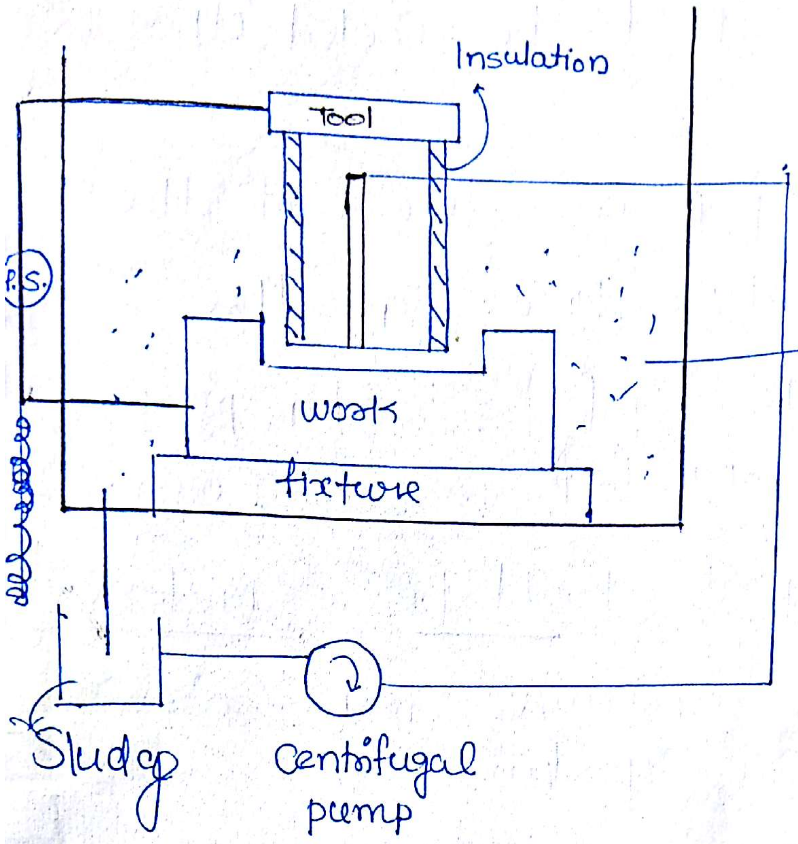
Un-Conventional Maching

Electrochemical machining (ECM):



tool work piece

Gap = 0.03–0.5 mm

CLA ~~Resistance~~ = 0.2–0.8 μ's ~~Roughness~~

Electrolyte

NaCl – Rough

$NaClO_3$ – finish

$Fe \rightarrow Fe^{2+} + 2e^-$

$NaCl \rightarrow Na^+ + Cl^-$

$H_2O \rightarrow H_2 + OH^-$

$Fe^{2+} + 2OH^- \rightarrow Fe(OH)_2$ ↳ sludg

Electrochemic grinding (ECG)

95% – electrolysis

5% – grinding.

ECM process is reverse of electrolysis i.e. removing the material atom by atom. Higher is the current setting, electrolysis rxn will be more ~~prominent~~ predominent and hence material removal rate will also be high.

Tool is insulated from all the size so that rxn doesn't takes place side edge. There is no tool wear in this machining process.

→ Before circulating the electrolyte back to the machining area it needs to be cooled otherwise it leads to overcuts.

→ In electrochemical grinding process 95% of the material removal takes place by the process of electrolysis and 5% by pure grinding. Since the GW tool ~~to~~ in ECG so it's bonding agent should be a metal

→ ECM instalation are expansive but its operational cost is very low.

→ During electrolysis rxn since H_2 gas is involved so there has to a safe passes to it's removal.

→ Small size steam turbine blades are produced by ECM. M (Bhel)

⇒ Medium size gas turbine blade are produced by investment casting

Large size water turbine blade are produced on a copying lathe using Sialon as a tool material.

