

NTM CONTD :-

NON TRADITIONAL MACHINING

METHODS [NTM]

The Limitations of Traditional Machining Methods:-

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1. Tool must be atleast 30-50% harder than work piece but sometimes the work piece itself is very hard and there is no tool which is harder than w/p.
2. Some materials will have very poor machinability. Such materials can't be machined with conventional methods.
3. Small size non circular holes can't be produced by using conventional methods. But large size small circular holes can be produced by using broaching operation.
4. Making small size circular holes is also not possible.
5. Making holes in highly brittle materials is not possible with conventional methods. (eg: Glass)
6. Machining of very soft material like rubber is not possible.
7. Manufacturing of complex concave curvatures is not possible.



The unconventional machining methods are :-

1. USM
2. EDM
3. ECM
4. WJM

5. AWJM

6. EBM

7. LBM

→ Mechanism by which Material Removal / chip formation takes place

→ Tool Material

→ Medium

→ Wear Ratio / Machining Ratio

$$= \frac{\text{Vol of Material Removed on Work Piece}}{\text{Vol of Tool Wear}}$$

→ Advantages of Process

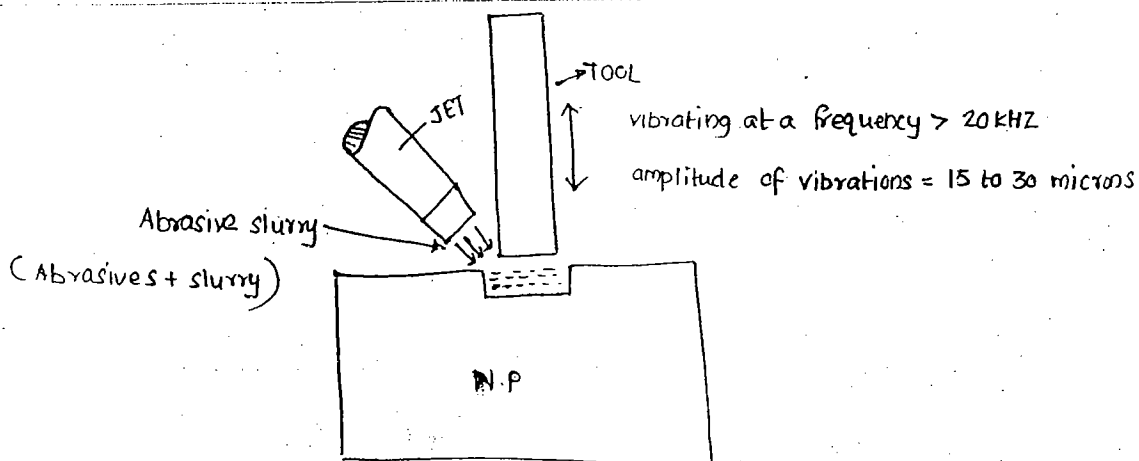
→ Disadvantages of Process

→ Applications

7 PARAMETERS

1. USM (Ultra Sonic Machining)

[MATCH THE FOLLOWING]



When the tool is vibrating at high frequency, the impact loads produced by the tool will be acting on to the

Abrasive particles which in turn produces impact loads on to the workpiece. When the impact loads are acting on to the w/p, if the w/p material is a highly brittle material, because of lower toughness the workpiece is getting fracturing due to Brittle Fracture. The chips produced due to this will be moving along with the Abrasive slurry. From the above the mechanism by which chip formation taking place is Brittle fracturing.

Tool Material:-

When the impact loads is acting on to the Abrasive particles, equal and opposite Reaction force produced by the Abrasives will be acting on to the Tool. If the tool is made by using hard material, the Brittle fracturing will take place on Tool also. Hence the wear of tool will be higher. To minimise the wear of the tool, tool must be made by using very soft material. The most commonly used tool material is Cu, Brass, M.S etc.

The medium used is Abrasive slurry i.e. Abrasives + slurry. The most commonly used Abrasive particles is Al_2O_3 , silicon carbide, Boron Carbide, Diamond etc. As the size of Abrasive particle is increasing, the Material Removal Rate increases first and then Reduces. The most commonly used size of Abrasive particles is 200 - 600 mm. Boron carbide Abrasives will be used with water as a

as a slurry. The composition of Abrasive slurry is 50-60% by volume is Abrasives.

