Advance Manufacturing Processes.

6th Sem.

by

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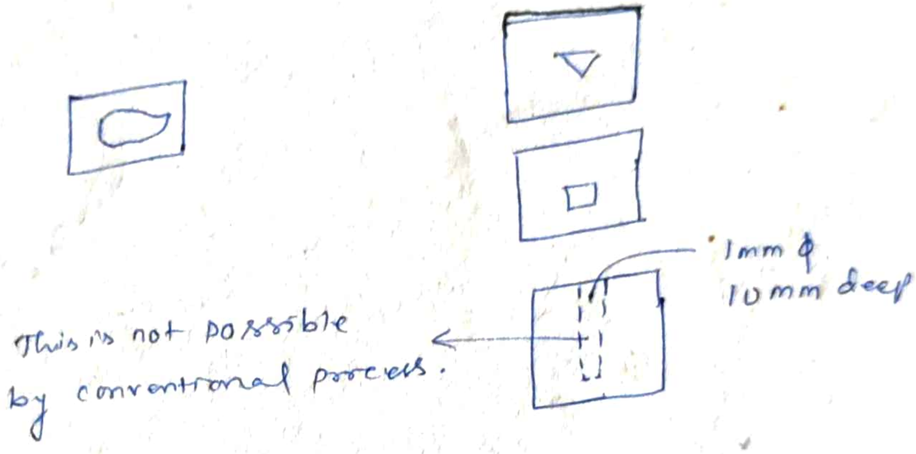
Conventional machining

There is physical contact between tool & job.

Non Conventional machining process

There is no contact between the tool & job.



The conventional methods of manufacturing like drilling, milling etc. are of little use for some applications.

The need of special processes has been responsible for the invention of a number of machining processes such as ultrasonic machining (USM), EDM (or) spark erosion machining ECM, LBM etc.

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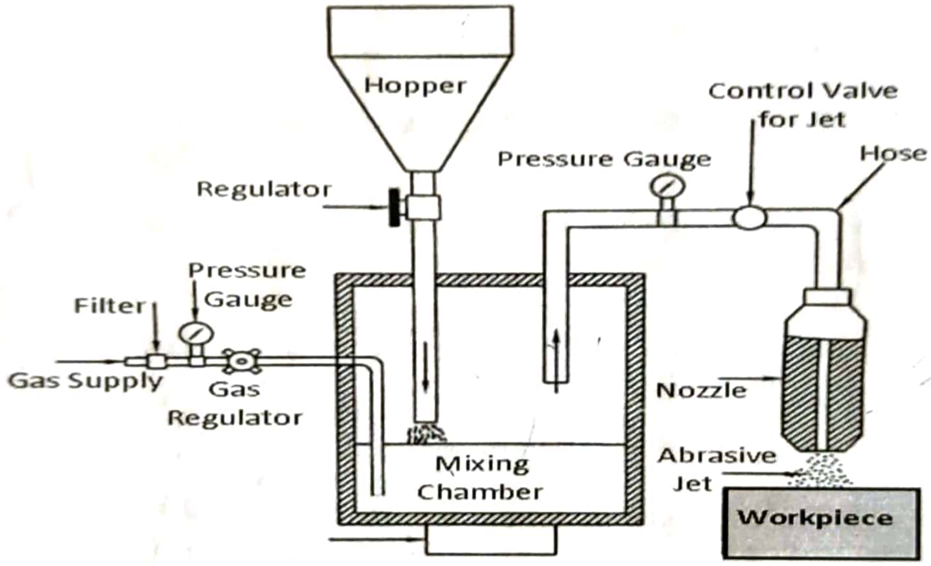
ABRASIVE JET MACHINING (or IMPACT EROSION MACHINING)

PRINCIPLE

In **abrasive jet machining** process, a stream (jet) of abrasive particles carried by the high-pressure gas or air (compressed air) is made to effect on the work surface through a nozzle, and the work material is removed by erosion due to the high-velocity abrasive particles. **AJM** uses a stream of fine grained abrasives (of size 10 to 50 microns) mixed with compressed air or some other carriers gas at high pressure. This stream is directed on the work surface by using a suitable nozzle. The velocity of carries gas or air is up to 200 to 400 m/sec.

Abrasive jet machining (**AJM**), also known as abrasive micro-blasting, pencil blasting and micro-abrasive blasting, is an abrasive blasting machining **process** that uses abrasives propelled by a high velocity gas to erode material from the workpiece.



Principle of Abrasive Jet Machining

Nozzle Materials

AJM nozzle is usually made of tungsten carbide or sapphire (usually life – 300 hours for sapphire , 20 to 30 hours for WC) which has resistance to wear. The **nozzle** is made of either circular or rectangular cross section.

Description of Equipment and Working

The setup for abrasive jet machining which consists of mixing chamber in which fine grained abrasive particles are filled through a holding device like a "Hopper".

The mixing chamber vibrates (upto 50 cycles/sec) and amplitude of these vibrations controls the flow of abrasive particles. To control the amplitude of vibration, regulator is placed in the system.

Compressed air or high pressure gas is supplied to the mixing chamber through a pipe line which carries a pressure gauge to control its pressure.

These particles mix in the stream of gas/ air pass through a pipe line, which carries a pressure gauge to control its pressure and pass through a nozzle. This stream of mixture of gas and abrasive particles is called as Abrasive Jet.

Working:

Through hopper, fine grained abrasive particle is filled in a mixing chamber.

The gas as air is supplies through the pipeline which carries a pressure gauge and regulator to control the flow.

The gas or air is supplied under pressure into the chamber, the pressure of gas varies from 2 to 3 kg/cm2 .

This mixture of abrasive particle and compressed air is passed through a nozzle on the surface of workpiece and due to high speed mixture erosion is caused and metal removal takes place.

Parameters in AJM:

- Carrier Gas:
  - A gas used should be non-toxic, cheap, easily available and capable of being dried easily.
  - Commonly used gases are air, nitrogen and carbon di-oxide.
- Type of Abrasives:

  Synthetic Diamond.

  Silicon Carbide.

  Aluminum Oxide.

  Boron Carbide.

  The abrasive used in the process should have a sharp and irregular shape and should have excellent flow charactertics.

  Commonly used abrasives are**aluminum oxide and silicon carbide** for general machining and grooving whereas sodium bi-carbonite for line finishing and dolomite for etching and light cleaning purpose.

- Jet Velocity:
  - The kinetic velocity of the abrasive jet is utilized for metal removal by erosion.

- The velocity is a function of nozzle pressure, nozzle design and abrasive grain size.
- Higher nozzle pressure results in greater MRR. Also, higher grain size produces higher MRR. The inside diameter of the nozzle is about 0.04mm.

- Stand-off Distance(SOD) or Nozzle Tip Distance (NTD):
  - It is the distance between the tipof nozzle and working surface of the workpiece to be machined.
  - Generally, it is kept about 0.7mm to 1.0mm.
  - The shape and size of cavity produced as well as the surface of the workpiece is affected by NTD.
  - If NTD increases, the velocity of abrasive particles striking on the workpiece also increases, hence MRR also increases.
  - Initially, MRR increases with NTD after which it remains unchanged for a certain NTD and then falls gradually.

MRR

Material removal rate depends onProcess Parameters like Gas **Pressure**, Velocity, Grain size, Abrasive shape, Nozzle **diameter**, Abrasive mass flow rate, Nozzle tip distance etc .

Advantages

Brittle Materials of thin sections can be easily maintained.

No direct contact between the tool and workpiece, hence less damage to the workpiece surface.

Holes of any shape and intricate cavities can be machined.

Initial investment is low as compared to other methods.

Power consumption is low.

Suitable for removal of deposits on surface
Wide range of surface finish can be obtained
High degree of flexibility
Suitable for nonconductive brittle materials

Disadvantages:

The material removal rate is low.

Poor machining accuracy.

High nozzle wear rate.

The soft material cannot be machined.

Suitable only for brittle materials

Chances of abrasive particles getting inserted in the work materials hence cleaning needs to be done after machining.

Used abrasive particle cannot be reused.

Applications of AJM:

The process is best suited for machining brittle and heat sensitive materials like glass, quartz, sapphire, ceramics, etc.

It is used for drilling holes, cutting slots, cleaning hard substance deburring, polishing, etc.

It is used for producing high quality surface.

It is used for reproducing design on a glass surface with the help of masks made of rubber, copper, etc.

AJM

Abrasive Particles

Generally used

- ~~Abrasive~~
- Aluminium oxide.
- Silicon Carbide.

For Light work & Polishing job

- sodium bi-Carbonate
- Calcium / magnesium Carbonate
- Nylone
- Taplone
- Glass powder

Velocity of Abrasive particle = 300 m/sec

Pneumatic pressure = Range (2.5 kg/cm^2 to 10 kg/cm^2)

Nozzle material

Tungsten Carbide — works for 30 hrs.

Ceramic — works for 300 hrs

Max cutting rate → NTD (7 to 13 mm)

Abrasive grain size

- 10 – 150 μm.

Flow Rate – 1–5 gm/min
5–10 gm/min (Normal)
10–20 gm/min (heavier)

AJM

Operating Parameters

a) Abrasive

- strength
- size
- shape
- mass flow rate

b) Carrier gas

It should be - non-toxic

- Cheap
- easily available
- Capable to dried
- Cleaned without difficulties

- CO_2
- N_2
- Air
- Argon

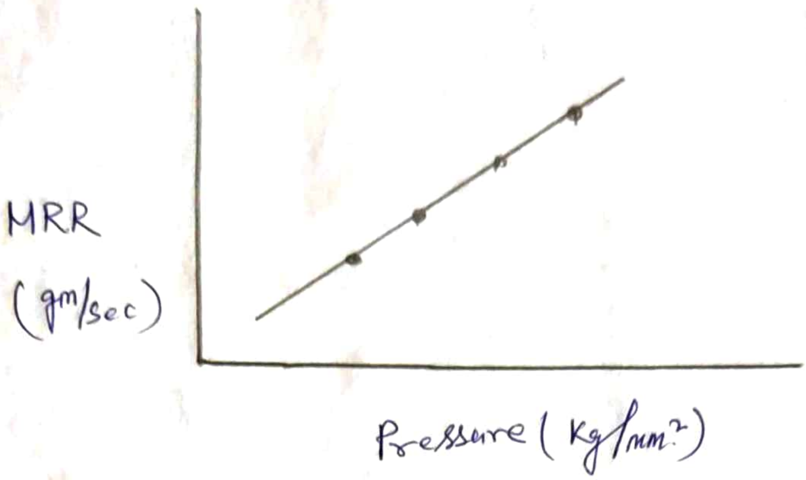
c) Nozzle

- Diameter
- materials

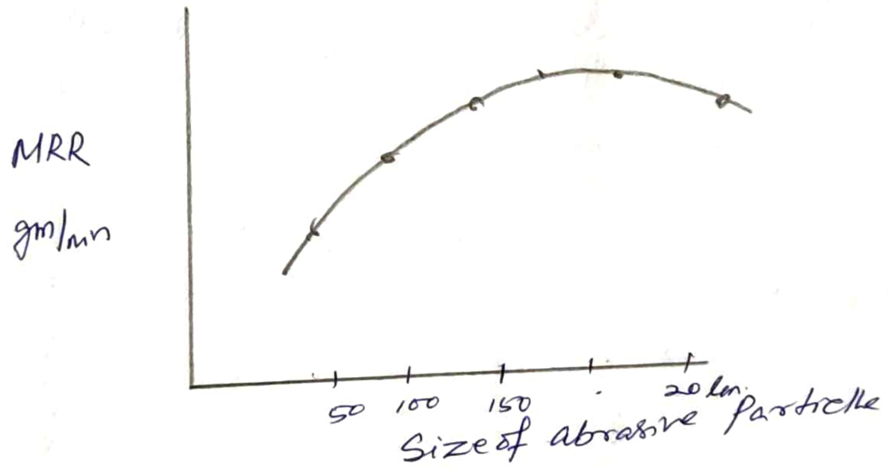
d) Other Parameters

- Distance
- Impact Angle
- Temperature
- Hardness.