(high current low voltage)

m - gram
I = A
t = S
$F = \frac{\text{Columb} = (A \times S)}{\text{mole}}$

mass $\propto$ charge(It)

$m = ZIt$

Z = electrochemical equivalent

$Z = \frac{e}{F}$ F = Farraday's Constant (96500) Columb/mole

$m = \frac{eIt}{F}$

$\left(\frac{m}{t}\right)(g/s) = \frac{(g/mole)(A)}{A \cdot S/mole}$

$= g/s$

e = chemical equivalent

$e = \frac{\text{Atomic weight}}{\text{Valency}} \left(g/mole \right)$

$$\frac{1}{e} = \sum \frac{x_i}{e_i}$$

material Removal rate (MRR) → $(cm^3/sec.)$

$MRR = \frac{eI}{F\rho} (cm^3/s)$ $MRR = \frac{EI}{F} (g/s)$

$\rho = g/cm^3$

Specific MRR $s = \frac{e}{F\rho} \left(\frac{cm^3}{A \cdot s} \right)$

Tool feed rate $= s \times S_1$
↳ Current density

$S_1 = \frac{I}{A} \left(\frac{A}{cm^2} \right)$, $I = \frac{\Delta V}{R}$ Feed $= \frac{cm^3}{A \cdot s} \cdot \frac{A}{cm^2}$

$R = \rho_s \cdot \frac{l}{A}$ $= cm/s$

Unit Always in 'CGS'

Q.6

$\rho = 6000$ kg/m³

iron $\begin{cases} wt = 56 \\ \text{Valency} = 2 \end{cases}$

Metal P $\begin{cases} wt = 24 \\ \text{Valency} = 2 \end{cases}$

$F = 96500$ coulomb/mole

MRR = 50 mm³/s   I = 2000 A

$$\frac{1}{e} = \Sigma \frac{x_i}{e_i}$$

	At wt	Valency		
P	24	4	x	$e_{fe} = 56/2$
Fe	56	2	$1-x$	$e_p = 24/4$

$$\frac{1}{e} = \frac{x}{24/4} + \frac{(1-x)}{56/2}$$

$$MRR = \frac{eI}{F\rho} = 50 \text{ mm}^3/\text{s}$$

$$\frac{\left\{\frac{1}{\left\{\frac{4x}{24} + \frac{(1-x)2}{56}\right\}}\right\} \times 2000}{96500 \times 6000 \times 10^3/10^6} = \frac{50}{10^3} \text{ cm}^3/\text{s}.$$

$$\frac{x}{6} - \frac{x}{28} = \frac{1}{14.475} - \frac{1}{28} \Rightarrow x = 25\%$$

Ans

Q.10

$$MRR = \frac{e\ I}{F \rho}$$

$e = 56/2 = 28$

$MRR = 2\ cc/min = \frac{1}{30}\ cc/sec$

$$2/60 = \frac{28 \times I}{96500 \times \cancel{9}.8}$$

$I = 896.07$ amp

Q.28

$$MRR = \frac{e I}{F \rho}$$

$e = 56/2 = 28$

$I = 480\ A$

$\rho = 7.6\ g/cm^3$

$$MRR = \frac{28 \times 480}{96500 \times 7.6} = 0.018$$

Q.27

$$MRR = \frac{16 \times 0.9 \times 2000}{96500} (gm/s) = 0.298\ gm/s$$

density not req. (gm/s)

Q.29

$$MRR = \frac{eI}{F\rho} \qquad V = IR$$

$$= \frac{55.85 \times (12 \times 3)}{2 \times 96500 \times 7860 \times \frac{10^3}{10^6}}$$

~~MRR = 0.0013 cm³/s.~~

$V = 12\ V$

$$R = \rho \frac{l}{A} = 3 \times \frac{0.25}{10 \times 25 \times 25} \times 100$$

$V = IR$

~~R = 0.012~~ $I = \frac{12}{0.012} = 1000\ A$

$$MRR = \frac{55.86 \times 1000}{2 \times 96500 \times 7860 \times \frac{10^3}{10^6}}$$

$MRR = 0.036\ cm^3/s.$

$$Feed = \frac{e}{F\rho} \times \frac{I}{A} = \frac{55.86}{2 \times 96500} \times \frac{1000}{25 \times 25} \times 100$$

$$= 5.88 \times 10^{-3}\ cm/s.$$

Q.30

$$\text{Feed} = \frac{e}{F\rho} \times \frac{I}{A}$$

$V = IR$

$I = V/R$

$$I = \frac{V \cdot A}{\rho \cdot l}$$

$$\frac{0.25 \times}{10 \times 60} = \frac{56 \times (V) A}{2 \times 96500 \times 7.86 \times \rho l \times A}$$