Wear Ratio of USM will be varying from 1.5 to 100. Generally wear Ratio is dependant on Brittleness of workpiece material. ie Higher the Brittleness, Higher the wear Ratio.

Tool	W.P	W.R
Cu	glass	100
Cu	ceramic	75
Cu	Tungsten	1.5
Cu	Quartz	50
Cu	H.C.S	1.1

Advantages of USM:-

1. Highly Brittle materials can be Machined very easily.
2. smaller size Non circular Holes can be produced.
3. Electrical conductivity of work piece is not Req'd.
4. It is not a Hazardous process

3 LIMITATIONS OF USM:-

1. $\frac{L}{D}$ Ratio upto 3 only will be possible

$L =$ ~~less~~ depth of Hole

$D =$ Dia of Hole

For deeper Holes the Abrasive slurry can't be supplied since gap present b/w w/p and Hole will be less.

2. Bcoz of Brittle fracture surface finish is very poor

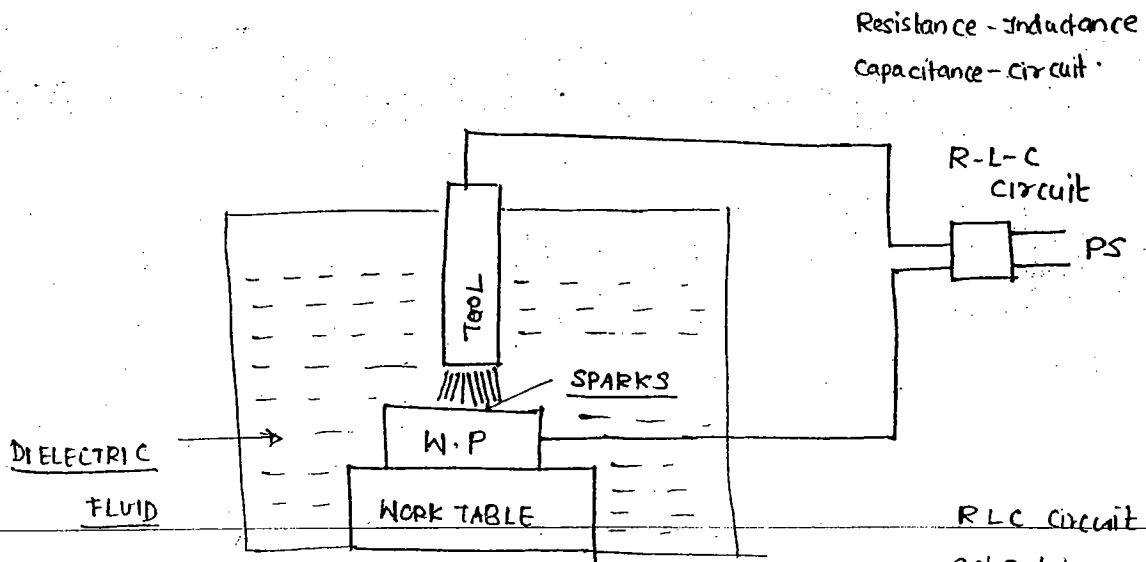
4. Specific cutting Energy Requirements are Higher

Applications:-

all

1. It is used for producing circular / Non-circular Holes in Highly Brittle Materials like Glass, ceramic, Tungsten carbide etc.
2. Dental Doctor uses USM for producing Holes in Human Teeth becoz it is a painless drilling methodology.
3. Holes of size upto 0.1mm can be produced by using USM.

2. EDM (Electric Discharge Machining)



When the Power supply is given to the

R-L-C circuit Nearly 75 - 85% of cycle time

Duration, the energy supplied by the Power supply

unit will be stored in the R-L-C circuit becoz R-L-C

circuit in electrical Technology is working like a flywheel

in mechanical systems. During remaining 20-25% of

cycle time duration, the energy stored in R-L-C circuit and

energy supplied by Power supply unit will be returned

R-L-C circuit
acts like a
flywheel in
Mechanical
System.

