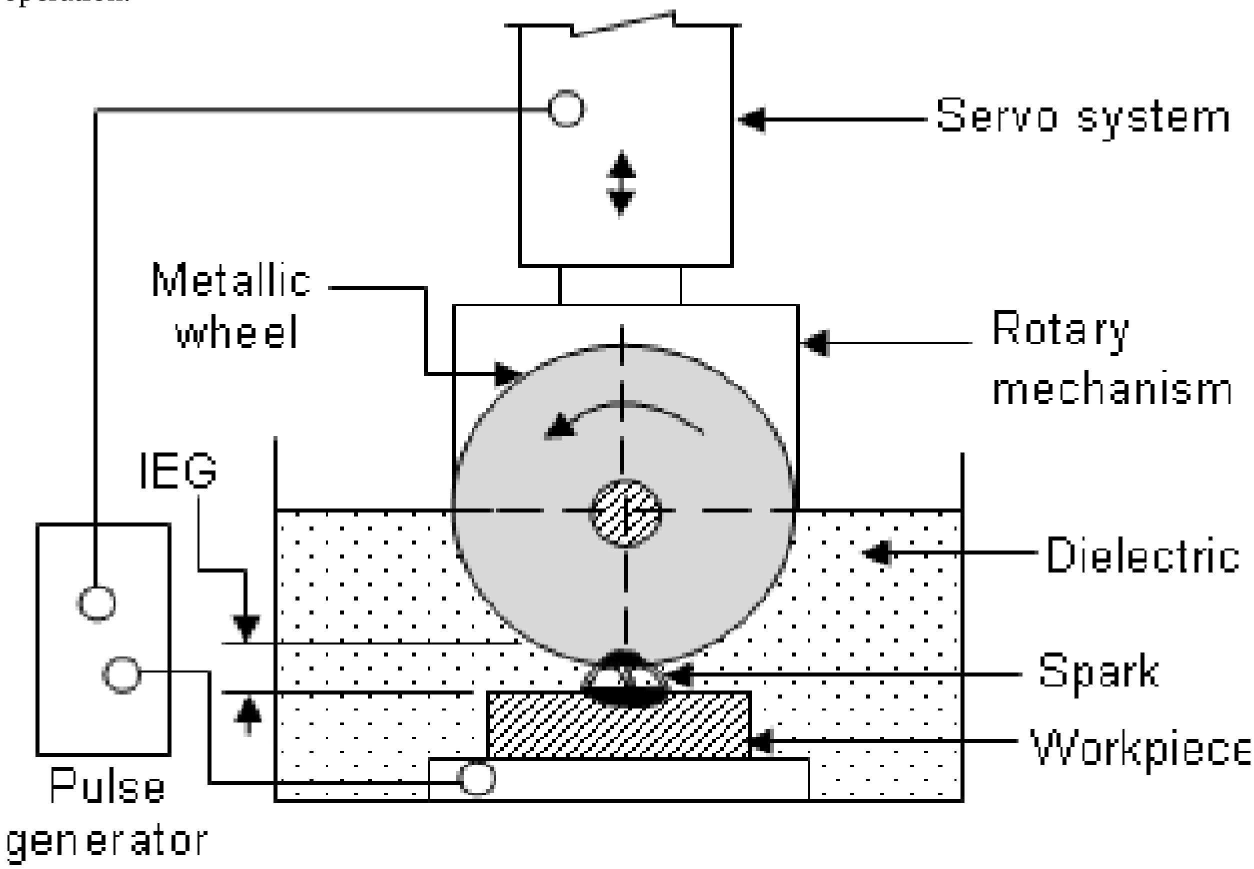
2. **Wire EDM**

EDM, primarily, exists commercially in the form of die-sinking machines and wire cutting machines (Wire EDM). In this process, a slowly moving wire travels along a prescribed path and removes material from the workpiece. Wire EDM uses electro-thermal mechanisms to cut electrically conductive materials. The material is removed by a series of discrete discharges between the wire electrode and the workpiece in the presence of dielectric fluid, which creates a path for each discharge as the fluid becomes ionized in the gap. The area where discharge takes place is heated to extremely high temperature, so that the surface is melted and removed. The removed particles are flushed away by the flowing dielectric fluids. The wire EDM process can cut intricate components for the electric and aerospace industries. This non-traditional machining process is widely used to pattern tool steel for die manufacturing.

The wires for wire EDM is made of brass, copper, tungsten, molybdenum. Zinc or brass coated wires are also used extensively in this process. The wire used in this process should posses' high tensile strength and good electrical conductivity. Wire EDM can also employ to cut cylindrical objects with high precision.