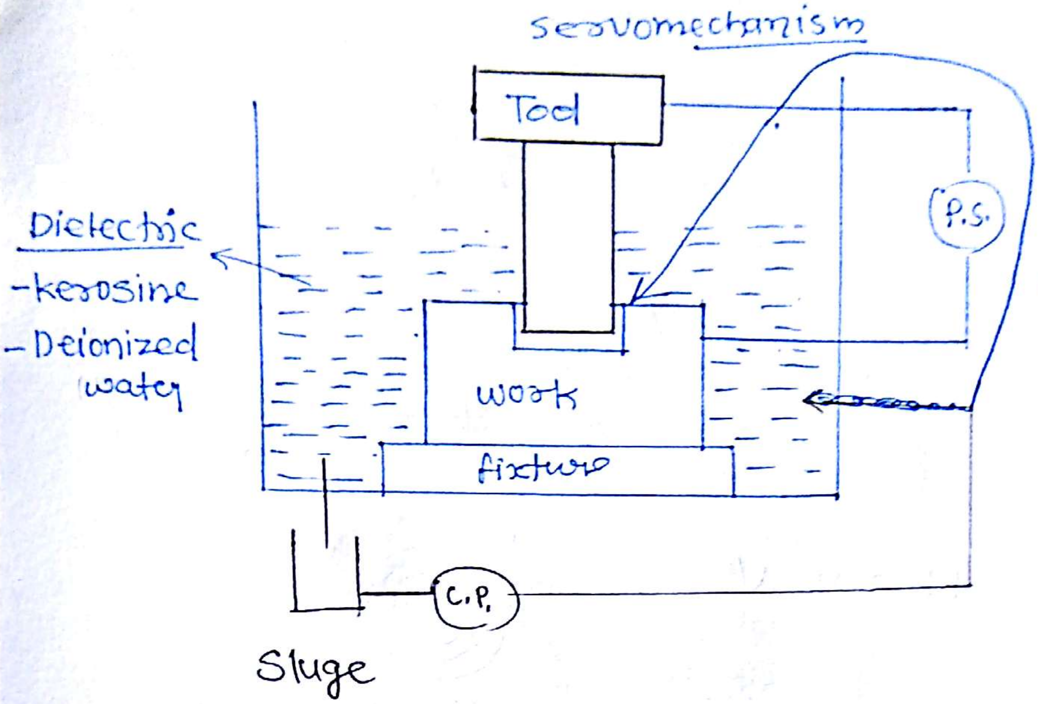
$$\frac{0.25}{10 \times 60} = \frac{56 \times V}{2 \times 96500 \times 7.86 \times \sout{7.86} \times \frac{2}{10} \times 3 \times \frac{50}{10}}$$

$V = 11.28$ V

So supply voltage $= \Delta V = 11.28 - 2.5$

$\Delta V = 8.78$ V.

Electro discharge machining (EDM's)