Spontaneously ~~set~~ so that wherever gap is present in the work piece such place sparks are produced i.e. at the tip of tool and work piece

Bcoz of sparking Heat is generated at the interface of tool and work piece. By using this Heat the work piece material is melting and evaporating. To increase the evaporation efficiency of the metals the sparking zone will be immersed in a dielectric fluid. Bcoz the evaporation is taking place inside the liquid and vapours are continuously coming out, At the ~~the~~ sparking zone pressure falls below partial pressure of water vapour in atmosphere and hence cavitation is occurring.

From the Above the mechanisms by which chip formation occurs is by melting and Vapourisation associated with cavitation also called as SPARK EROSION & CAVITATION.

To Avoid the heat generation within the tool, the tool material must be made by using High electrical conductivity material. To minimize the melting of tool, the M.P of tool must be as high as possible. The tool will be made by using cu / tungsten / cu-tungsten alloy etc will be used. The medium used is Dielectric fluid, the most commonly used is kerosene and sometimes mineral oil also can be used.

[No catching of fire to kerosene Bcoz O₂ is

Wear Ratio induced is varying from 0.1 to 10. The wear Ratio mainly depends on the ~~met~~ difference b/w the M.P of Tool and Work piece material. 2/2

When ~~for ex~~ M.P of Tool is very much higher than work piece, the high wear Ratio's can be obtained for ex during machining of Al as WC as tool the wear Ratio obtained will be 10. During machining of steel work pieces using Cu as tool the wear Ratio obtained is 0.1.

Advantages:

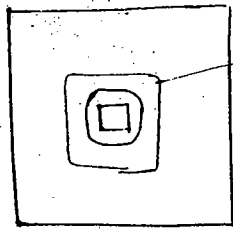
1. $\frac{L}{D}$ Ratios as high as 20 is possible.
2. There is no physical contact b/w Tool and work piece so no forces are acting in machining so no residual stresses are generated in machining.
3. out of all the unconventional machining methods, EDM is the one which gives highest MRR, and EBM will give the lowest MRR.

4. Beoz melting and evaporation is the Mechanism of chip formation, the mechanical properties of W.P material will not affect the Material Removal Rate (MRR).

5. surface finish produced will be Better.

Disadvantages :-

1. Work piece material must be electrically conductive.
2. perfect square cornered Holes can't be produced.



Hardening effect

(Heating will be taking place near to hole) since it is immersed in fluid, heating and quenching takes place i.e. Hardening

Hardening effect will be taking place i.e. near to the hole

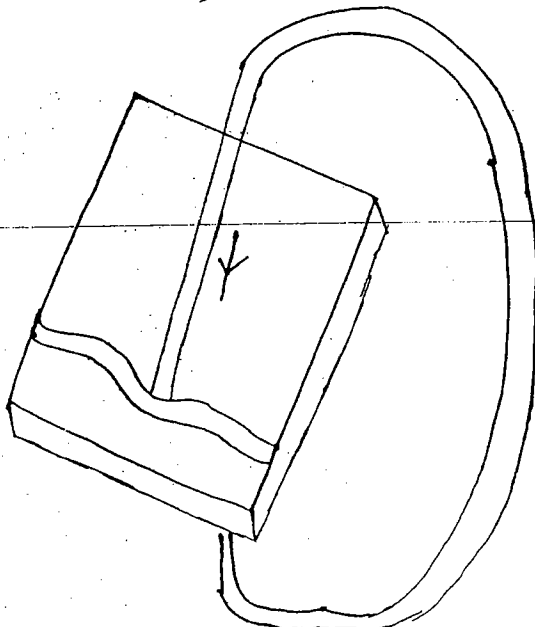
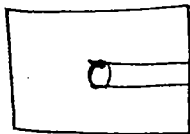
Hardness of work piece is increased.

Applications:-

1. used for producing very small size holes like holes in diesel injection nozzle.
2. used for producing holes in air brakes.
3. used for die sinking etc.