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.

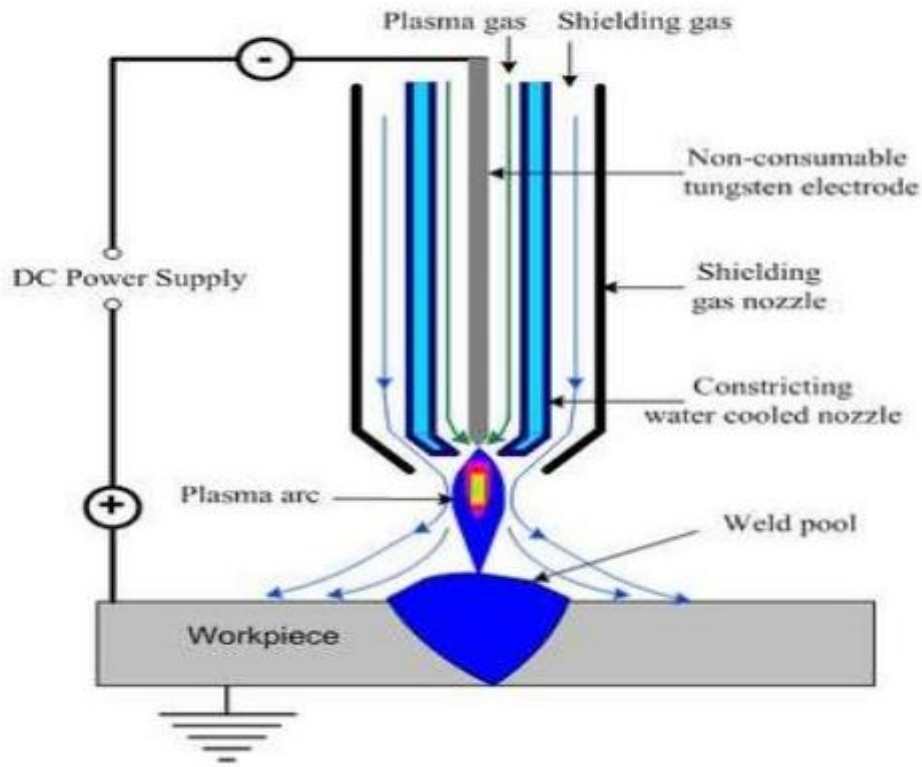


3. Principle of Plasma Arc Machining
   - A high frequency spark is used to initiate a pilot arc between the tungsten electrode (cathode) and the copper nozzle (anode) both of which are water cooled.
   - Pilot arc is then cut off and the external arc generates a plasma jet which exists from the nozzle at high velocity.
   - Plasma jet heats the workpiece by striking with electrons and by transfer of energy from high temperature, high energy gas.
   - The heat is effective in cutting the workpiece upto thickness of 50mm.

   Construction
   - The equipment can be used to machine a wide range of materials and thickness by suitable adjustments of power level, gas tight, gas flow rate, speed.
   - The direct current is supplied to the tungsten electrode (cathode) from the power supply.
   - The tungsten electrode is heated to a very high temperature and generates high frequency spark.
   - A high frequency spark initiates a pilot arc between the tungsten electrode (cathode) and the copper nozzle (anode).
   - Gas is supplied to the ceramic chamber through plasma gas inlet at high velocity. Due to the heat liberated from the tungsten electrode gas is heated to a very high temperature. The collision between atoms increases and results with ionization.

- Increase in collision causes pilot arc to cut off and the external arc generates a plasma jet which exit from the nozzle at high velocity. Plasma jet strikes the work piece and heats the surface. The heat produced melts the workpiece and the velocity gas stream blows the molten metal away.

PLASMA ARC MACHINING



Mechanism of Material removal

- The metal removal in plasma arc machining is basically due to the high temperature produced.
- The heating of workpiece is as a result of anode heating, due to direct electron bombardment plus convection heating from the high temperature plasma that accompanies the arc.
- The heat produced is sufficient to raise the workpiece temperature above its melting point and the high velocity gas stream effectively blows the molten metal away.
- Under optimum conditions, upto approximately 45% of the electrical power delivered to the torch is used to remove metal from the workpiece.
- Plasma arc cutting was primarily employed to cut metals that form a refractory oxide outer skin.
- The arc heat is concentrated on a localized area of the workpiece and it raises it to its melting point.
- The quality of cut is affected by the heat flow distribution; uniform heat supply throughout the thickness of the material produces a cut of excellent quality.