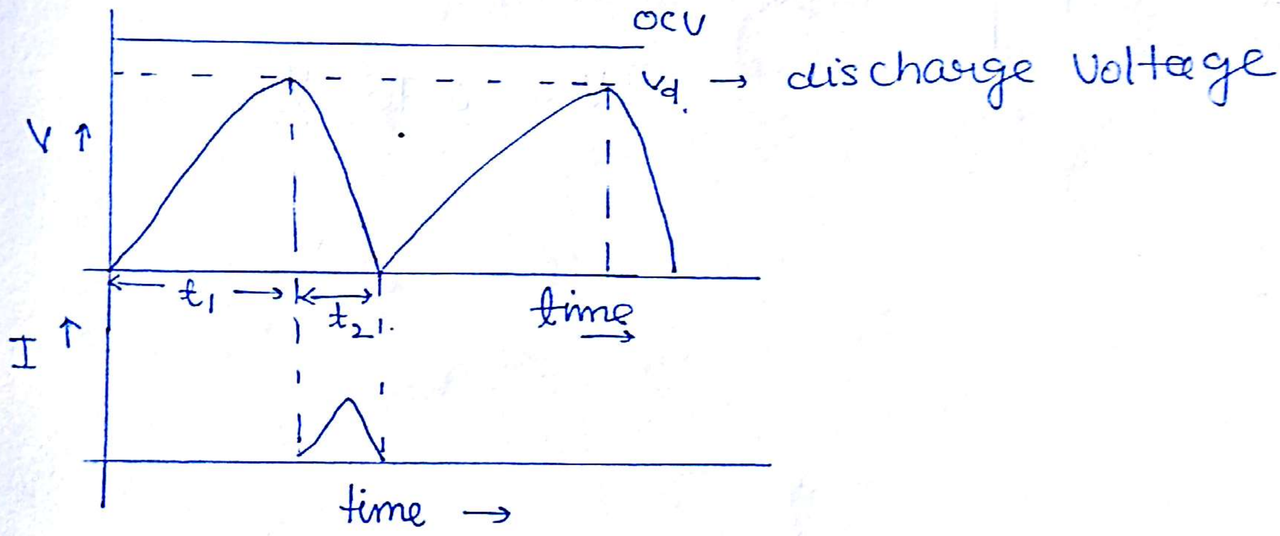


Tool work piece Gap

Gap = 0.025 - 0.05mm

Ra = 0.25 μs

(CLA)



In EDM power source is a capacitor. bank. During the major portion of cycle capacitor bank charges and the movement Voltage accross the capacitor reaches the discharge Voltage entire capacitor bank discharge, Dielectric which was not Conducting before turns to Conducting in a very small region. As a result of that one spark will be produce at the tip of the tool transported through the dielectric and bombards the work.

→ Mechines of material removal is melting Vapourisation and erosion. So we will be getting ~~cratering~~ cratering type surface on the work. Since spark is produce at the tool so a portion of tool material also melt out.

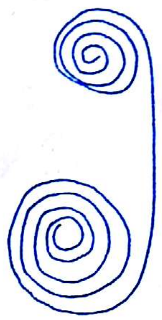
→ Graphite is the most frequently tool material in EDM because not only it is having very high melting point but also it can be machined to a great degree of accuracy.

- After some amount of machining removed material will accumulate b/w tool w.P. Gap ~~and~~ This will affect MRR. So servo mechanism is connected to the tool which sence the voltage between the tool and work. when the Voltage decrease below a certain value servo mechanism withdraw the tool and

⊕ Flushing mechanism remove all the material from the machining area, Servo mechanism again place the tool back to it's position.

* principle of wire cut EDM is exactly same but tool in the form of wire continuously moving over the spool. So that there is a uniform wear over the wire. Process is used to cut any profile in work.

* EDM process is used in die sinking



* If kerosin is the die electric, a portion of it will burn ~~living~~ leaving carbon residues. These carbon residues act like a solid lubricant which helps in chipping of work piece material so surface finish within the creater is very good.

* K ↑, MRR ↓, tool wear ↓

Analysis :- $V_d = V_o\left(1 - e^{-\frac{t}{RC}}\right)$

V_d - discharge Voltage
V_o - open circuit voltage.
R - Resistance
c - capacitance.

$$\frac{V_d}{V_o} = 1 - e^{-\frac{t}{RC}}$$

$$e^{-t/RC} = 1 - \frac{V_d}{V_o}$$

$$-\frac{t}{RC} = \ln\left(\frac{V_0 - V_d}{V_0}\right)$$

$$t = RC \ln\left(\frac{V_0}{V_0 - V_d}\right)$$

Frequency of spark $f = \frac{1}{t}$

Energy transfer/spark $= E = \frac{1}{2} C V_d^2$

Average power $P_{avg} = \frac{E}{t_1 + t_2}$

t_1 = idle time (No spark)
t_2 = spark time

$$t_2 <<< t_1$$

$$P_{av} = \frac{E}{t}$$

$$P_{avg} = \frac{1}{2}\frac{C}{t} V_d^2 = \frac{1}{2}\frac{C}{t} V_0^2 \left(1 - e^{-\frac{t}{RC}}\right)^2 \times \frac{R}{R}$$

$$\therefore \frac{t}{RC} = N$$

$$P_{avg} = \frac{V_0^2}{2NR}\left(1 - e^{-N}\right)^2$$

$$\frac{dP}{dN} = \frac{V_0^2}{2R}\left\{\frac{N\{2(1-e^{-N}).(0+e^{-N})\} - (1-e^{-N})^2}{N^2}\right\} = 0$$