* ECM (Electrochemical Machining)

• WIRE CUT EDM.



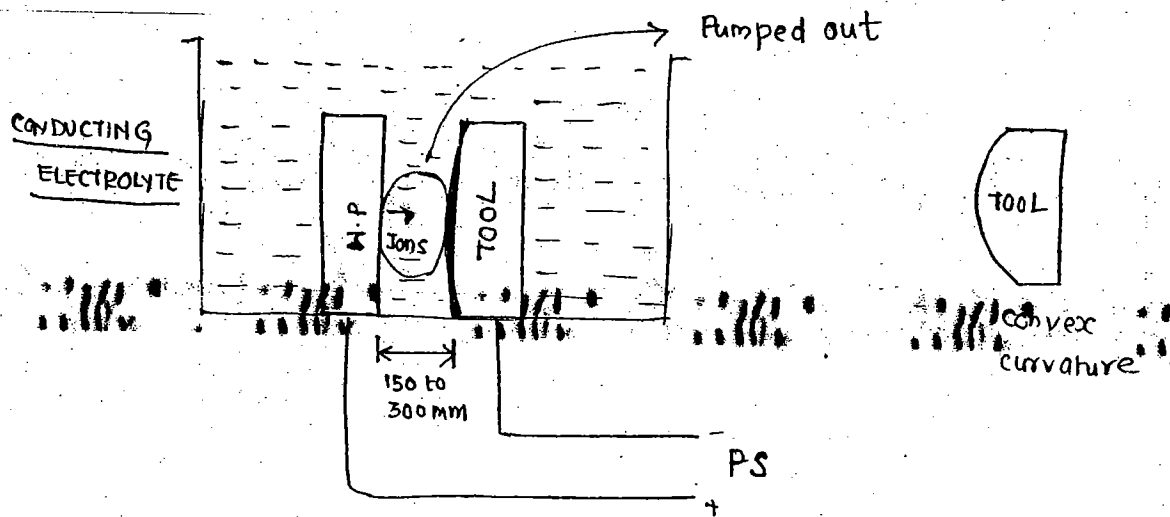
Wire cut EDM is similar to EDM but used for cutting sheets into complex shapes. In this process a continuously moving wire will be used as tool so that the sparks are produced b/w circumference of the

progressing, in case of EDM length of tool will be reducing.
 But in case of wire cut EDM the diameter of wire will be Reducing

2/3

Mainly used for cutting of sheets into complex shapes.

3. ECM (Electro chemical Machining operation) :-



When the power supply is given to the workpiece and the tool, because of Faraday's Law of electricity, the ions are displacing from the workpiece and trying to deposit over the tool. Before that depositing when the electrolyte present b/w the tool and workpiece ~~will~~ will be pumped out continuously so that ions displaced from the workpiece are also moving along with the electrolyte. Hence there is no disturbance taken place to the tool. The same tool can be used for producing infinite no. of components. From this the mechanism by which the chip formation taking place is due to ion displacement.

The Material Removal Rate or No. of ions displaced is directly proportional to the gram atomic weight of work piece material.

(b) directly proportional to current density of ECM process.

(c) Inversely proportional to the distance b/w the tool and work piece.

(d) directly proportional to the electrical conductivity of electrolyte. i.e. for Rough machining process, High electrical conducting electrolyte is used also called as passivating electrolyte. and for finish machining operations low electrical conductivity electrolytes is used. i.e. it is also called as Non passivating electrolyte.

(e) In Addition to above the electrolyte must be chemically stable, low viscous and High Specific Heat.

Tool Material:-

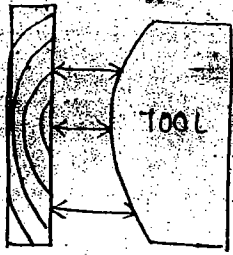
If the tool and work piece are made by using same material and work piece is connected to +ve terminal of power supply more no. of ions are displacing from the work piece. ∴ Tool must be made by using same material as that of work piece.

Medium:-

The medium used is conducting electrolyte preferably Salt solution.

Wear Ratio:-

Wear Ratio is infinite since tool is not wearing out i.e. tool wear is zero.