Advantages:

- Any material, regardless of its hardness and refractory nature can be efficiently and economically machined.
- Faster cutting speeds due to high velocity and high temperature of cutting gas.
- Requires minimal operator training.
- Process variables such as type of gas, power, cutting speed, etc, can be adjusted for each metal type.
- As there is no contact between tool and work piece a simply supported workpiece is adequate.

Disadvantages:

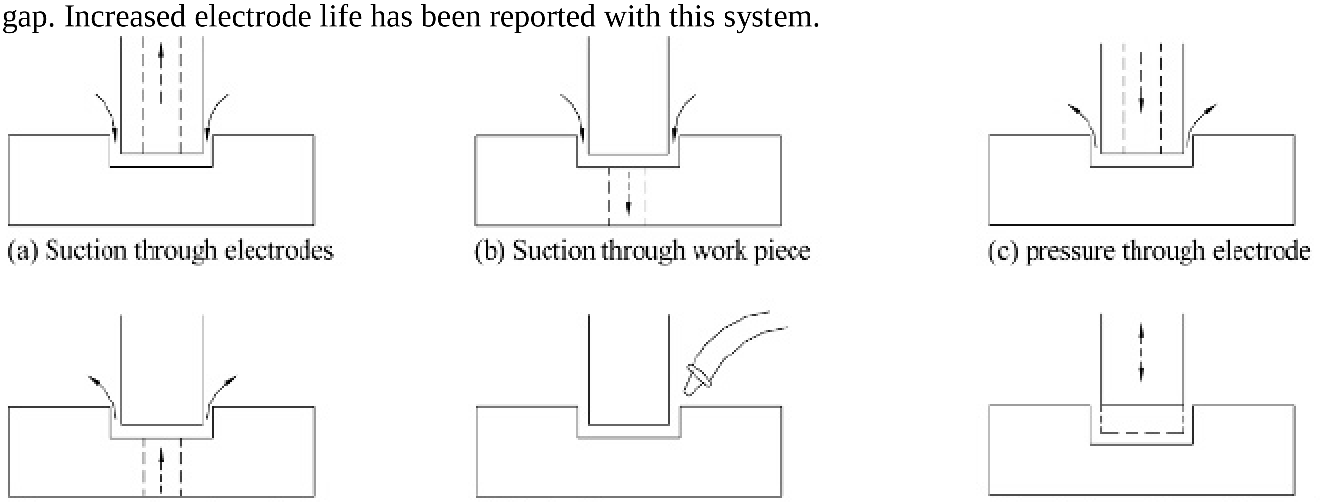
- High equipment cost.
- The high temperature, high velocity impinging gas causes metallurgical alterations in the workpiece material.
- Shielding and noise protection adds additional equipments and also burden on the operator's precautions.

4. Flushing Techniques in EDM

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.

Flushing Four methods: 1. Normal flow 2. Reverse flow 3. Jet flushing 4. Immersion flushing

1. Normal flow (Majority): Dielectric is introduced, under pressure, through one or more passages in the tool and is forced to flow through the gap between tool and work. Flushing holes are generally placed in areas where the cuts are deepest. Normal flow is sometimes undesirable because it produces a tapered opening in the workpiece.
2. Reverse flow: Particularly useful in machining deep cavity dies, where the taper produced using the normal flow mode can be reduced. The gap is submerged in filtered dielectric, and instead of pressure being applied at the source a vacuum is used. With clean fluid flowing between the workpiece and the tool, there is no side sparking and, therefore, no taper is produced.
3. Jet flushing: In many instances, the desired machining can be achieved by using a spray or jet of fluid directed against the machining gap. Machining time is always longer with jet flushing than with the normal and reverse flow modes.
4. Immersion flushing: For many shallow cuts or perforations of thin sections, simple immersion of the discharge gap is sufficient. Cooling and debris removal can be enhanced during immersion cutting by providing relative motion between the tool and workpiece. Vibration or cycle interruption comprises periodic reciprocation of the tool relative to the workpiece to effect a pumping action of the dielectric.
5. Synchronized, pulsed flushing is also available on some machines. With this method, flushing occurs only during the non-machining time as the electrode is retracted slightly to enlarge the gap. Increased electrode life has been reported with this system.