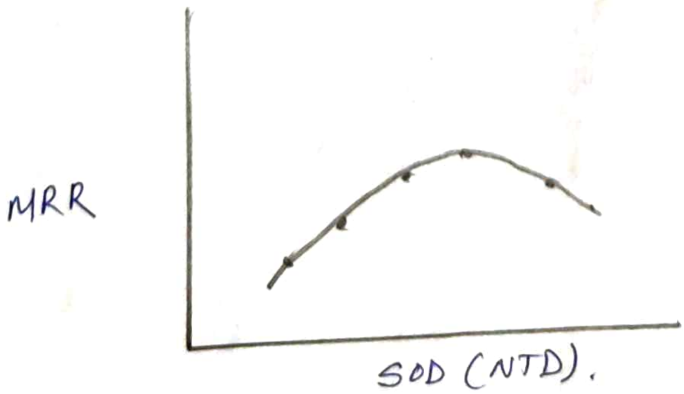
AJM ① Effect of Pressure



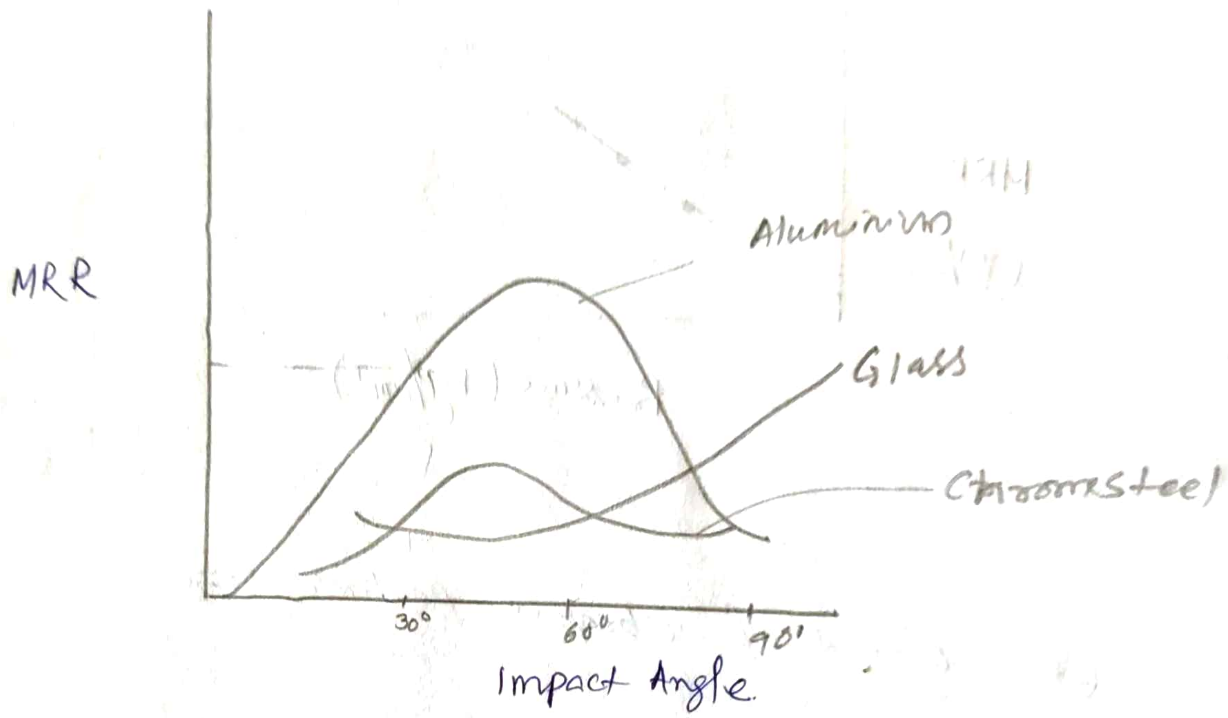
② Effect of abrasive particle Size



③ Effect of Standup Distance (b/n Nozzle & w/p

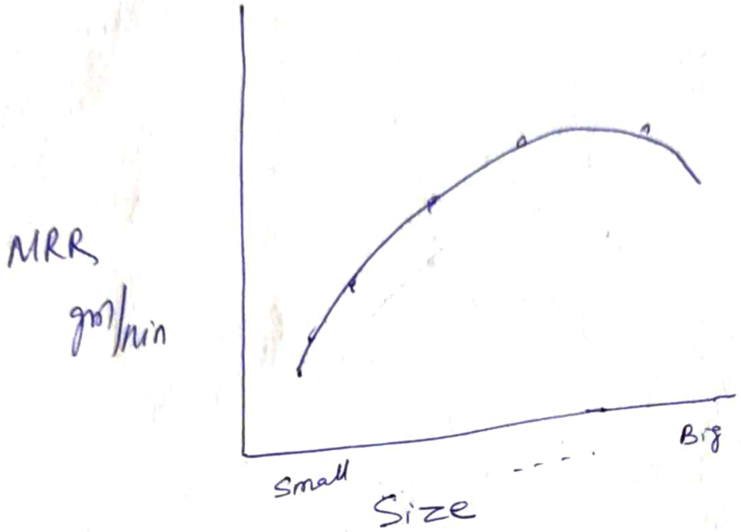


(4) Effect of Impact Angle

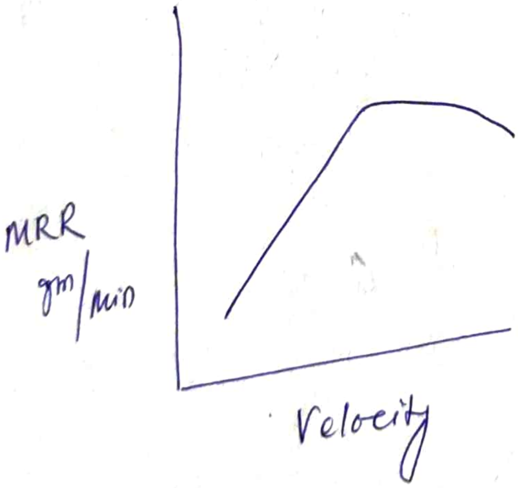


AJM

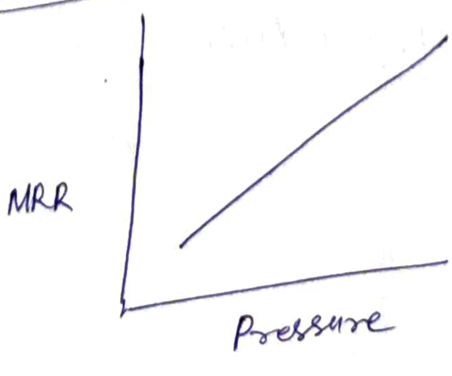
① Effect of Particle Size Vs MRR



② Effect of Velocity Vs MRR



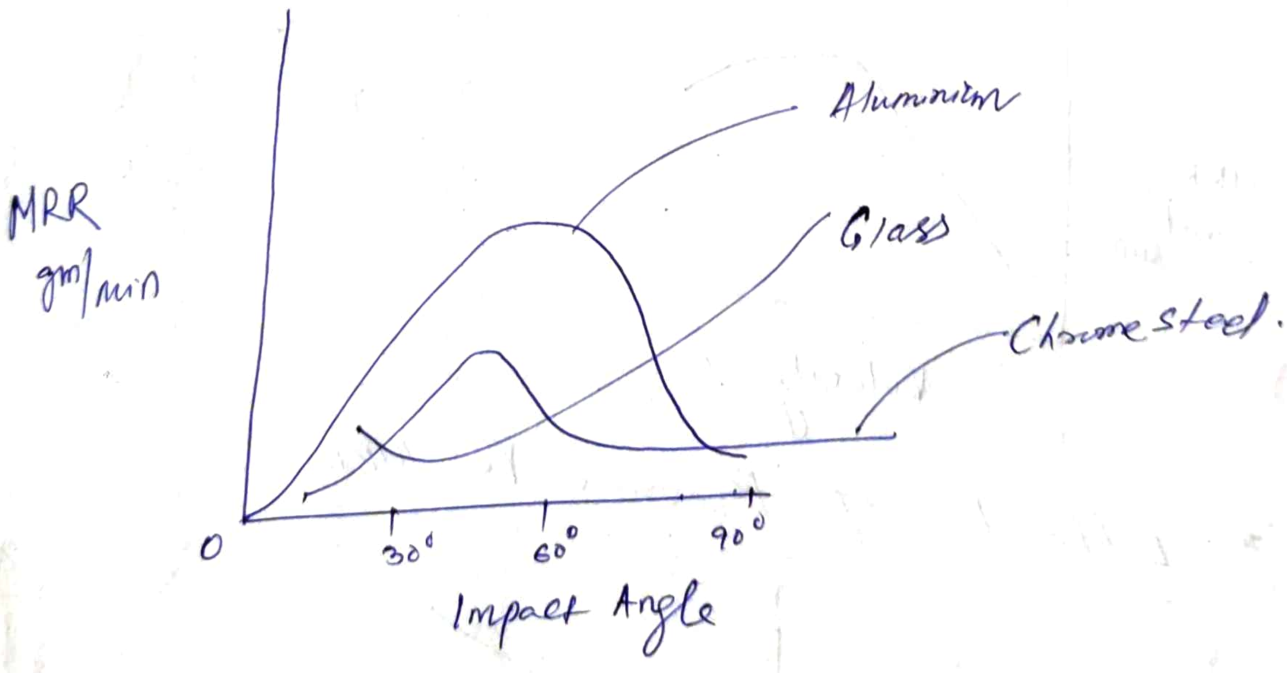
③ Effect of Pressure Vs MRR



(4) Effect of SOD (NTD) Vs MRR

(5) Effect of Impact Angle Vs MRR

(Brittle material)



ULTRASONIC MACHINING

PRINCIPLE OF USM

Ultrasonic machining is a subtractive manufacturing process that removes material from the surface of a part through high frequency, low amplitude vibrations of a tool against the material surface in the presence of fine abrasive slurry.

MECHANISM

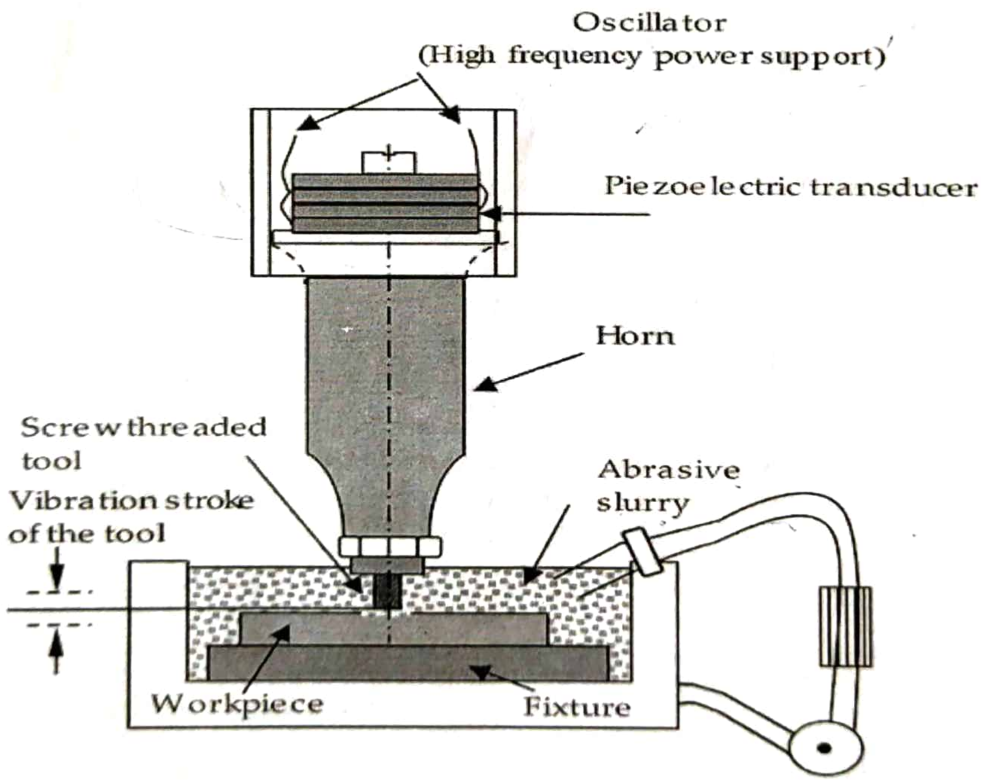
In this process the material of the workpiece is removed by the repetitive impact actions of slurry of abrasive particles. The erosion takes place by the abrasive particles which are carried by a liquid medium in the fromof slurry.

Parameters of USM

Parameters of USM are abrasive size, the effect of slurry concentration and viscosity, effect of amplitude, the effect of frequency, effect of tool and work materialetc. To obtain high results in terms of accuracy and precision, we need to consider the optimal value of these parameters.

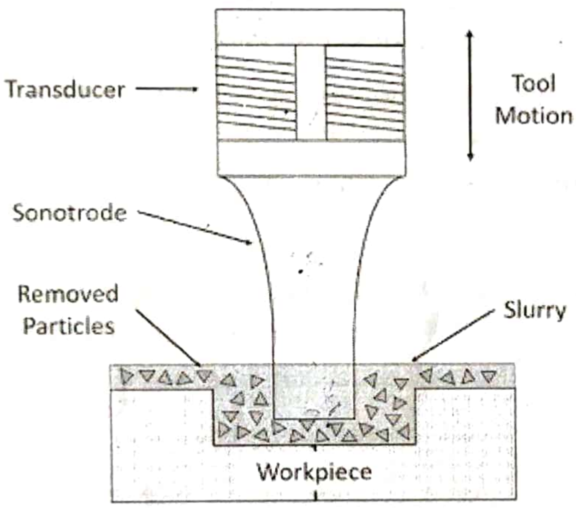
Function of the transducer

The function of transducer is to convert **electrical energy into mechanical vibration** using the principle of piezoelectric or magnetostriction.



Ultrasonic Machining (USM) also called as ultrasonic vibration machining is a machining process in which material is removed from the surface of a part by low amplitude and high frequency vibration of a tool against surface of material in the presence of abrasive particles.

- The motion of the tool takes place vertically or orthogonal to the surface . The tool travel with an amplitude of 0.05 mm to 0.125 mm (0.002 in to 0.005 in).
- The slurry is formed by mixing fine abrasive grains in the water. This slurry is made to flow across the w/p and the tip of the tool during machining process. The abrasive gain particles in the slurry helps in the removal of the material form the surface of the w/p. The grain sizes of the abrasive material are typically ranges from 100 to 1000μ. The smaller grains (i.e. higher number of grain) results in smooth surface finishes.
- This machining process is usually used to machine brittle materials
- An electric current at high frequency (in the ultrasonic range i.e. 18 kHz to 40 kHz) is used to generate mechanical vibration of low amplitude and high frequency. The mechanical vibration generated is used for machining the surface of a part in the presence of abrasive grain particles in the form of slurry. The slurry flows across the tool and workpiece. When the tool presses against the w/p, the slurry containing abrasive particle chips off the materials from the surface.



The function of various parts

Transducer:

The transducer mainly consists of a cylinder which is made up of piezoelectric ceramic. It converts **electrical energy into mechanical vibration.** Transducer then vibrates sonotrode at low amplitude and high frequency.

Sonotrode:

It is made of low carbon steel. One end of it is connected with the transducer and other end contains tool. The sonotrode vibrates at low amplitude and high frequency and removes material from the w/p by abrasion .