Advantages:-

1. complex, concave curvature components can be produced easily by using convex, concave curvature tools
2. Bcoz tool wear is zero, same tool can be used for producing infinite no. of components.
3. Bcoz there is no direct contact b/w tool and work piece, no forces, no residual stresses.
4. Bcoz ion displacement is the mechanism by which material removal is taking place, the surface finish produced is excellent

LIMITATIONS:-

1. out of all the unconventional machining methods ECM requires highest specific cutting energy
2. work piece material must be electrically conducting.
3. Generally preferable for producing contours only.
4. sharp corners is not possible to produce.

Applications:-

mainly used for producing complex shape of components like Turbine Blades.

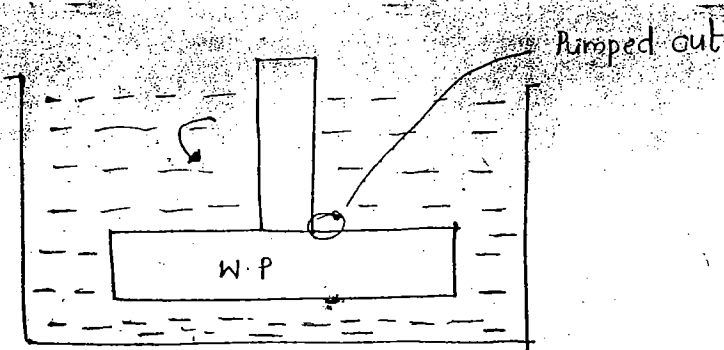
$$MRR = \frac{AI}{ZF}$$

F = Faraday's Const.

A - Atomic wt of w/p
I = Current



ECG (Electro chemical Grinding)



$$\text{Material Removal} = \text{Electro chemical} + \text{Mechanical}$$

In ECG the Rotating Grinding wheel will be used as a Tool

so that the Material Removal is Taking place due to electrochemical process and Mechanical process as 90:10 %.

The Gap b/w Tool and Work piece is mainly controlled by

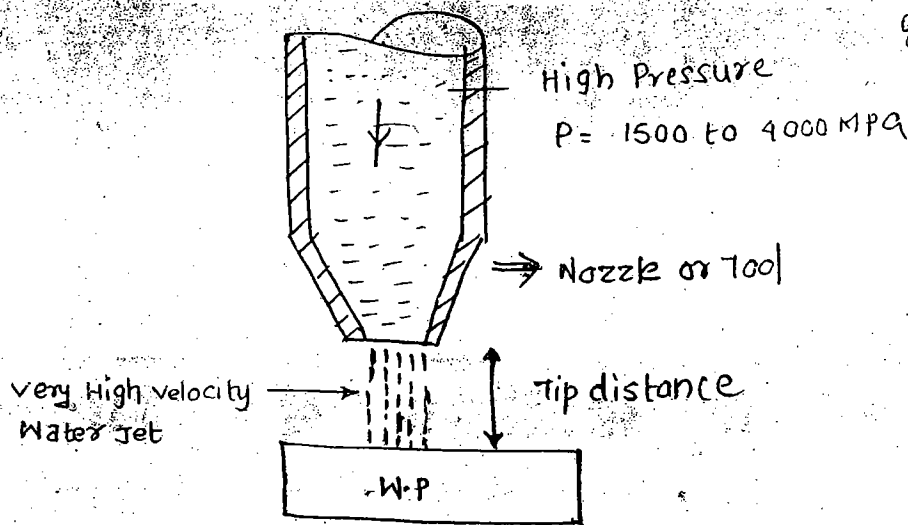
using of Abrasive particles present in the Grinding wheel.

Applications:-

used for Grinding of very Hard work pieces like Grinding of carbide cutting tools.

Even though carbide cutting tools are ReGrindable by using ECG it is Not preferable because the cost of ECG is much Higher than New cutting Tool itself.