so $2N(1-e^{-N})e^{-N} = (1-e^{-N})^2$

$$2Ne^{-N} = 1 - e^{-N}$$

$$N = \frac{1-e^{-N}}{2e^{-N}}$$

$$2N + 1 - e^{+N} = 0$$

$$N = 1.26$$

So $$t = RC \ln\left(\frac{V_o}{V_o - V_d}\right)$$

$$N' = \frac{t}{RC} = \ln\left(\frac{V_o}{V_o - V_d}\right)$$

$$1.26 = \ln\left(\frac{V_o}{V_o - V_d}\right)$$

$$\Rightarrow \boxed{V_d = 0.72\, V_o}$$

for max^n power generation discharge Voltage is 72% of open circuit Voltage.

pg.33
Q.17

$V_d = 100\,V$ $P = 1\,kW$

$t = 25\,\mu s$

$$P = \frac{E}{t} = \frac{1}{2}\frac{C V_d^2}{t}$$

$$1000 = \frac{1}{2} \times \frac{C \times (100)^2}{25 \times 10^{-6}}$$

$$C = \frac{50}{1000000} \Rightarrow C = ~~0.005\,F~~$$

$C =$

$$C = 5\,\mu F$$

Q. 31

$R = 10\ \Omega$ $V_c = V_s \times 0.716$ $N = 1.26$

$C = 200\ \mu F$

~~$P = \frac{1}{2}\frac{C V_d^2}{t}$~~ $\frac{t}{RC} = N =$ ~~1.26~~

$t = 1.26\ RC$

$t = 1.26 \times 10 \times 200 \times 10^{-6}$

$t = 2.56$ ms

Q. 32

$P = 5$ kW.

SPC = 12 kW

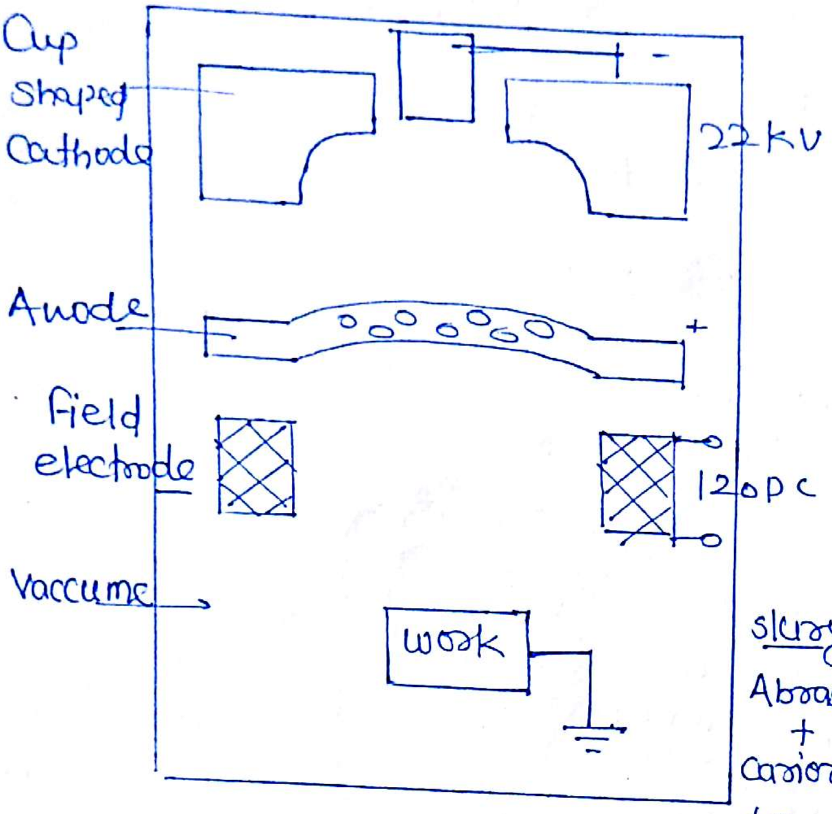
Specific.c. $= \frac{F_c V}{MRR}$ → Power