Control Unit:

The control unit consists of an electronic oscillator which produces an alternating current at high frequency. The frequency produced is usually in between 18 kHz to 40 kHz in ultrasonic range.

Advantages of Ultrasonic Machining:

This process is used for drilling both circular and non-circular holes in very hard materials like carbide, ceramics, etc.

This process is best suited for brittle materials.

The machining operation is simple and requires less time.

This process is economical.

Disadvantages of USM :

1. It can be proved slower than the conventional machining processes.

2. Creating deep holes is difficult because of the restricted movement of the suspension.

3. It is arduous to select the perfect tool geometry for creating hole of certain dimension. The holes created may be of larger sizes because of side cutting.

4. High tool wear because of continues flow of abrasive slurry.

Applications:

1. Hard and brittle materials can be machined like tungsten carbide, diamond and glass. These are difficult to machine in conventional m/c-ing process.

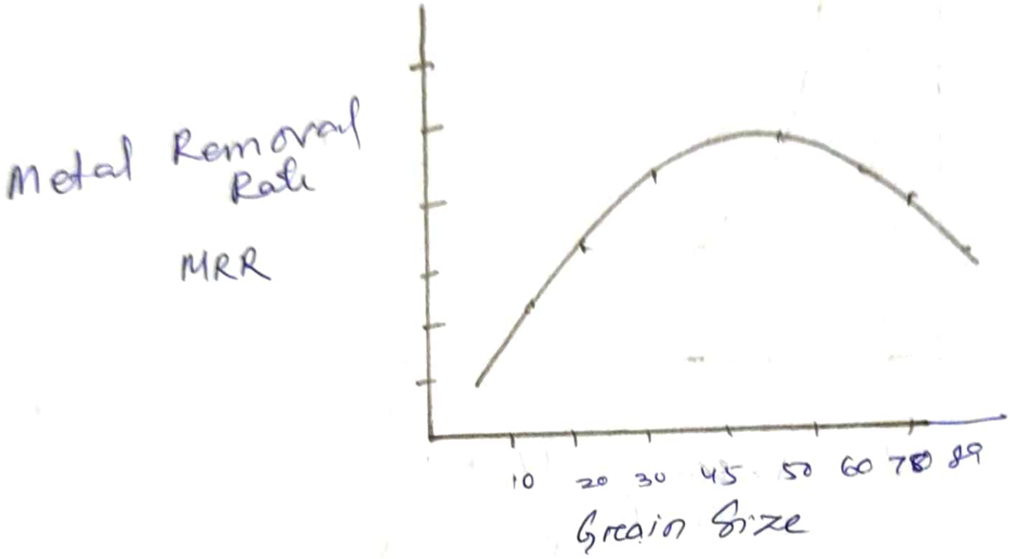
2. Wire drawing dies of tungsten carbide can be drilled by this process.

3. Circular as well as non-circular holes can be done with straight or curved axes.

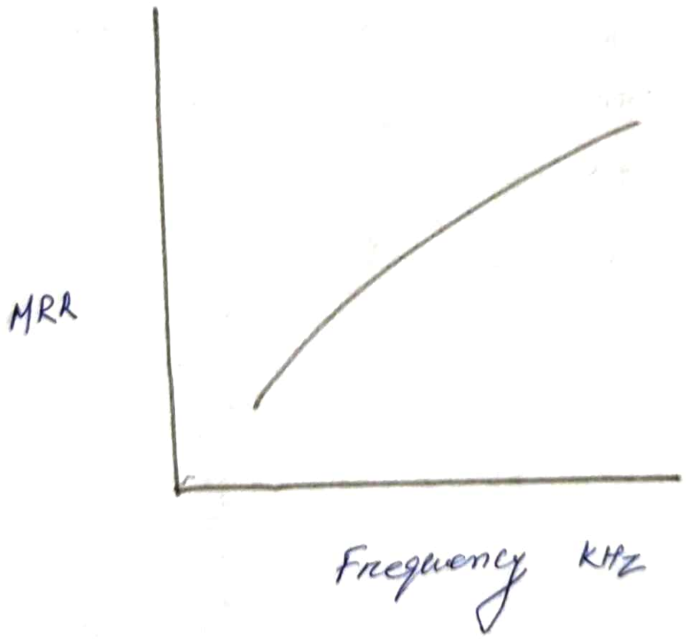
4. It has been proved successful in machining geranium, silicon quartz and synthetic ruby etc.

USM

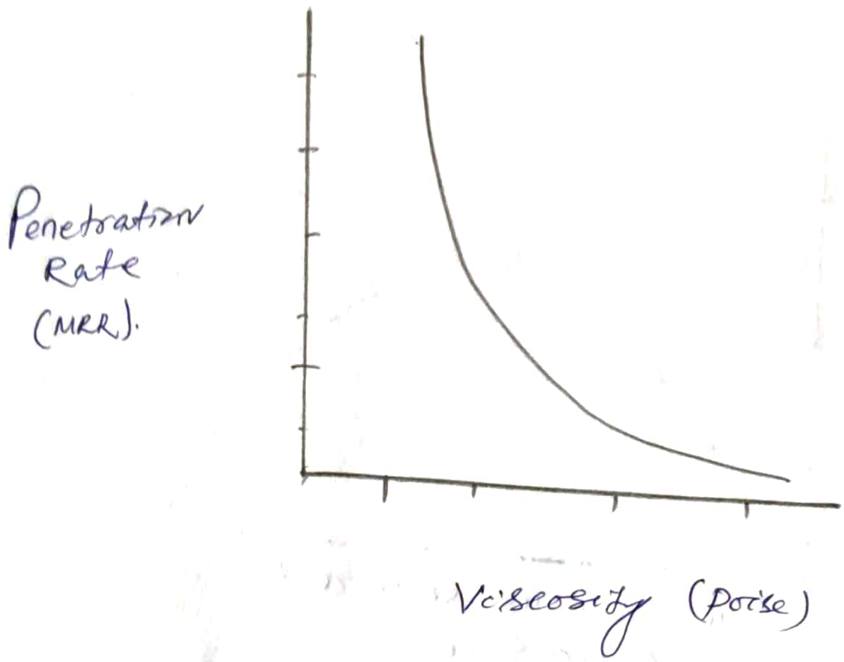
① Effect of Abrasive Size Vs MRR



② Effect of Frequency Vs MRR



③ Effect of Viscosity of Carrier fluid Vs MRR



USM

- Generally the tool oscillates at frequency
  — 15 to 30 KHz

- Piezo electric effect

- Electrical Energy converted into mechanical vibration.

- Slurry (mixture of water (Liq) & Abrasive Particle)

Most commonly used Abrasives

- Boron nitride
- Aluminium oxide
- Silicon carbide
- Boron carbide.

- Boron nitride is expensive but gives good machining rates

- Boron carbide is economical (gives better results)

To increases the cutting (rate) time

(Add to slurry (glass, germanium, ceramic) give 20–40% more cutting time than Boron carbide)

- Diamond dust can also be added

· Carrier fluid

- Water
- Benzene
- Glycerol
- oil

USM

USM Characteristics

- Mechanics of material removal — Brittle fracture caused by impact of abrasive grain due to tool vibration at high frequency

Medium — Slurry

Abrasives — B_4C, SiC, Al_2O_3, diamond (100–500μ grain size)

Vibration — 15 — 30 KHz

Amplitude — 20 — 100 μm

Material (Tool) — Soft Steel.

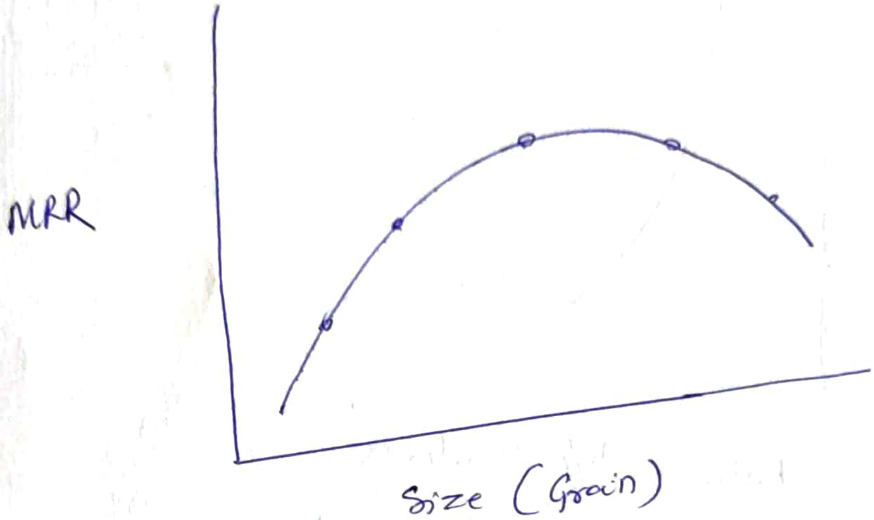
Critical Parameters

- Frequency, Amplitude
- Tool material
- Grit size
- Abrasive material
- Slurry
- concentration
- viscosity

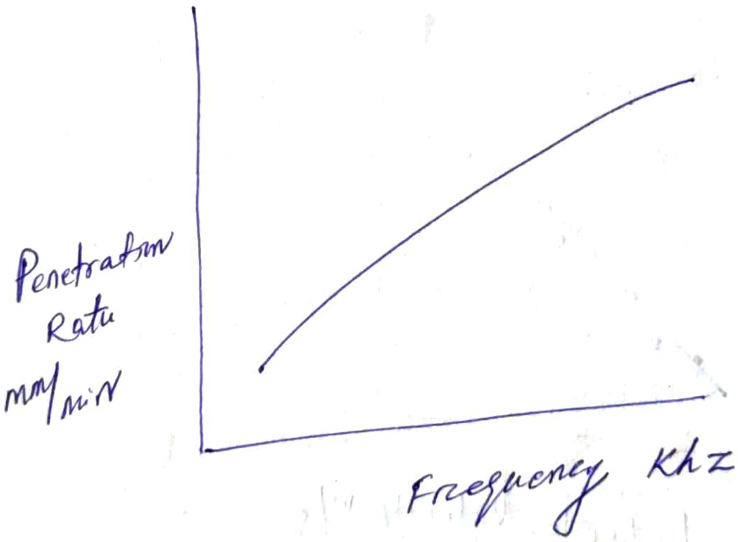
Shape → Irregular.

USM

① Effect of Abrasive size Vs MRR

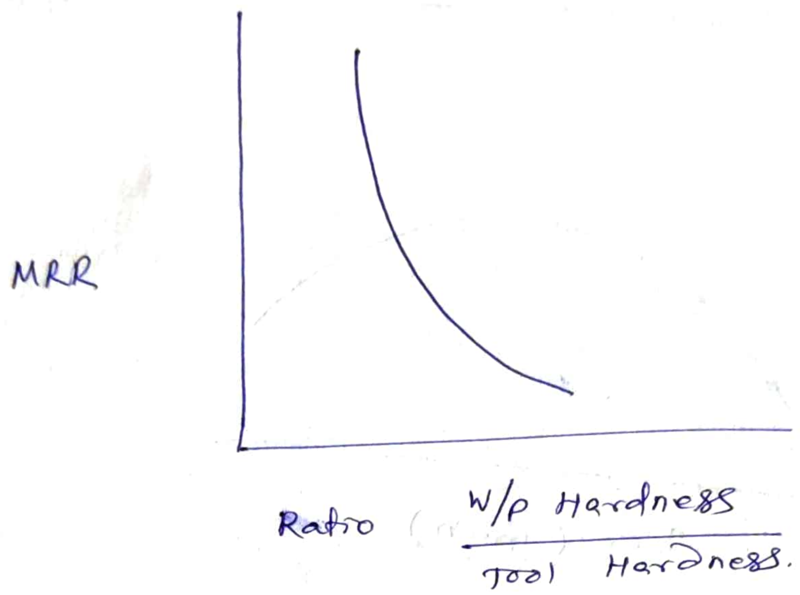


② Effect of frequency of vibration Vs MRR

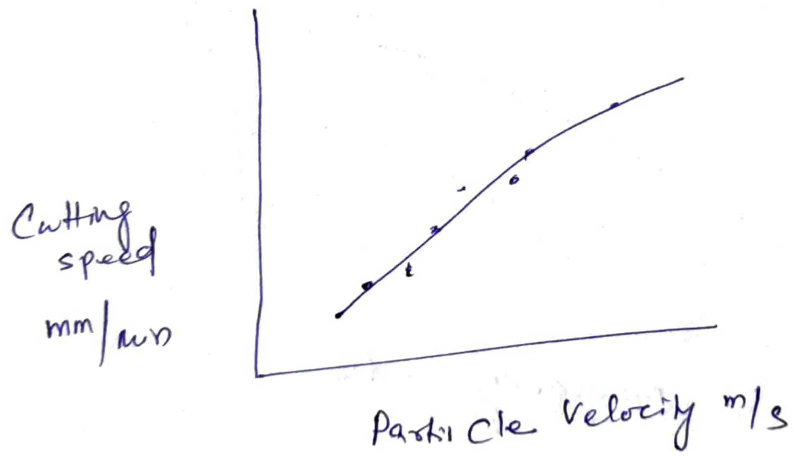


③ Effect of viscosity Vs MRR

(4) Effect of Hardness ratio of W/p & Tool



(5) Effect of Abrasive grain Velocity Vs Cutting Speed



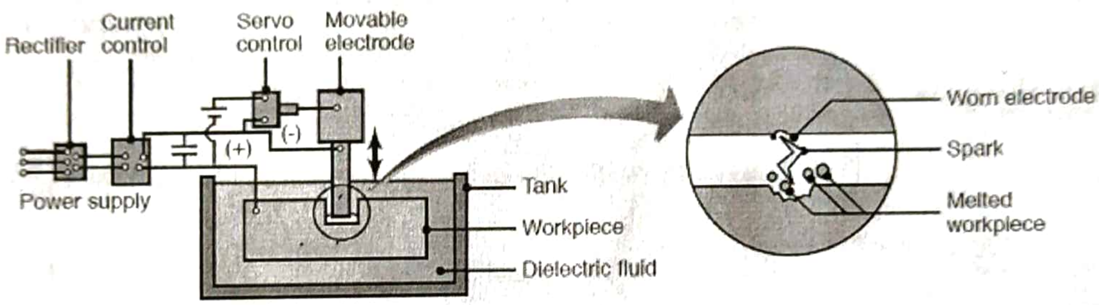
EDM (Spark Erosion Machining)

PRINCIPLE

Electrical discharge machining process works on the basic **principle** of spark generation and metal removed by spark erosion. ... The spark generated by this process produces heat, which remove metal by erosion and evaporation. In this machining process both the work piece and tool must be made by conductive material.