4. WATER JET MACHINING [WJM]



When the Very High Pressure water is passing through the convergent nozzle the pressure energy is converted into velocity energy. Water is coming out from nozzle at very high velocity. When this high velocity water jet is impinging on to the work piece continuous impact load will be produced on the work piece so that the work piece material is plastically deforming and fracturing will be taking place i.e. mechanism by which material removal takes place is plastic deformation and fracturing. It is also called as etching process.

To withstand for high pressures of water, nozzle or tool is made by using tungsten carbide. wear ratio is infinity since nozzle wear is almost zero.

Adv.:-

used for machining of very soft materials like rubber.

Disadv.:-

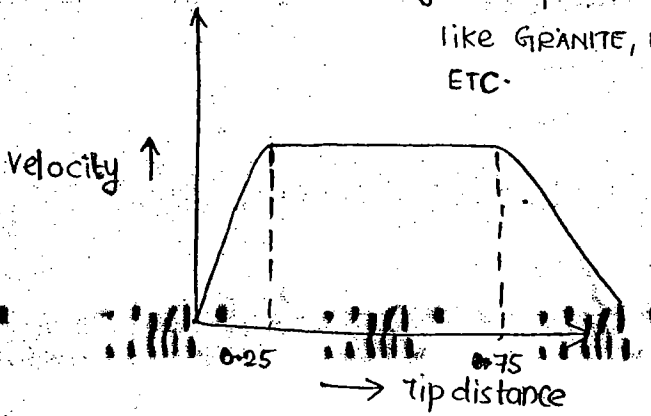
Pressurizing water to very high

It can't be used for Machining of Hard materials

AJM

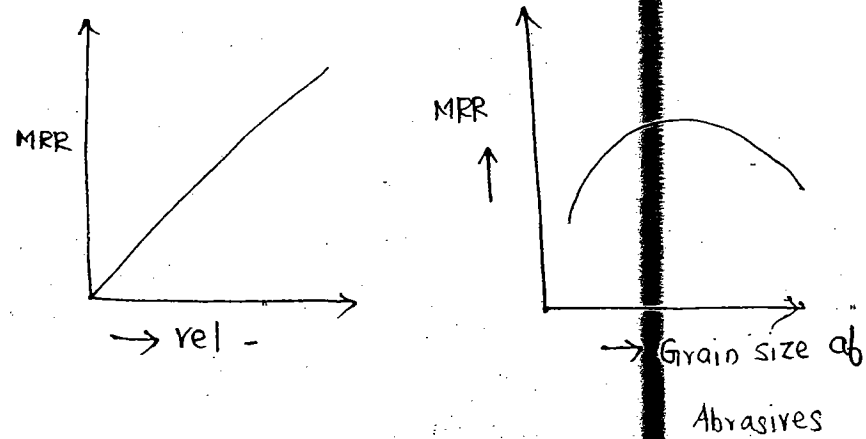
To overcome the disadvantage of Machining of Hard work pieces by water jet Machining, Abrasive particles are added into the water so that Abrasive particles also will be coming out from nozzle tip at very High velocity. when this High velocity Abrasives are impinging on to Hard work piece it is possible to produce plastic deformation in Hard work pieces also. Hence the fracturing and chip formation is taking place. This is called Abrasive water Jet Machining (AWJM) or Abrasive Jet Machining. It is mainly developed for cutting of Hard Materials

like GRANITE, MARBLE, COMPOSITE MATERIALS ETC.



At High Tip distances the Air Resistance also comes into play. Hence the vel Reduces.