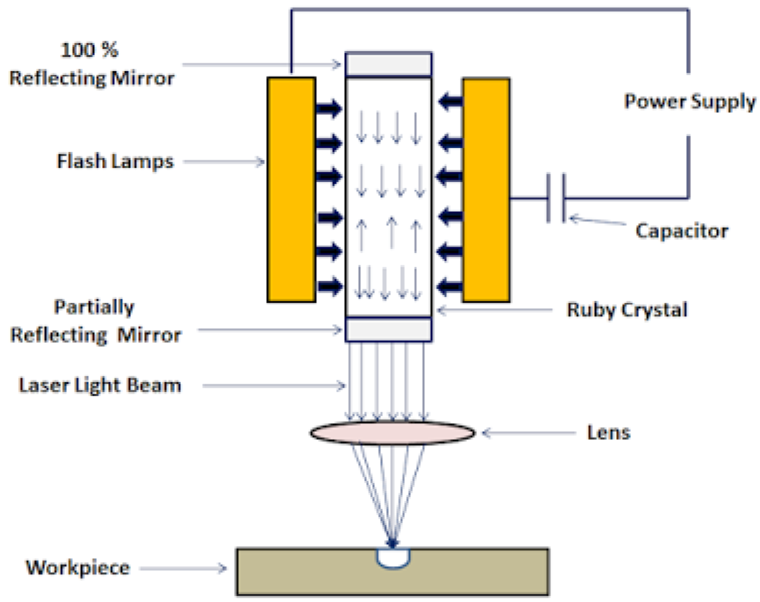
(a) Suction through electrodes (b) Suction through work piece (c) pressure through electrode

(d) pressure through work piece (e) jet flushing (f) periodic cycling of electrode

5. **Laser Beam Machining (LBM)** is a form of machining process in which laser beam is used for the machining of metallic and non-metallic materials. In this process, a laser beam of high energy is made to strike on the workpiece; the thermal energy of the laser gets transferred to the surface of the workpiece. The heat so produced at the surface heats melts and vaporizes the materials from the workpiece. Light amplification by stimulated emission of radiation is called **LASER**.

It works on the principle that when a high energy laser beam strikes the surface of the workpiece. The heat energy contained by the laser beam gets transferred to the surface of the workpiece. This heat energy absorbed by the surface heat melts and vaporizes the material from the workpiece. In this way the machining of material takes place by the use of laser beam.

The various main parts used in the laser beam machining are



1. A pumping Medium: A medium is needed that contains a large number of atoms. The atoms of the media are used to produce lasers.
2. Flash Tube/Flash Lamp: The flash tube or flash lamp is used to provide the necessary energy to the atoms to excite their electrons.
3. Power Supply: A high voltage power source is used to produce light in flashlight tubes.
4. Capacitor: Capacitor is used to operate the laser beam machine at pulse mode.
5. Reflecting Mirror: Two types of mirror are used, first one is 100 % reflecting and other is partially reflecting. 100 % reflecting mirror is kept at one end and partially reflecting mirror is at the other end. The laser beams comes out from that side where partially reflecting mirror is kept.

Working of Laser Beam Machining

A very high energy laser beam is produced by the laser machines. This laser beam produced is focused on the workpiece to be machined.

When the laser beam strikes the surface of the workpiece, the thermal energy of the laser beam is transferred to the surface of the w/p. this heats, melts, vaporizes and finally removes the material from the workpiece. In this way laser beam machining works.

Advantages

- It can be focused to a very small diameter.
- It produces a very high amount of energy, about 100 MW per square mm of area.
- It is capable of producing very accurately placed holes.
- Laser beam machining has the ability to cut or engrave almost all types of materials, when traditional machining process fails to cut or engrave any material.
- Since there is no physical contact between the tool and workpiece. The wear and tear in this machining process is very low and hence it requires low maintenance cost