PROCESS PARAMETER

The parameters considered are pulse current, gap voltage and pulse-on-time, whereas the responses are electrode wear rate and material removal rate.



Description of Equipmentand Working

Power Supply:
In a EDM process a high frequency current used to generate spark between electrode and work piece. This spark generates heat and remove metal form work piece.

Dielectric fluid (Kerosene or Transformer oil)and flushing system:

The dielectric fluid acts as a vehicle to drive away the chips and thus preventing them from sticking to the surface. This fluid acts as flushing system for chips. It also helps in increasing the metal removal rate by promoting spark between tool and work. This fluid also works as coolant medium.

Tool and tool holding devices:

In EDM process, tool also erodes due to spark hence the selection of tool depends on wear ratio and cost of material. The most commonly used electrode material are

Copper

Tungsten alloy,

Cast Iron,

Steel,

Silver tungsten alloy,

graphite.

Work piece and work holding devices:

In this process only good conductors of electricity can be machined. So the work piece should have good electric conductivity. This process does not depend on hardness of work piece so there is no criteria of hardness.

In this process, work piece should be well electric conductive.

- First both work piece and tool are submerged into dielectric fluid. The dielectric fluid help to control the arc discharge. This also removes suspended particles of work piece material and tool from the work cavity.
- A servomechanism is used which maintains a very small gap between the work piece and the tool. This gap is desirable for proper arc formation. It is about the thickness of very small.
- The tool is made as the opposite shape of work piece.
- A high frequency current supplied to electrode, which produces a spark(due to Capacitor) between the tool and work piece. This spark generates high in work cavity.
- The metal removed from the work piece due to erosion and evaporation.
- The chips or suspended particle between tool and work pieceshould be removed to prevent them to form bridge that causes short circuit. This is done by continuous supply of dielectric fluid.
- The EDM produce a cavity slightly larger than the electrode because of overcut.

Output Characteristics

During this process, the main machining **output** parameters are the material removal rate (MRR), tool wear ratio (TWR) and surface roughness (Ra) of the workpiece. It is desirable to obtain the maximum MRR with minimum TWR and surface roughness

Advantages of EDM

- Cut internal corners with very small radii.
- Every conductive material can be cut by this process.
- It is independent on hardness of workpiece so hardened work piece can be machined easily.
- Complex die section and complex shapes can be produce accurately.
- Thin section can be easily machined without deforming the part.
- Cut thin slots in extrusion dies with wire **EDM**.
- Produce blind and high aspect ratio pockets with sinking **EDM**.
- Produce non-round openings and cavities.
- An alternative to broaching for 2D shapes like gears.

Disadvantages

- In this machining process high tool wear occurs.
- Tool wears limits accuracy and surface finish of metal.
- Only good conductors of electricity can be machined by EDM.

Applications of EDM.

- Die Making. Dies are tools used to cut or shape materials into a solid product. ...

EDM

- MRR in EDM is due to metal erosion by interrupted electrical discharges.

- Dielectric medium
  - Kerosine
  - Transformer oil

- DC power supply
  Consist of Capacitor, Resistance (RC circuit)

- Work pc connected to +ve (Anode)
- Tool " " -ve (Cathode)

MRR

The vol. of metal removed/sec ∝ N (No. of sparks/sec)

$$N = \frac{1}{RC} \ln \frac{E}{(E - V_d)}$$

V_d = Discharge voltage

E = Supply "

R_c = Charging Resistance

C = Capacitance

$M = MRR$

$$M \propto N \times \frac{1}{2} C V_d^2$$

$$M = \lambda \frac{V_d^2}{R} \ln\left[\frac{1}{1-\left(\frac{V_d}{E}\right)}\right]$$

Where λ = Constant of Proportionality.

—

No. of sparks/sec → (Range - 3000 to 10,000)

R kept → Sufficiently high.

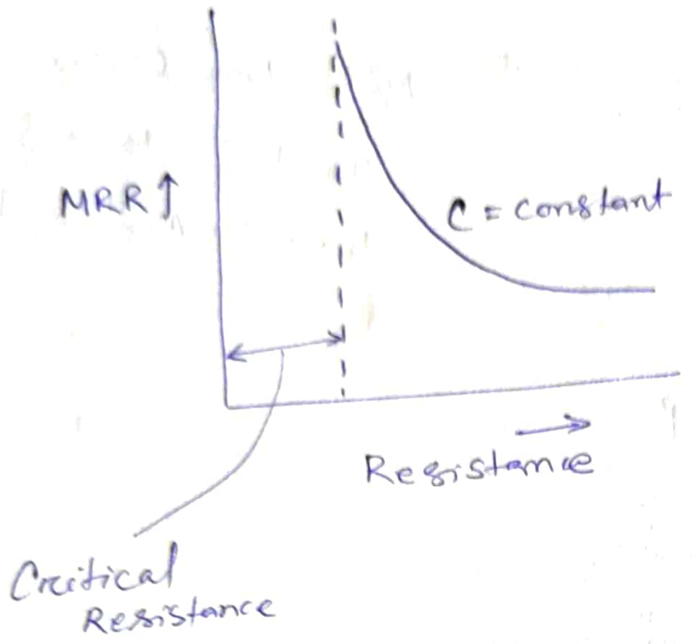
Tool Materials

— Soft material like

- Copper
- brass
- Silver tungsten
- Copper tungsten.

EDM

① Effect of Resistance Vs MRR



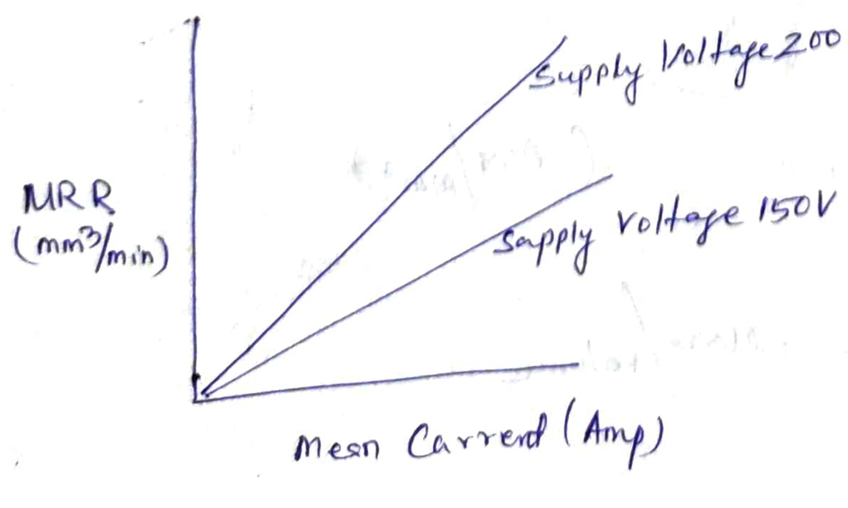
- "MRR" will increase with decreasing 'R'
- However "R" can not be made very low, because in that arcing will occur instead of sparking.

* Critical Resistance

The mean value of resistance that will prevent arcing is known as Critical Resistance.

② Effect of Voltage & Current Vs MRR

Dielectric medium - Kerosine
Tool - Brass
W/P - Low. Carbon Steel

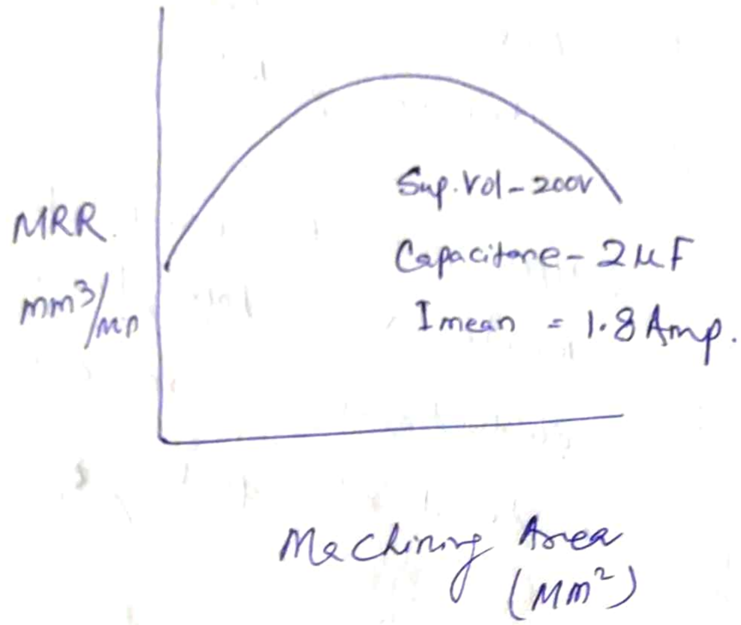


③ Effect of Machining Area Vs MRR

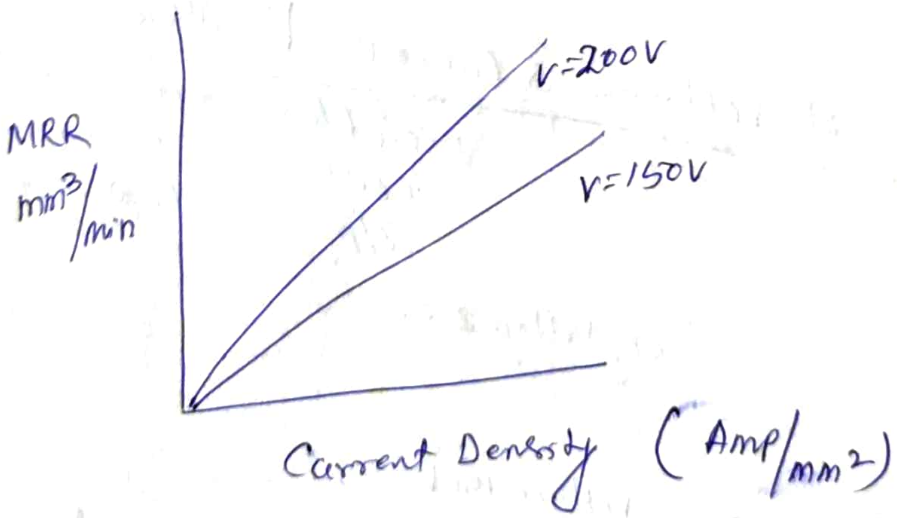
W/P - Low Carbon Stee

Tool - Brass

Dielectric Medium - Kero



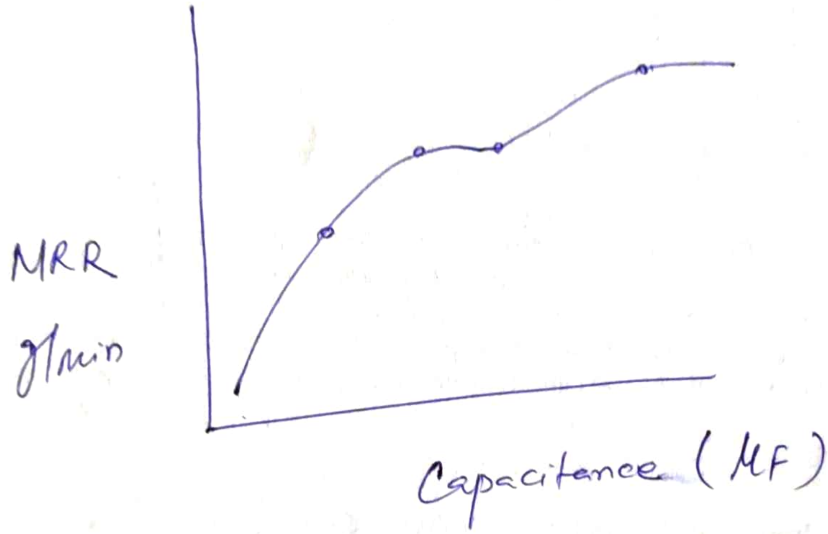
④ Density (Current) Vs MRR



Density = Mass/volume.

EDM

Capacitance Vs MRR

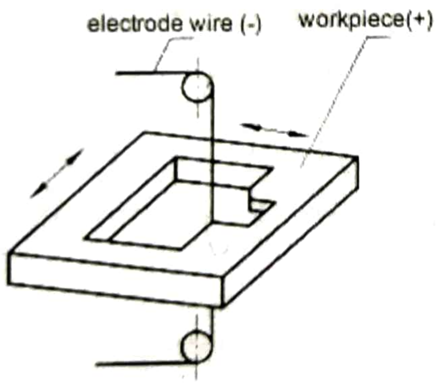


- Mold Making. Molds are containers that transform liquid or substance into the shape of the container. ...
- Small Hole Drilling. Without **EDM**, drilling small holes would be difficult.