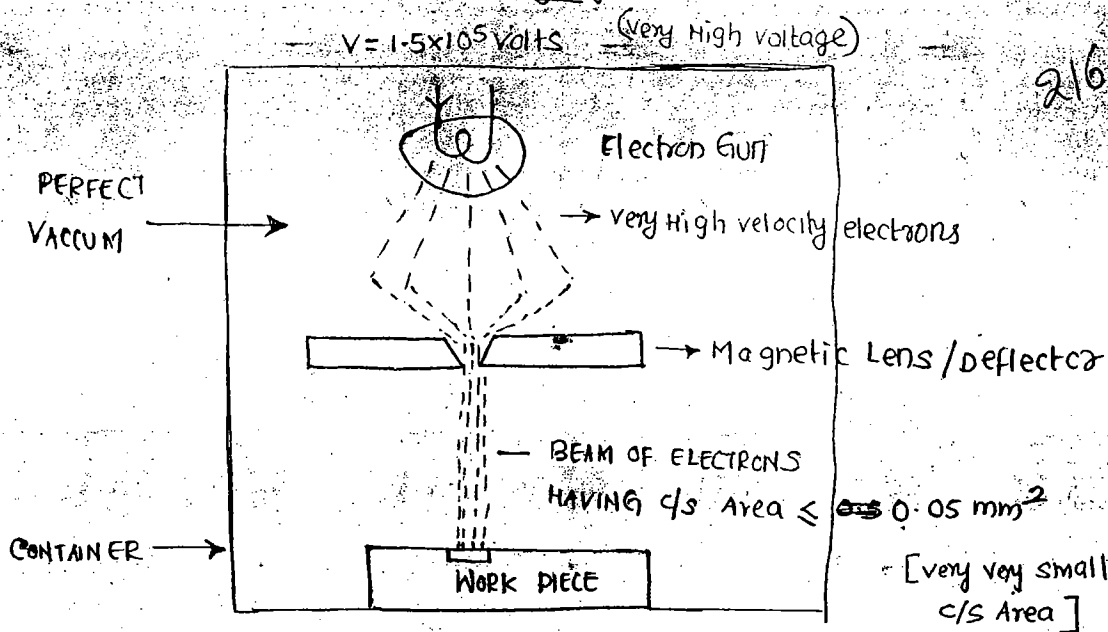
Optimum Tip distance = 0.25 to 0.75mm



REASON why water particles can't be used for M/ching Hard work pieces

[Because water particles are soft, when high velocity water particles are impinging on Hard work piece, without producing any plastic deformation, water particles are simply reflected away.

EBM (Electron Beam Machining)



When very High voltage power supply is given to the electron gun, it produces very High velocity electrons in all the directions.

By providing a Magnetic lens or deflector all the High velocity electrons will be collected and formed like a Beam of

electrons which is Having c/s Area $\leq 0.05 \text{ mm}^2$. when this High velocity electron Beam is impinging on to the work piece, the K.E of e^- is converted into Heat energy.

∴ the Heat is getting generated at work piece. this Heat will be used for melting and vaporisation of the work piece material. From the Above mechanisms of material removal is by melting and vaporisation. After the Magnetic deflector bcoz of presence of Air Resistance the e^- may get dispersed again. To Avoid this the total setup will be kept in the container and perfect vacuum is maintained inside the container. Becoz of perfect vacuum Highly Reactive metals can be machined very easily without any oxidation.

[Work piece is fully protected from atmospheric

In this Electron Gun is used as Tool • The medium is perfect vacuum • Wear Ratio is infinite.

Advantages:-

1. Very very small size Holes can be produced.
2. Surface Finish Produced is Good.
3. Highly Reactive Metals like Al and Mg can be machined very easily.

Limitations:-

- ① Maintaining Perfect Vacuum is very difficult.
- ② Material Removal Rate is very low.
- ③ Beccz the total equipment is kept inside the container the Machining process can't be seen by operator.

Applications:

Used for producing very very small size Holes like Holes in diesel • injection Nozzles, Air Brakes etc.

Electron Beam Welding:-

If voltage of power supply to electron gun is reduced to about 70-80,000 volts the vel of e^- is reducing, the Heat generated at workpiece is reducing. ∴ workpiece is only melting and No evaporation is taking place. This Melting of work piece can be used for