$12 \times MRR = 5 \times 10^3$ (MRR in mm^3/min)

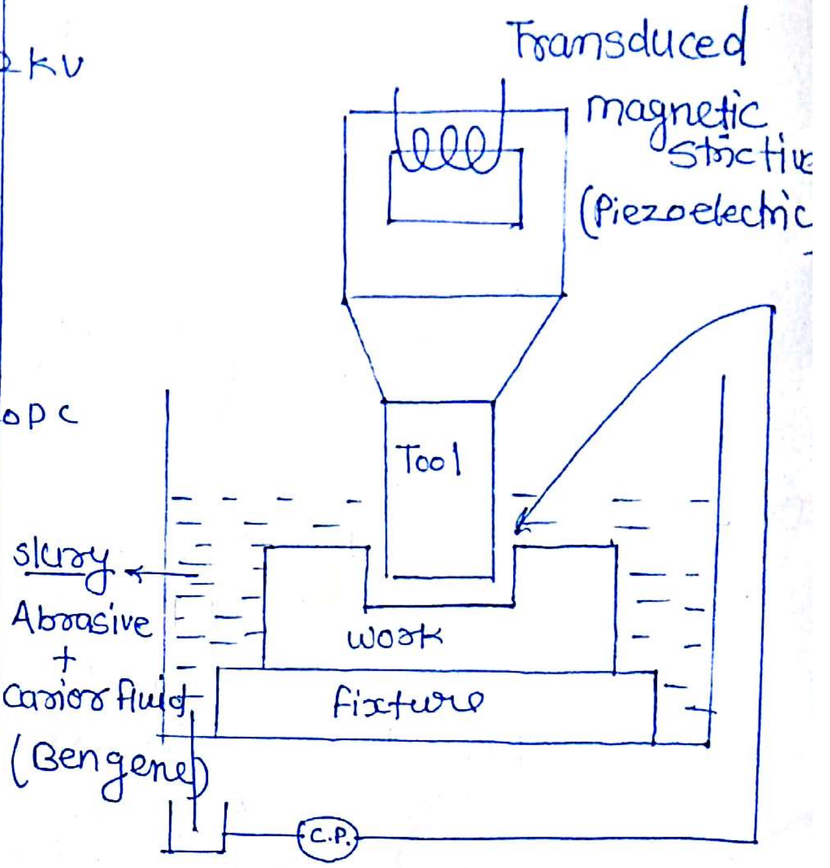
$12 \times \overset{50}{\cancel{150}} \times 10^{-6} \times \cancel{10^3} \times 1 \times V = 5 \times \cancel{10^3}$

$V = \frac{10^5}{36}$ mm/min

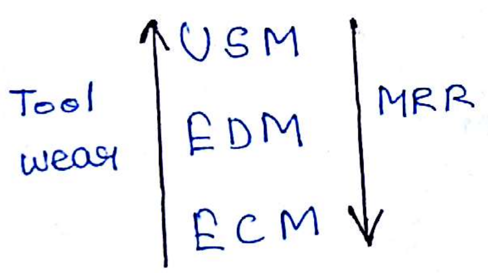
Electro Beam Machining

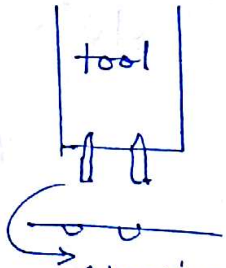


Ultrasonic Machining



Tool wear & MRR





Gap = 0.25MM
CLA Ra = 0.25 - 0.75MS
USM

Abrasive goes stuck to tool and abrasive cut tool chance of tool wear More

For machining by ECM & EDM work piece is need to be conducting in Nature. For non-conducting like ceramics, Glass etc. USM is used.

~~For~~

USM - Brittle

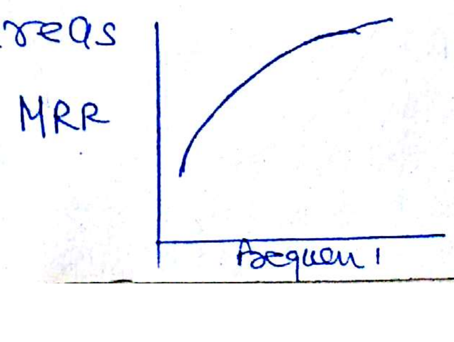
Transducer are used to produce a vibration at very high frequency. There are some Ni based material when kept in magnetic field they changes dimensions at very high frequency called magnetostrictive transducer.