WIRE EDM

Wire EDM process, the **wire** carries one side of an electrical charge and the workpiece carries the other side of the charge. When the **wire** gets close to the part, the attraction of electrical charges creates a controlled spark, melting and vaporizing microscopic particles of material.**Wire EDM** machining works by creating an electrical discharge between the **wire** or the electrode and the **work** piece. As the spark jumps across the gap, material is then removed from the **work** piece and the electrode.

Wire EDM machining works by creating an electrical discharge between the wire or the electrode and the work piece. As the spark jumps across the gap, material is then removed from the work piece and the electrode.



Advantages

A major advantage of wire EDM over conventional EDM is that the continuous supply of wire minimizes the wear that occurs with a fixed electrode.

A wire EDM machine can consume a lot of wire, however, adding expense. Many wire EDM machines are self-threading so that if a wire breaks the process can be continued almost without interruption.

Another major advantage is that parts may be cut after heat treatment which eliminates the possibility of distortion arising from post-machining treatments. Also, because the wire EDM method exerts no tooling pressure upon the workpiece, small, delicate parts are easily machined. Very fine surfaces are possible.

Limitations

Wire EDM is a slow process .

It can be increased by stacking identical parts and cutting them all at once.

Multi-head machines are available to cut multiple identical parts simultaneously.

Reel of Consumables wire is costly.

Time consumes for loading and unloading.

Wire Cut EDM Applications

Manufacturers use EDM wire cutting machine operation for an extensive range of applications. Because the process can cut very small pieces, Additionally, the process is cost-effective for low quantity projects and can prove to be beneficial in prototype manufacturing.

It is important to remember that the wire in the process is constantly moving, and not to be reused. As a result, the copper, brass, or other metallic wire can be miles long.

Most machining operations using wire EDM begin with a rough pass with a fairly fast feed rate and high dielectric flow.

LASER

LASER means -

Light Amplification by Stimulated Emission of Radiation.

It is a non - conventional machining process In this process, the metal is removed from the work piece by heating, melting and vapourcesing.

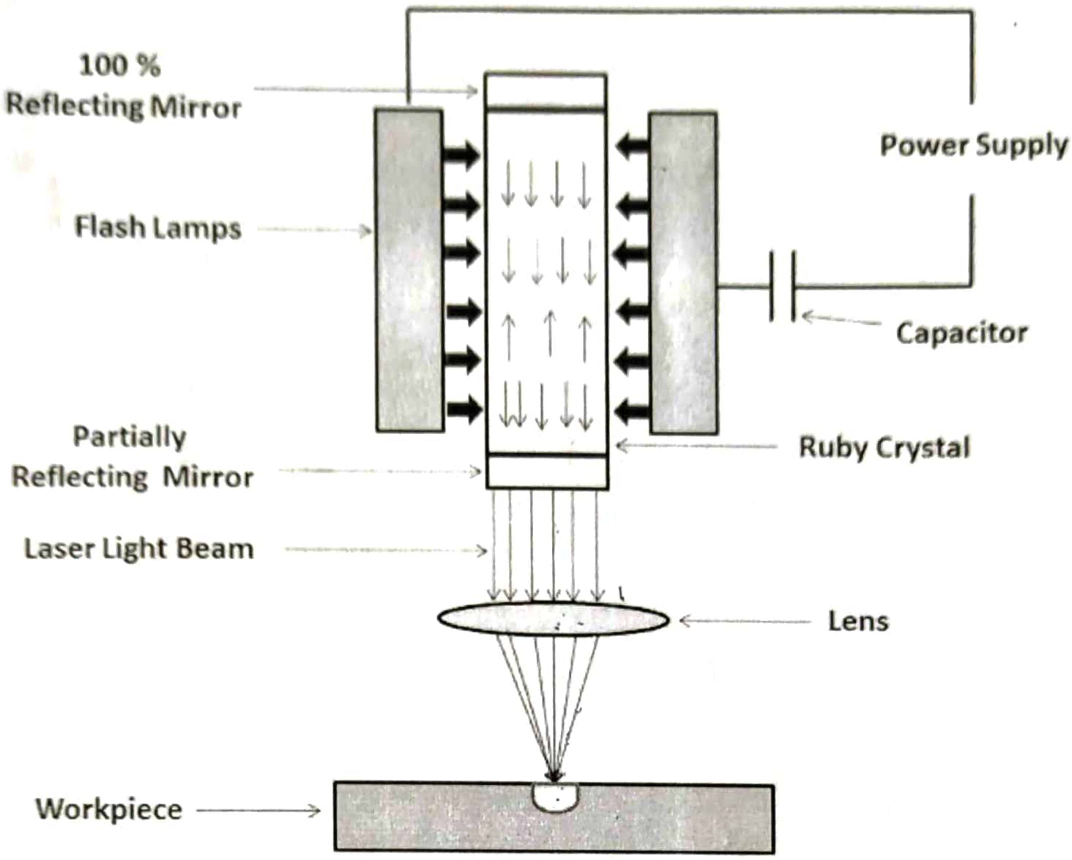
Laser beam machining (LBM) utilises the energy from the coherent beam called LASER.

The basic principle is that. Under proper condition light energy of a particular frequency is used to stimulate the electrons in an atom to emit additional light with exactly the same characteristic of original light source.

The laser beam is focussed with the help of the lens and the work pk is placed near the focal plane (point) of the lens, simultaneously a short pulse of laser melts and vapourise the material.

The explosive escape of the vapourrised metal helps in removing molton metal from the hole as droplets.

This process is used for making small holes. (0. 125 mm to 1.25 mm with a length to diameter ratio up to 100.



Equipments and Main Parts :-

1)Power Supply:-
The power supply is used in laser beam machining to provide energy for the excitation of electron from lower energy level to higher energy level.

2)LaserDischargeTube :-
Laser material is filled in laser discharge tube. The excitation of electron and coming back to its original state takes place inside this laser discharge tube. One side of discharge tube is partially transparent and other side is 100% reflected. It is situated between the xenon lamps.

3) Laser Material:

There are many kinds of laser materials available but in laser machining mostly CO_2 and Nd:YAG is used. Carbon dioxide is a laser material which emits light in infrared region. Carbon dioxide can provide power upto 25 KW power in continuous wave mode. Nd:YAG is a solid state laser which can deliver light through optical fiber. In pulse mode it can produce upto 50 kW power and in continuous mode it can produce power upto 1 KW.

Focusing lens :Focusing lens is used to focus the light at the workpiece. It is a convex lens.

LASER

Advantages:

1 It can be used to cut ruby material.

2) No tool cost because no physicla tool is required for replacement of tools.

3) No delamination is caused as there is no physical contact with the workpiece.

4) It can be easily automated and is very flexible.

5) Complex shapes of different sizes can be machined.

6) It gives very good surface finish.

7) Micro holes can be drilled in workpiece with high accuracy.

Disadvantages:-

1) Very high capital and maintenance cost.

2) It cannot be used to produce blind hole.

3) It can lead to safety hazards.

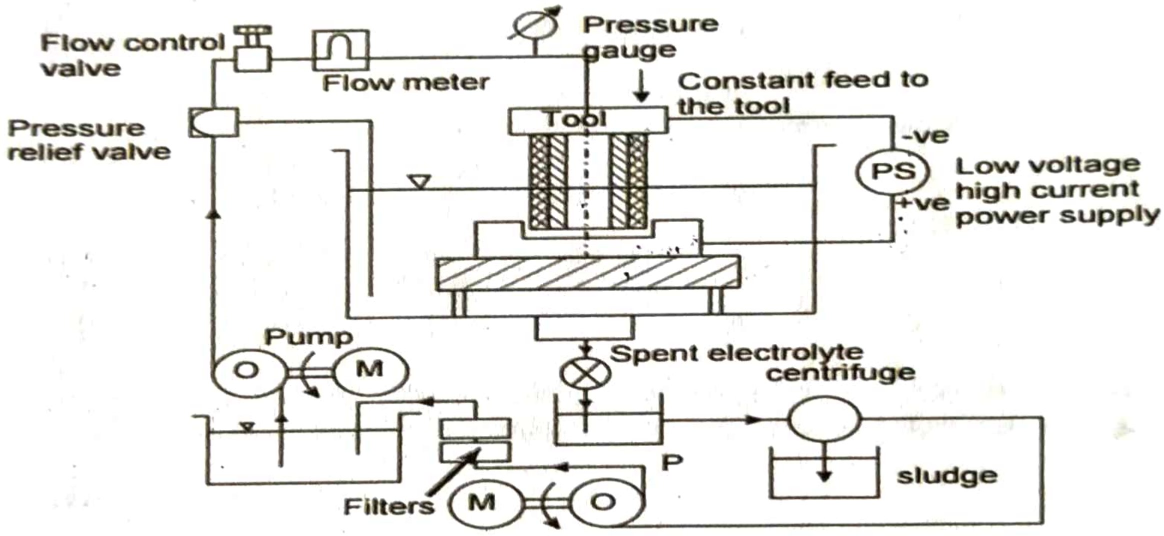
Applications

- Welding of non-conductive and refractory material.
- Cutting complex profiles for both thin and hard materials.
- Used to make tiny holes. Such as the holes in the nipples of the baby feeder.
- Mass-micro machining
- Can be used for dynamic balance of rotating parts.
- Some special heat treatment of materials.
- For producing fine and minute holes.

ELECTRO-CHEMICAL MACHINING (ECM)

PRINCIPLES

Electro-Chemical Machining (ECM) is works on the principle of Faraday law of electrolysis which state that if two electrodes are placed in a container which is filled with a conductive liquid or electrolyte and high current , low voltage power supply applied across them, metal can be depleted form the anode (Positive terminal) and plated on the cathode (Negative terminal). This is the basic principle of electrochemical machining. In this machining process, tool is connected with the negative terminal of battery (work as cathode) and work-piece is connected with the positive terminal of battery (work as anode). Both are placed in a electrolyte solution with a small distance, in the same time metal removed from work-piece.



EQUIPMENT:

Power supply:

In electrochemical machining, high current and low value of potential difference around 10-25V is desirable.

Electrolyte supply and cleaning system:

It consists of piping system, storage tank, pump, control valve, pressure gauge, heating or cooling coil etc.

Working

Electrochemical machining works inverse as electroplating process. Metal is removed form anode into electrolyte and convert into slag form by reacting opposite ions available in electrolyte. This process works as follow.

- The tool is connected to negative terminal and work is connected to positive terminal.

- When the current passes through electrode, reaction occur at anode or workpiece and at the cathode or tool.
- Due to potential difference ionic dissociation take place in electrolyte.

NaCl ↔ Na+ + Cl-
H_2O ↔ H+ + OH-

- When the potential difference applied between the work piece and tool, positive ions move towards the tool and negative ions towards the work piece.
- Thus the hydrogen ion moves towards tool. As the hydrogen reaches to the tool, it takes some electron from it and converts into gas form.
- When the hydrogen ions take electron from tool, it creates lack of electron in mixture. To compensate it, a ferrous ions created at the work piece (anode) which gives equal amount of electron in mixture.

2H+ + 2e- = H2 ↑ at Cathode

Fe = Fe+ + + 2e- at Anode

- These Ferrous ions react with opposite chlorine ions or hydroxyl ions and get precipitate in form of sludge.

Iron (Fe) ↔ Fe++ + 2e-

Fe++ + 2Cl- ↔ FeCl2
Fe++ + 2(OH)- ↔ Fe(OH)
Fecl2 + 2(OH)- ↔ Fe(OH)2 + 2Cl

- This will give ferrous or iron into electrolyte and complete the machining process. This machining process gives higher surface finish because machining is done atom by atom.

Advantages:

- It can machine very complicated surface.
- A single tool can be used to machining large number of work-piece.
- Less tool wear occur.
- Machining of metal is independent on strength and hardness of tool.
- ECM gives very high surface finish.

Disadvantages:

- High initial cost .
- Design and tooling system is complex.
- Nonconductive material cannot be machined.
- Required more Space and floor area.

Application:

- ECM is used to machining disk or turbine rotor blade.
- It can be used for slotting very thin-walled collets.
- ECM can be used to generate internal profile of internal cam.
- Production of satellite rings , connecting rod, gears and long profile etc.

ECM

Common electrolyte used in ECM

1. Sodium
2. Potassium
3. Chloreride

] Mainly.

- Also
  - Calcium
  - Magnesium.
  - Phosphate.

ECM (Electro Chemical Machining)

It is based on "Faraday's Law of Electrolysis"

* D.C Supply passed through them, The metal on +ve pole gets deplated & its metal is deposited on the -ve pole.

* Metal Removal rate is higher at the entry side than the exist side of electrolyte.

Metal Removal Rate

It is the volume of metal removed (V_m)

$$V_m = \frac{IN\eta}{96500 \cdot n \cdot d} \cdot t$$

Where V_m = Vol. of metal removed cm^3

I = Current (amp)

N = Atomic wt. of the metal (W/P)

η = Efficiency of process.

n = Valancy of W/P metal

d = Density (g/cm^3) of W/P

t = Duration of current flow.

When the circuit is connected

Metal atoms (having large excess of free electron) looses electron to the +ve terminal.

$$M \longrightarrow M^{n+} + ne^- \rightarrow \text{oxidation.}$$

(At the surface of wk/pc)

Now M^{n+} ion is loosely held on the metal surface. The electrolyte comprising of +ve H ion & Cl (-ve) ion passes through the junction.

$$nCl^- + M^{n+} \longrightarrow nMCl$$

(electrolyte) (salt) (debris)

The salt thus passes along with the electron.