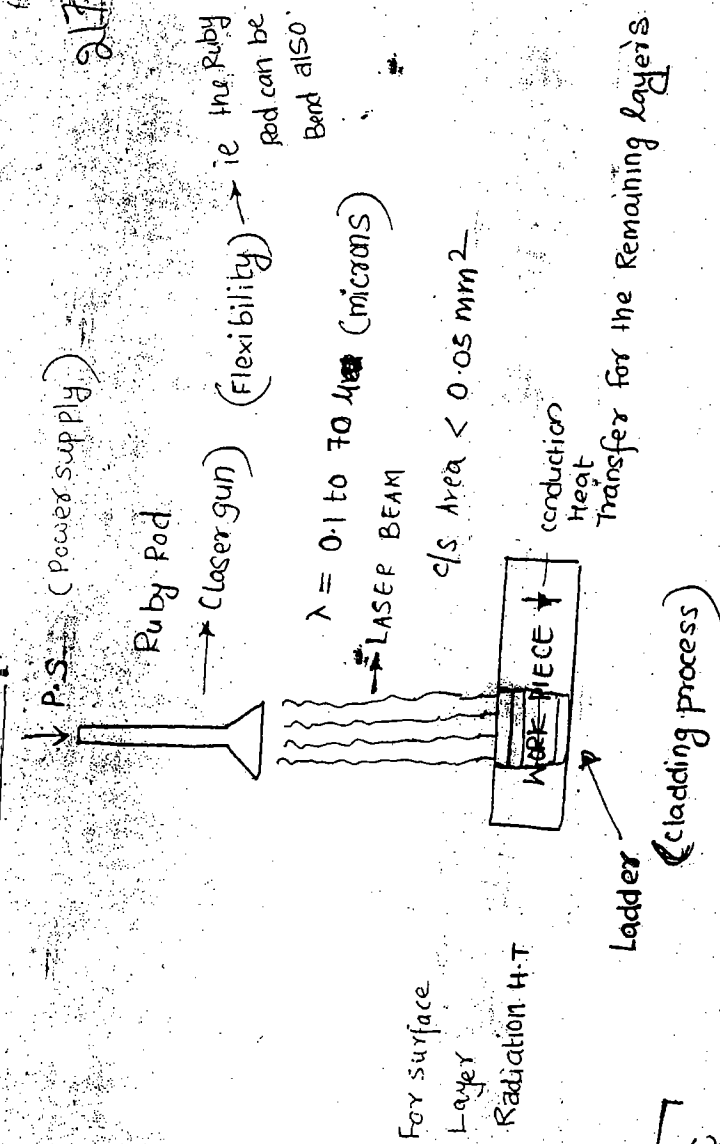
④ Work Piece

Material is
Should be
electrically
conducting

⑤ out of the
unconventional
Methods ERM
will give the
Lowest MRR

⑥ used only for
circular Holes

7. LASER BEAM MACHINING



When power supply is given to laser gun, it produces High intensity EM waves having wavelength 0.1 to 70 μm; the laser beam has cross sectional area of < 0.05 mm². When this laser beam is impinging on to the workpiece the electromagnetic wave energy is converted into Heat energy onto surface of workpiece. ∴ surface layer of w/p is melting and evaporating. But for further layers Heat is transferring by conduction process. When the first layer is evaporating the 2nd layer of material is exposing for EM waves and this also will get melted and evaporated. Like this layer by layer of workpiece material is getting exposing EM waves melting and evaporating. Hence this process is looking like a ladder called as cladding process. From the above mechanism of metal Removal is by melting



Since most of metals are opaque in nature, the heat transfer by radiation can be taken as a surface phenomena

Tool Material

Ruby Rod

Medium

Air

Wear Ratio is ∞ since there is almost no wear of the tool.

Advantages:-

1. No vacuum is reqd hence process will be easier.
2. The size of Hole and slots produced is same as that of EBM.
3. Bcoz the Ruby Rod is flexible, to some extent the zig zag Holes can be produced by using LBM.
4. No need to have electrical conductivity of work piece material.

Disadvantage:-

Energy or Power Reqd for LBM is very high.

$$\lambda = 0.1 \text{ to } 70 \mu\text{m} \text{ (microns)}$$

Practically we use (0.4 to 0.6 μm) \rightarrow $P = 5000 \text{ to } 6000 \text{ MW}_{\text{reqd}}$

usually they are located near Nuclear Power plants.

If less amount of power supply is used then it becomes Laser Beam welding.

\rightarrow Bcoz of presence of flexibility of Ruby Rods the Zig-Zag Holes can also be produced by using LBM.

\rightarrow Applications of LBM are same as EBM.