→ There are some other Ni based material when kept in electric field they changes dimension at very high frequency called piezo-electric transducer.

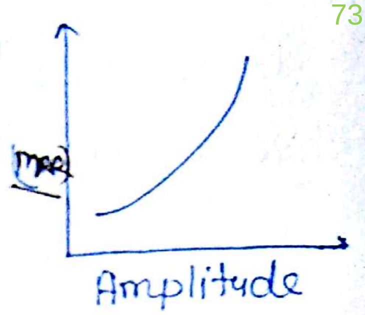
→ With the help of a connector these vibration are transfer to tool. ~~the~~ Tool is made up of some ductile material so abrasive will be embeded into the tool material. During the downward journey of tool these abrasive hammer the brittle work material and hence a portion of work material will chip out.

→ A portion of tool material will also work harden and after some time a portion of tool material will also be eroded.

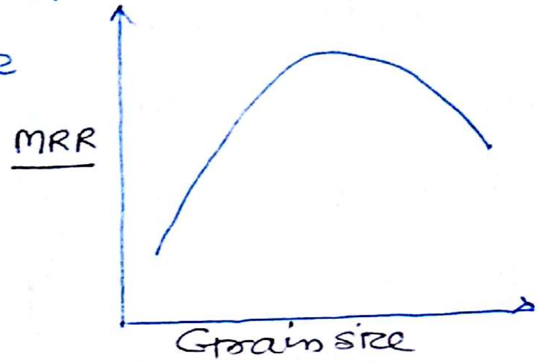
⇒ By increasing the frequency more No. of times Impact on the work and this will increas the MRR



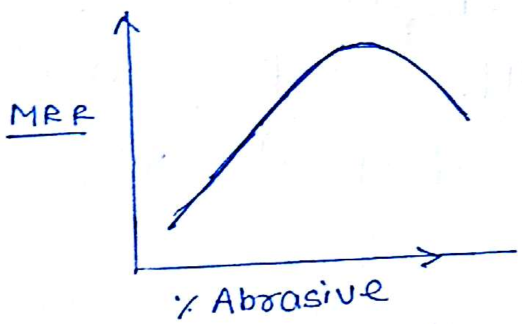
→ By increasing the amplitude Abrasive will have more time accelarate this will increase the impact and hence MRR will go up.



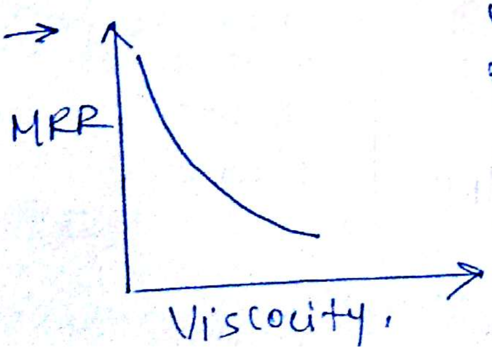
→ Initially by increasing the size of abrasive impact will be on the larger area this will increase MRR but when the grain size ~~is~~ exceeds beyond a certain Value since the size is approching towards to amplitude, there is no sufficient time for abrasive to accelarate this will decrease the MRR.



→ Initialy by increasing the Concentration of abrasive impact will be there at more no. of places so MRR will go up. But when concentration exceeds beyond certain Value there will be collision b/w Abrasive So there will a portion of ~~abrasive~~ momentum will be loss This will decrease MRR.



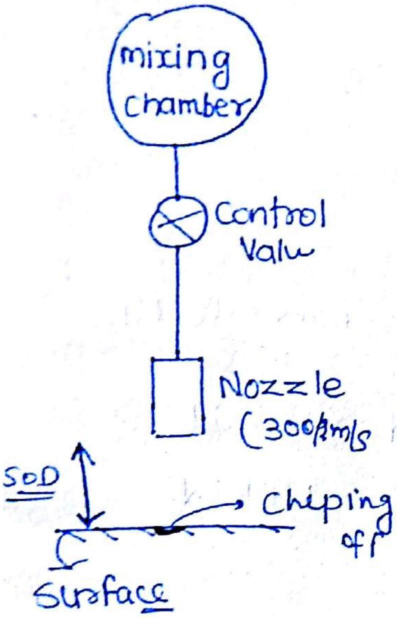
→ when the viscosity of carriour fluid is high flushing will be improper so a portion of removed material will remain in tool workpiece Gap. so these abrasives First Colide



with these chips and loses the portion of energy So laser energy will be left for machining.