The H^+ ion product by the electrolyte recieves electrons from the tool, which is accumulated with electron - from the -ve terminal.

$$nH^+ + ne^- \rightarrow nH_{(atoms)} \text{ — Reduction.}$$

Since H gas can not remain in atomic state.

$$nH + nH \longrightarrow nH_2 \text{ (molecule gas)}$$

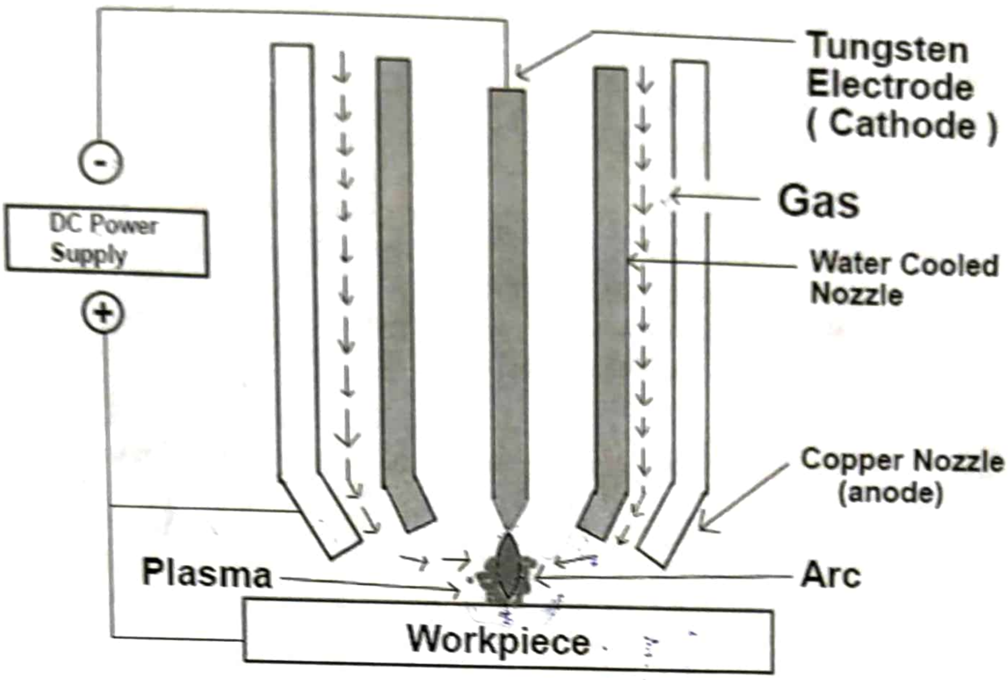
$$H + H \longrightarrow H_2 \rightarrow \text{bubbles out.}$$

Plasma
Plasma Arc Machining is used to remove material from the workpiece. In this process, a high velocity jet of high-temperature gas is used to melt and remove material from the workpiece. This high velocity of hot gas is also **known as plasma jet.**
When a gas or air is heated at a temperature of more than 5000 °C, then it will start getting ionized into positive ions, negative ions and neutral ions. When the gas or air is ionized its temperature reaches from 11000 °C to 28000 °C and this ionized gas is called **plasma** which is used to remove materials is called **Plasma Arc Machining**.

The gas used in plasma arc machining is chosen according to the metal which is used as the workpiece. It is used for cutting alloys steels, stainless steel, aluminum, nickel, copper and cast iron.
When a solid is heated to the melting point, it turns into liquid and when a liquid is heated, it turns into gas.
If a gas is heated to nearly 2000 °C, the molecules will dissociate into separate atoms.
If the temperature is further raised to nearly 3000 °C, electrons of atoms of gas will be displaced and the atoms are ionized and this ionized gas is called plasma.

Working principle

PAM process uses ionized plasma to transfer heat. The plasma is obtained by forcing gas through an electric arc generated between cathode and andode.
The high temperature plasma jet melts the metal and remove material from the workpiece.



Plasma Arc Machining

Description of Equipment

1 Plasma Gun:

Different gases like nitrogen, hydrogen, argon or mixture of these gases are used to create plasma. This plasma gun has a chamber which has a tungsten electrode. This tungsten electrode is connected to the negative terminal and nozzle of the plasma gun is connected to the positive terminal of the DC power supply. The required mixture of gas is supplied to the gun. A strong arc is produced between the anode and the cathode.

After that, there is a collision between the electron of the arc and the molecules of the gas and due to this collision, gas molecules get ionized and heat is generated.

2 Power Supply:

DC Power Supply is used to develop two terminals in the plasma gun. Heavy potential difference is applied across cathode and anode so that arc produced is strong and is able to ionize the gas mixture and convert it into plasma.

3 Cooling Mechanism:

A cooling mechanism is added to the plasma gun as heat is produced in it as hot gases continuously pass out from the nozzle.A water jacket is used to cool the nozzle. The nozzle is surrounded by water jet.

4 Workpiece:

Different materials can be worked using this plasma arc machininglike aluminum, magnesium, carbon, stainless steel and alloy steels can be worked using this process.

Construction and Working:

The plasma arc cutting torch carries a tungsten electrode fitted in the chamber.
This tungsten electrode is connected to the negative terminal of the DC power supply.
At the bottom of the chamber, there is a copper nozzle that is connected to a positive terminal of the DC Power Supply and acts as an anode.
The rest of the chamber is made of insulating material and acts as an insulator.
Gas enters the chamber through a small passage present at the right side of the chamber.
The cathode and the anode remain cool despite the hot gases passing through them as they are water cooled.

At first,D.C power is supplied to the circuit, a strong arc is produced between the cathode (electrode) and the anode (nozzle).
After that, gas is supplied to the chamber. This gas can be hydrogen, nitrogen, argon or mixture of these gases chosen according to the metal to be worked.
The gas used in the process is heated using the arc produced between the cathode and the anode. This gas is heated to very high temperatures from 11000 °C to 28000 °C.
As the arc comes into contact with the gas, there is a collision between the electron of the arc and the molecules of the gas and the molecules of the gas will dissociate into separate atoms.
Due to the high high temperature generated from the arc, electrons from some atoms will be displaced and atoms are ionized (electrically charged) and the gas turns into plasma. As the gas is ionized, a large amount of thermal energy is liberated.
After the gas is ionized, this high temperature ionized gas is directed towards the workpiece with high velocity.
The electric arc has some other benefits like it increases the temperature of ionized gas, makes the beam almost parallel, and increases the velocity of the gas.
As the plasma jet reaches the workpiece, the plasma melts the workpiece and the high-velocity gas blows away the molten metalto remove material

Advantages

1) Hard as well as brittle metals can be easily machined with this process.
2) Plasma Arc Machining gives a faster production rate.
3) Small cavities can be machined using this process with good dimensional accuracy.
4) It can be used for rough turning of very hard materials.
5) It is also used in machines that are used to repair jet engine blades.

Disadvantages

1) The equipment used in Plasma Arc Machining are very costly.
2) Metallurgical changes take place on the surface of the workpiece.
3) The consumption of inert gas is high.
4) As oxidation and scale formation takes place, shielding is required.

Applications

1) It is used in mill applications.
2) It is also used in the nuclear submarine pipe system.
3) Used in welding rocket motor case.
4) Used in welding of stainless steel tubes.
5) It is used for profile cutting

PAM

+ Dept of HAZ (Heat Affected Zone) – about 4 mm perephery

+ Flow Rate of Gas – 2 to 11 m^3/hr
+ Voltage – 400V
+ Power – 200 kW
+ Current – 150 to 1000 Amp
+ Cutting Rate – 250 to 700 mm/min
+ Machining Accuracy – 1.5 mm
+ Mechanics of metal Remove – Melting
+ Medium – PLASMA
+ Tool – Plasma jet
+ Max temp – 16000°c to 28000°c
+ Max. Velocity of Plasma jet – 500 m/sec
+ Power Range – 2 – 200kW
+ Max metal Removal Rate – 150 cm^3/min.
+ Max plate thickness – upto 200mm.
+ Cutting Speed – 0.1 to 7.5 m/min
+ Voltage – 30 – 250 V

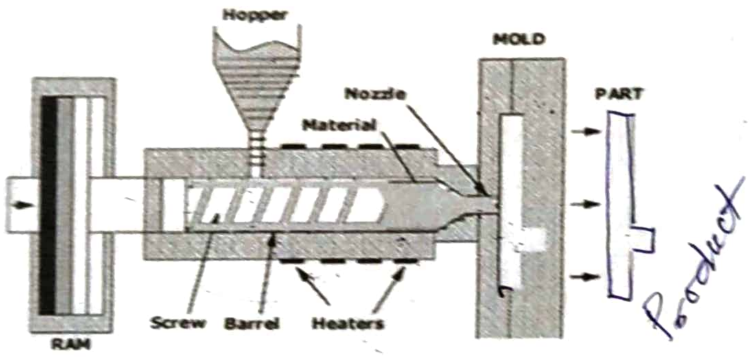
Plastic Processing

Plastic processing can be defined as the process of converting the plastics raw material into semi-finished products. It can be processed with the following methods: machining, compression moulding, transfer moulding, injection moulding, extrusion, rotational moulding, blow moulding, thermoforming, casting, forging, and foam moulding.

Plastic Injection Moulding

Plastic injection moulding is the process in which a thermoplastic polymer is heated above its melting point (conversion of the solid polymer to a molten fluid) and the same with low viscosity, injected into a mould cavity and solidifies to produce the final product.

The basic manufacturing process of injection moulding:-- plastic is melted in the plastic injection moulding machine and then injected into a mould under high pressure. Then, the material is cooled, solidified and finally released by opening the two halves of the mould.



Injection Moulding Materials

Polypropylene

Polycarbonate

Polyoxymethylene (POM)

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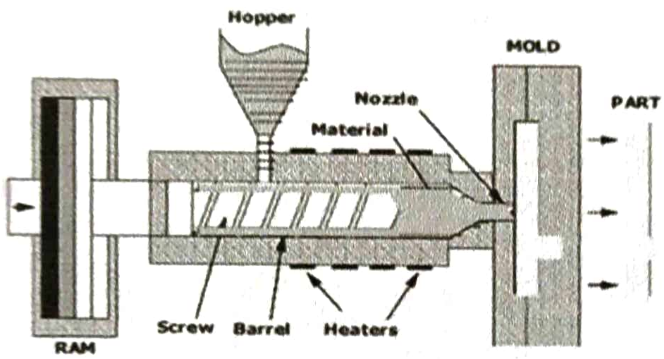


Injection Moulding Materials

Polypropylene

Polycarbonate

Polyoxymethylene (POM)

Basic Injection Molding Process

1- Close the mould
2- Injection (Heated plastic into the mould)
3- Cooling
4- plasticizing the resin
5- Injection
6- Removing

Basic Injection Moulding Process

step 1: close the mould.

step 2: injection. (the heated plastic is injected into the mould.)

step 3: cooling. ...

step 4: plasticizing the resin. ...

step 5: ejection. ...

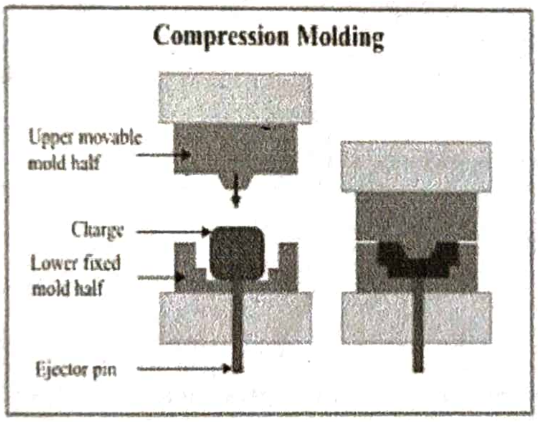
step 6: removing

Compression Moulding

Compression moulding is the **process** in which a plastic material is placed directly into a heated metal mould cavity then compressive force (hydraulic or pneumatic) applied and closed for a specified period to shape of the mould. Two types of raw plastics materials are most often used for compression moulding

Thermoset plastics – Four kinds of thermosets are polyurethane, unsaturated polyesters, phenolic and silicones.

Thermoplastics – Four common types are polyethylene, polypropylene, polystyrene, and acrylics



STEPS

The material is placed into the mould.

The product is heated until somewhat soft and pliable.

A hydraulic tool presses the material against the mould.

Once the material is hardened and desired shape then mould is ejected.

Advantages of Compression

Compression moulding is one of the least expensive ways for mass production.

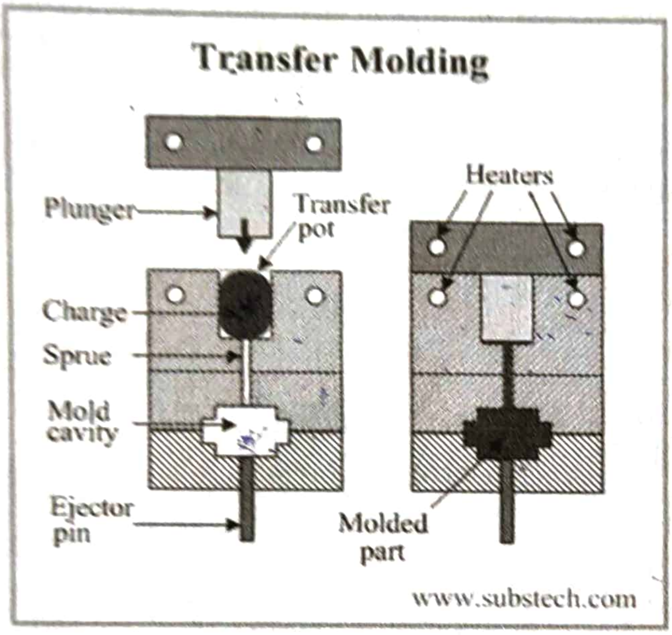
It is cost-effectiveness.

This method is highly efficient.

Transfer moulding

Transfer Moulding is a process in which a pre-weighed amount of a polymer is preheated in a separate chamber (transfer pot) and then force the material into a preheated mould through a sprue, taking a shape of the mould cavity .

Transfer moulding is used for manufacturing electronic components with rubber or plastic like metal prongs, semiconductor chips or ceramics can be placed within the mould before the material is injected.