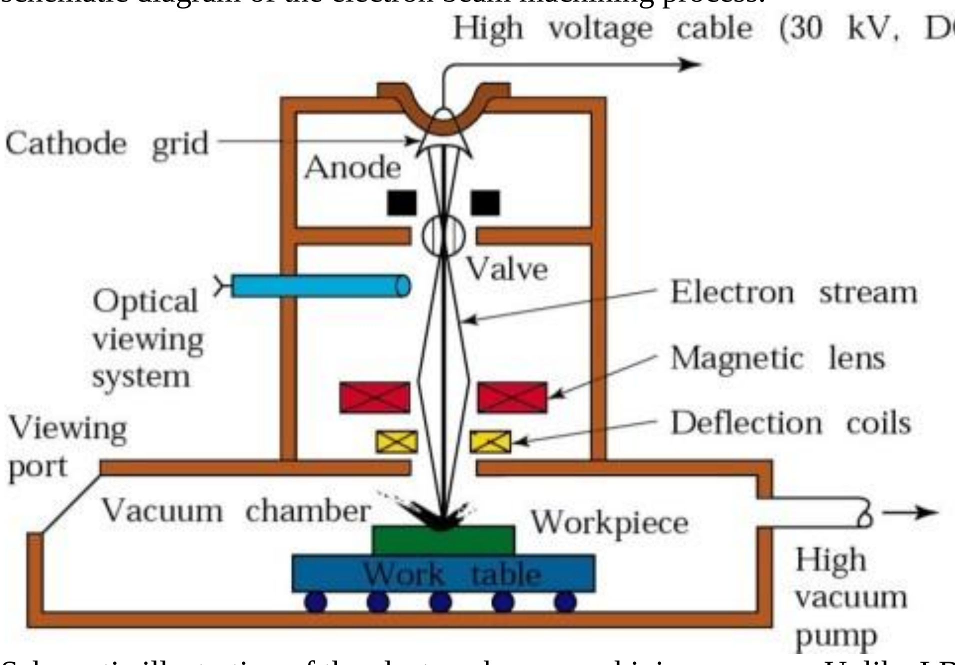
- This machining process produces object of very high precision. And most of the object does not require additional finishing
- It can be paired with gases that help to make cutting process more efficient. It helps to minimize the oxidation of w/p surface and keep it free from melted of vaporized materials. Produces a very high energy of about 100 MW per square mm of area.
- It has the ability to engrave or cut almost all types of materials. But it is best suited for the brittle materials with low conductivity.

Disadvantages

- High initial cost. This is because it requires many accessories which are important for the machining process by laser.
- Highly trained worker is required to operate laser beam machining machine.
- Low production rate since it is not designed for the mass production.
- It requires a lot of energy for machining process.
- It is not easy to produce deep cuts with the w/p that has high melting points and usually cause a taper.
- High maintenance cost.

6. **Electron Beam Machining (EBM)**

The source of energy in electron beam machining is high-velocity electrons, which strikes the surface of the workpiece and generate heat. Electrons escape from the hot surface and a voltage of 50 to 200 kV helps to accelerate them. These high energy electrons possess high energy density generally in the order of 10ˆ4 kW/mm². Thin and high energy stream strikes the workpiece. As a result, the kinetic energy of the electrons is converted to heat energy. This heat energy is more than sufficient to melt and even vaporize any material. Electrons can penetrate only a few atomic layers of the metals and can melt metal up to a depth of 25 mm. The electron beam traveling at a speed of ¾ of the velocity of the sound is focused on the material to be machined. To focus the electron beams electro-static or electromagnetic lenses are used. Generally, electron beam machining is done in a high vacuum chamber to avoid the unnecessary scattering of the electrons. The following figure shows the schematic diagram of the electron beam machining process.



Schematic illustration of the electron-beam machining process. Unlike LBM, this process requires a vacuum, so workpiece size is limited to the size of the vacuum chamber.

For observing the process of machining an optical viewing system consisting of lens and prism is also incorporated. The beam can be controlled very accurately and focused on width as small as 0.002 mm.

The electrons on impingement over the workpiece heat it up and raise its temperature to a value as high as 5000°C. Due to this the material melts and vaporizes locally.
Recent developments have made it possible to machine outside the vacuum chamber. In this arrangement, the necessary vacuum is maintained within the electron gun proper by removing gases as soon as they enter. The full vacuum system is more costly, but it has the advantage that no contaminating gases are present and the electron gun can be located at a considerable distance from the workpiece.

Advantages of EBM

- Very hard, heat resistant materials could be machined or welded easily
- No physical or metallurgical damage results in the workpiece.
- Close dimensional tolerance could be achieved since there is no cutting tool wear.
- In electron beam welding there is virtually no contamination and close control of penetration is possible.
- Holes as small as 0.002 mm diameter could be drilled.

Disadvantages of Electron Beam Machining Method

- The equipment costs high and operator of high skill is required for carrying out operations.
- The power consumption is exceedingly high
- It is not very suitable for sinking deep holes if the sides must be parallel. In other words, it is not possible to have perfectly cylindrical deep holes by this method.
- Unless special care is taken the bottom of a through hole would become cone-shaped.
- It is most suitable for machining operation where much less material is to be removed. The material removal rate being of the order of a fraction of a milligram per sec.
- The electron beam operation can be carried out only in a vacuum.