→ This process is economic only for Brittle materials

Abrasive jet machining :- (AJM)

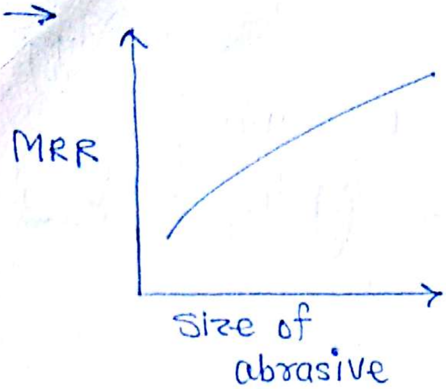


A mixture of abrasive and carior Fluid comes out through the Nozzle at a very high speed (300m/s). when Abrosive bombard the Brittle Material there will be localized crack and due to high speed wind crack will be propogated and chip will be gone away.

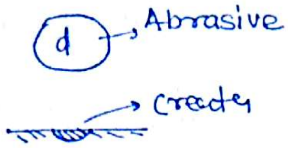
→ This Nozzle is by power matellurgy and there will be wear on nozzle.

Application

1. making very fine hole.
2. Cleaning mellatic molds
3. Machining in-accessable area
4. cutting force in forge Component
5. Removing parting line.

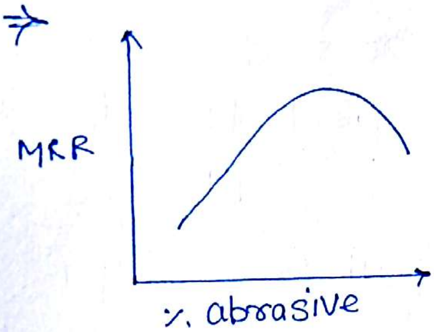
→ 

By increasing the size of abrasive since impact will be on larger area so MRR will go up



MRR = (Vol. of creater) (No. abrasive / time)

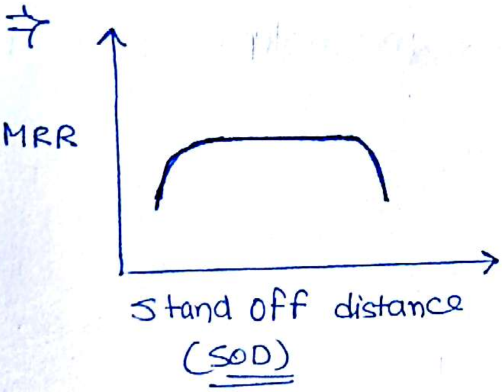
$\propto d^3$ — diameter

→ 

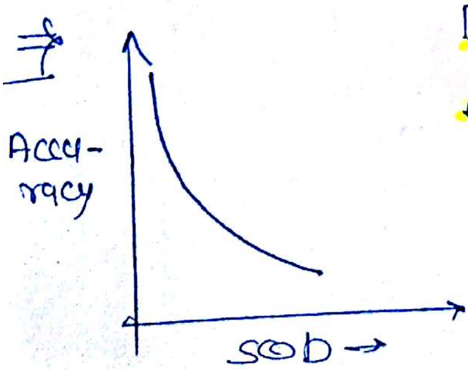
(same as USM)

% Abrasive ↑ impact is more so MRR ↑

when % Abrasive ↑ beyond a limit collide and loss Momentum lost so MRR ↓

→ 

Initially by increasing the stand off distance ~~accel~~ more time will be available for accelation this will ↑ the momentum by in a certain range of SOD there will be a balance b/w accelaration and drag, so MRR almost constant seen. When SOD exceeds beyond a certain value drag will overpower the momentum and MRR ↓.

→ 

By increasing the SOD due to Mushrooming effect machining will loose accuracy.