Advantages of TM:

Provides better uniformity.

Reduced tooling lead times compared to a full Injection tool.

More accurate and consistent than compression moulding.

Disadvantages of TM:

More expensive tooling than a Compression mould.

Slower production cycle than an injection tool.

Plastic extrusion process

Extrusion

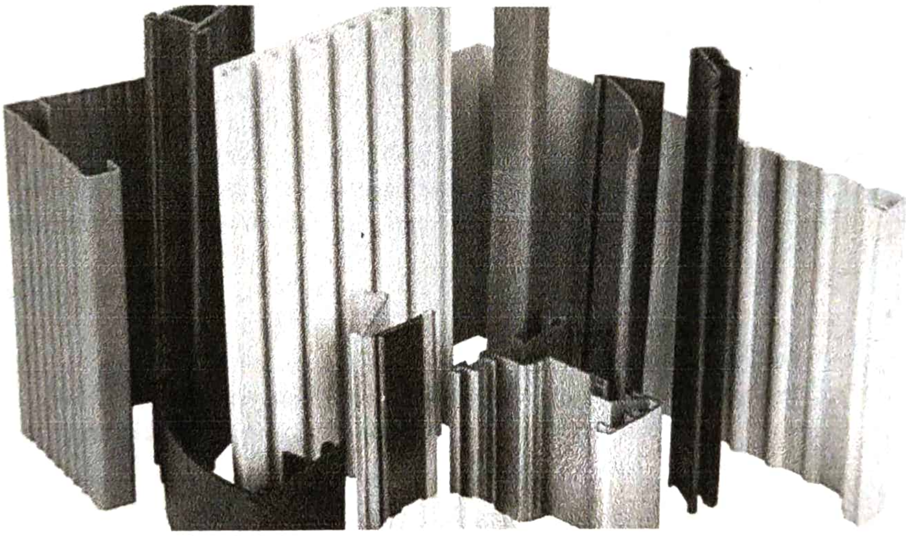
Extrusion is a process where a material is pushed through a tool with a specialized shape called a die, producing continuous objects of a fixed cross sectional profile.

Plastics Extrusion

The raw material (polymer) in the form of granulates, is gravity fed into the hopper and through the feed throat, drops on a rotating screw. rotation of the screw forces the plastic forward through a heated barrel. As the plastic is conveyed through the barrel the channel or thread of the screw decreases, thus compressing the plastic.

Plastic extrusion works by melting, processing and re-melting a type of plastic referred to as thermoplastic resins. The thermoplastic beads go through a hopper which puts them into the machine.

.....



Along with injection molding, plastic extrusion is one of the most widely used manufacturing processes for the forming of plastics, It is used to create objects with a continuous profile such as pipes, tubing, and door profiles.

The plastic extrusion process

- A **hopper**, where the raw plastic is kept
- A **feed throat**, where the plastic enters the barrel from the hopper
- A heated **barrel**, containing a **screw** driven by a **screw drive motor** that forces material to the feedpipe
- A **breaker plate**, fitted with screens to filter the material and maintain pressure

- A **feedpipe**, where molten material exits the barrel and is delivered to the die
- A **die**, which shapes the material into the desired extrusion .
- A **cooling system**, which helps the extrusion solidify .

Common extrusion plastics include:

- Polythene (polyethylene): Extruded between 400°C (low density) and 600°C (high density)
- Polystyrene: ~450°C
- Nylon: Between 450°C and 520°C
- Polypropylene: ~450°C
- PVC: Between 350°C and 380°C
- Plastic extrusion applications

Plastic extrusion profiles are .... tubing, door profiles, automobile parts.

Pipes and tubing

Plastic piping and tubing, sometimes made from PVC or the aforementioned thermoplastics, is a common plastic extrusion application because it has a simple cylindrical profile. Exterior gutters are one example of extruded tubing.

Wire insulation

Many thermoplastics have excellent electrical insulation and thermal stability, making them suitable for extruded wire and cable insulation and jacketing. Plastic extrusion companies may also use fluoropolymers for this purpose.

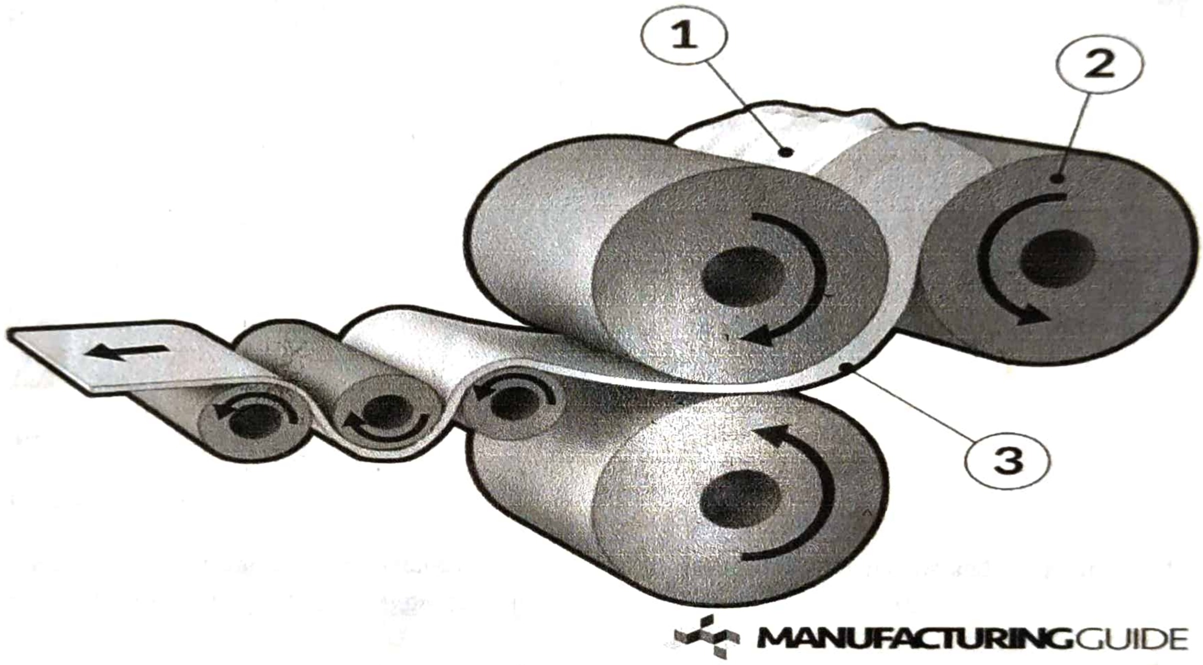
Window and door profiles

Plastic door and window frames are highly suited to extrusion due to their continuous profile and length. PVC is a popular material for this plastic extrusion application and all plastic extrusion profiles related to household fittings.

Calendering

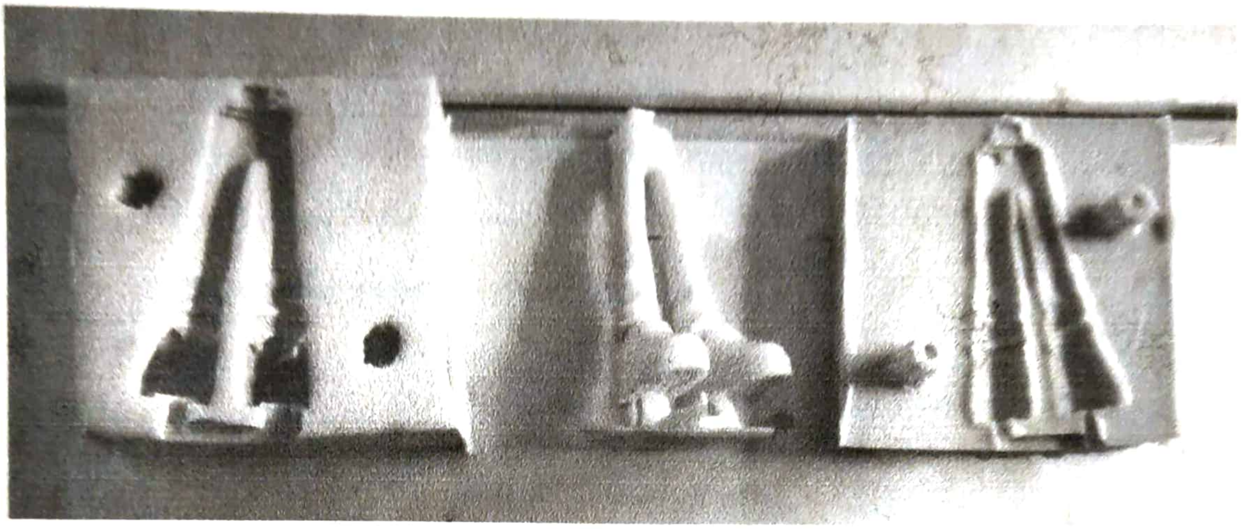
Calendering is the process of making sheets by compressing a material through a pairs of heated rolls. The rolls in combination are called calenders.

Calendering is a process for production of rolled sheets of specific thickness .Calendering of molten polymers is a process for the production of continuous sheet or film by squeezing between a pair of heated counter-rotating rolls.



Plastic Casting Process

Casting involves introducing a liquefied **plastic** into a **mould** and allowing it to solidify.



Steps for Plastic Casting

i. Pattern making

(Pattern making can use computer-assisted systems to design the dimensions and geometry of the mould.It follows by packing of aggregated plastic material around the pattern).

ii. Core Making

(This processinvolves placing of solid materials inside the mould cavity as a way of creating interior surfaces of a casting . Most of the plastic part designs need the inclusion of cores in the casting mould).

iii. Melting and Pouring

Melt the plastic material properly before placing it in the mould.

iv. Moulding

It allows creating the casting mould.The plastic material fills the casting mould which is subsequently allowed to cool and solidified and finally remove from the cavity.

v. Finishing

In some instances, cracks in sprues or casting mould thus use different ways of finishing techniques to achieve proper appearance and texture.

Finally proceed to further post-treatment process like painting of electroplating depending on various elements.

ADVANTAGES/DISADVANTAGES :-

Plastic casting process has little or no internal stresses.

The cost of equipment(mould and tooling) is relatively low .

It is applicable for lightweight.

It is a suitable for making complex/ complicated profiles .

The dimensional tolerances slightly match the particular requirements.

The rate of output in plastic casting is slow.

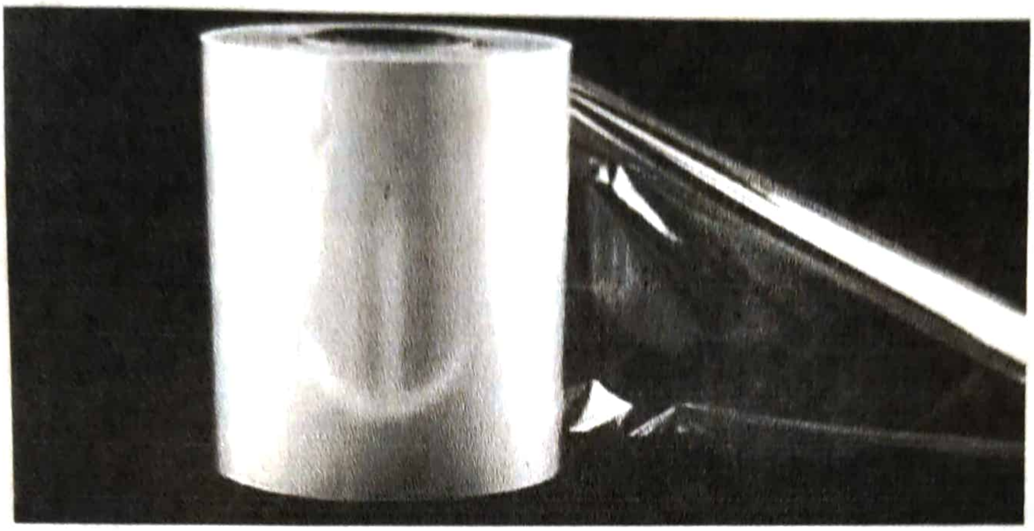
It can be difficult to manage air bubbles and moisture .

Plastic Materials used for casting .

- Polystyrene
- Acrylic
- Nylon type 6
- Polyester
- Polyurethane

Lamination

Lamination is the coating of the outer surface of anything to be protected from external impact or environmental damage. Lamination also enhances the styling, appearance, and the durability of the product. Synthetic resin and film are two of the common plastic compounds used for lamination. During this process, pressure and heat are used simultaneously to make lamination. Synthetic resin lamination is usually done to create an adhesive layer between two substrates. On the other hand, film lamination is carried out to create a plastic barrier on the exterior of the product.



Sheet Forming

Thermoforming is a manufacturing process where a plastic sheet is heated to a pliable forming temperature, formed to a specific shape in a mould, and trimmed to create a usable product. ... Thermoforming differs from injection moulding, blow moulding, rotational moulding and other forms of processing plastics.

Blow Moulding

Blow moulding is a moulding process used in the manufacturing industry to create hollow objects made of plastic. Like other moulding processes, it involves the use of heated, liquid material that's forced into a mould cavity under pressure.

The materials used for blow moulding include Polyethylene (High Density, Low Density and Linear Low Density), Polypropylene, Polyethylene-Terephthalate (PET), and PVC.

Injection blow moulding is used for the Production of hollow objects in large quantities. The main applications are bottles, jars and other containers. The Injection blow moulding process produces bottles of superior visual and dimensional quality compared to extrusion blow moulding.

Advantages :

- The costs in blow moulding are lower as compared to injection moulding.
- Machinery costs is low.

Disadvantages of blow moulding

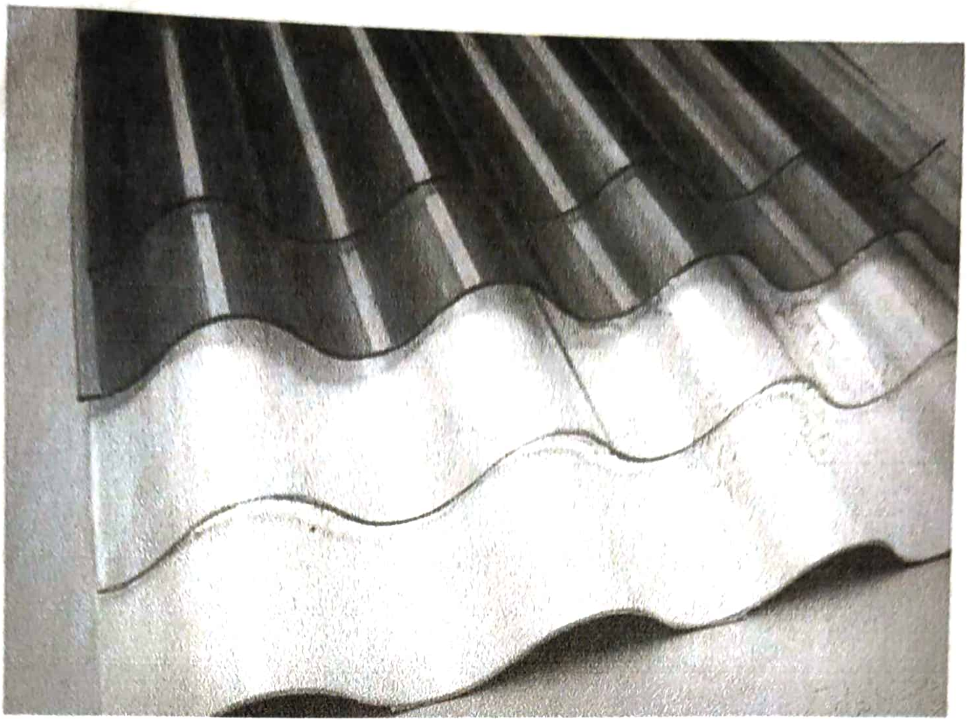
- Limited to hollow parts.
- Low strength.
- Trimming is necessary to make wide neck jars spin.
- Limited to thermoplastics (rotational **moulding** can be used with thermosets)

Reinforcing

Fibre-reinforced plastic (FRP) also called fiber-reinforced polymer.

Fiber-reinforced plastic is a composite material made of a polymer matrix reinforced with fibres. The fibres are usually glass (in fibreglass), carbon (in carbon fiber reinforced polymer), aramid, or basalt.

Reinforcements are used to enhance strength, elasticity and mechanical properties of a plastic mixed with fine silica, carbon black, talc, mica, and calcium carbonate, as well as short fibres of variety of materials, can be incorporated as particulate fillers. Sometimes other fibres such as paper or wood or asbestos have been used. The polymer is usually an epoxy, vinylester or polyester thermosetting plastic, and phenol formaldehyde resins are still in use. FRPs are commonly used in the aerospace, automotive, marine, and construction industries.



Applications

Plastic is the perfect material for use in packaging goods. It accounts for the largest usage of plastics world wide and is used in numerous packaging applications including containers, bottles, drums, trays, boxes, cups and vending packaging, baby products and protection packaging.

Also used in....

packaging,

in building and construction,

in textiles,

consumer products,

transportation,

electrical and electronics

and industrial machinery.

Additive manufacturing

Additive manufacturing, also known as 3D printing, rapid prototyping or freeform fabrication, is 'the process of joining materials to make objects from 3D model data, usually layer upon layer, as opposed to subtractive manufacturing methodologies' such as machining.

It is a transformative approach to industrial production that enables the creation of lighter, stronger parts . As its name implies, additive manufacturing adds material to create an object.

Additive manufacturing (AM) processes are a types of methods that fabricate parts by adding elements and segments of a designed feedstock material. These materials can range from polymeric and plastic to metallic and ceramic. Based on different needs, a specific method can be implemented.

Needs of AM

Implemented properly, additive manufacturing can significantly reduce material waste, reduce the amount of production steps, inventory being held, and reduce the amount of distinct parts needed for an assembly.

With additive manufacturing, you can print the assembly as a single piece, saving money and time from start to finish. Image: With additive manufacturing you can print multiple movable parts in a single piece, potentially saving time on assembly and material.

Fundamentals of additive manufacturing

Unlike casting, forming or powder processing, additive manufacturing (AM) does not require a mould or tool to shape the surfaces of an object. Unlike cutting, AM techniques do not involve removal of material.

Advantages of Additive Manufacturing

- The Cost Of Entry Continues to Fall. ...
- You'll Save on Material Waste and Energy. ...
- Prototyping Costs Much Less. ...
- Small Production Runs Often Prove Faster and Less Expensive. ...
- You Don't Need as Much On-Hand Inventory. ...
- It's Easier to Recreate and Optimize Legacy Parts.

Advantages of AM Introduction

- Elimination of design constraints
- Allow parts to be produced with complex geometry with no additional costs related to complexity
- Build speed, reduction of lead time
- Flexibility in design
- No expensive tooling requirements
- Dimensional accuracy
- Wide range of materials (polymers, metals, ceramics)
- Well suited to the manufacture of high value replacement and repair parts
- Green manufacturing, clean, minimal waste

Disadvantages –

Production cost is high – With the use of techniques other than additive manufacturing, parts can be made faster and hence the extra time can lead to higher costs. Besides, high-quality of additive manufacturing machines may cost high

Types of Additive Manufacturing

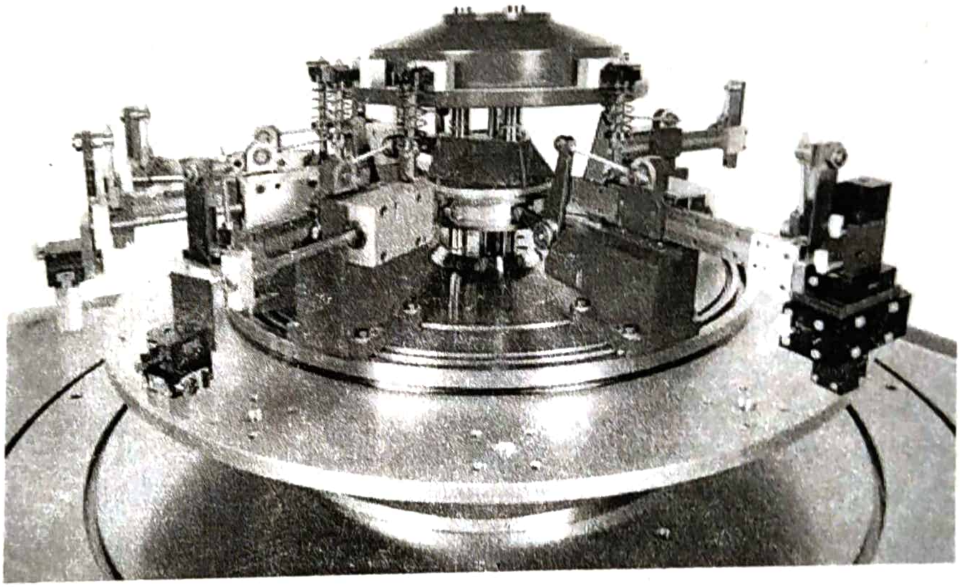
- Binder jetting.
- Directed Energy Deposition.
- Powder Bed Fusion.
- Sheet Lamination.
- Material Extrusion.
- Material Jetting.
- Vat Photo Polymerization.

Special Purpose Machine (SPM)

Concept

Special Purpose Machines (SPM) are those machines which are not available off the shelf. These are not covered in standard manufacturing programs. Therefore those have to be designed & tailor made as per the customer's specific requirements. They are also called as bespoke machines.

Special Purpose Machines is a complete delivery of industrial machines. Special purpose machines are manufactured by workshops with special skills, where many processes are used to deliver a product. Special Purpose Machines is a high productivity machine, with specially designed tooling and fixture, dedicated for mass producing the same component day in and day out.



General purpose elements

The elements which are common to various types of machines serving different applications are called general purpose elements. Examples of these elements are nuts, bolts, keys, axles, shafts, couplings, bearings etc.

Design

The Special Purpose Machines (SPM) have crucial role in manufacturing industries to enhance the productivity. In most of the manufacture processes drilling and riveting operations are performed on separate machines, consequently productivity is not efficient. The modifications in drilling and riveting machines with depth controllability, multi spindle drilling head, self-pierce riveting for sheet materials. In this special purpose machine work piece are drilled on drilling spindle and then riveted on orbital riveting spindle.

Automation and technological advancements have drastically changed the manufacturing industry.

Piercing is a type of shearing operation which creates a open hole in sheet metal by separating interior section. The removed metal is discarded as strap. In general piercing operation is done in mechanical presses using piercing tool. Piercing tools are developed with indexing method by piercing 1 or 2 holes at a time. To do 4 holes the tool is allowed to do first hole and then the first hole is located to do piercing of other holes. The productivity and quality of the work is increased by this machine. The use of Special Purpose Machines minimizes human errors.

A Special Purpose Machine (SPM) plays an important role to increase productivity. Most of the machines require settings every time. But here the SPM designed for drilling is one such kind of machine which consists of multi spindle drilling head. The Components are placed horizontally and held intact by hydraulic clamps. The spindles travel towards the component by a pneumatic force. Electric motor drives the spindle head containing drill. This increases the productivity, accuracy and also reduces machining time.

Productivity Improvement by SPM

Often, when highly accurate components are to be produced in relatively large volumes, manufacturers may not have a clear idea in utilising widely used CNC machines or less commonly used Special-Purpose (SPM) machine tools. Consequently, the most economical method may not be selected. Manufacturer is deciding the most economical method by presenting the basic components of SPM machines and how they are used, the necessary steps in configuring these machines, and a detailed economical analysis where a comparison of the unit costs per piece is made.

REPAIR CYCLE

It is the maintenance work that consists of replacement or repair of components. Different sensors are connected to each machine to detect the performance. It is pre-maintenance before breakdown or failure.

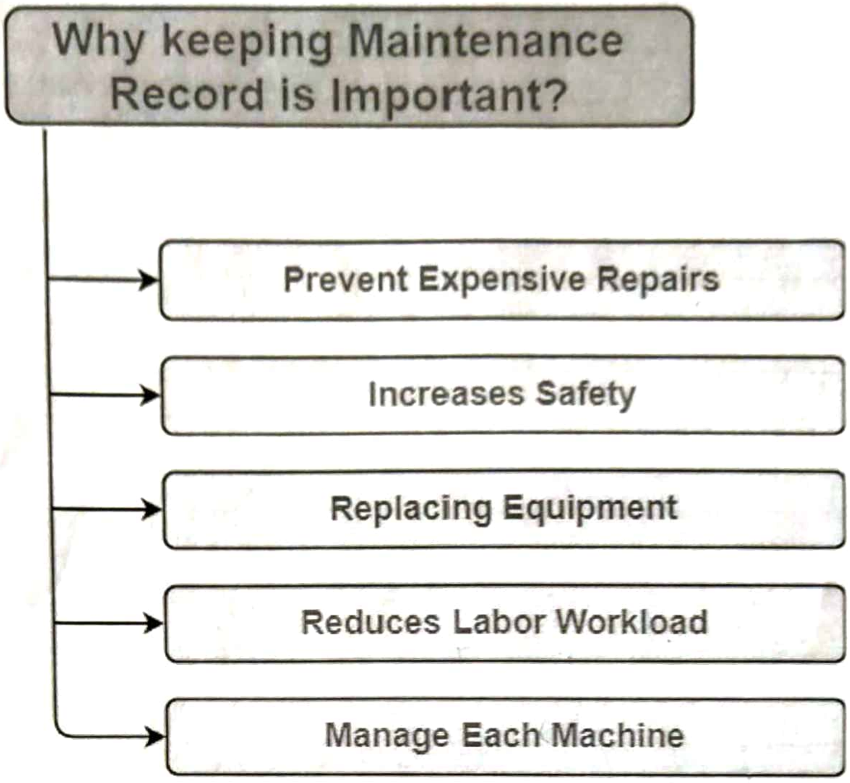
The **Complexity** of **Repairing**, Adjusting, and Aggregating of Extensions in Abstract Argumentation. ... - The **Repair** problem asks whether a given set of arguments can be modified into an extension by at most elementary changes.

An **operation and maintenance manual** is a comprehensive document that provides all the details necessary about a physical plant as well as individual pieces of equipment to help the **maintenance** staff keep everything running smoothly.

A **maintenance manual** is an essential part of a regular **maintenance** program. The **manual** should include a log book and housekeeping plan for the day-to-day care and management of a heritage place. Make a **maintenance manual** part of the conservation plan for a heritage place to provide for its ongoing care.

A **maintenance manual** is a technical communication document intended to give recommendations and information necessary to maintain the system effectively.

Maintenance record, as name suggests, is a document that includes information regarding each **repair** and **maintenance** work that is done on asset or equipment. In simple words, it keeps tracks of assets failures and repairs. It is one of best way to maintain health and safety management.


Why keeping Maintenance Record is Important?
Prevent Expensive Repairs
Increases Safety
Replacing Equipment
Reduces Labor Workload
Manage Each Machine

Equipment Maintenance Log

Equipment description: ______________________________

Serial Number: ____________________ Model Number: ____________________

Date:	Action Taken/Comments:	Initials

Total productive maintenance (TPM) is the process of using machines, equipment, employees and supporting processes to maintain and improve the integrity of production and the quality of systems.

Reduction in workplace accidents

Reduction in manufacturing costs

Increase in product quality

8 Pillars of Activity

- **Pillar** 1: Autonomous Maintenance. ...
- **Pillar** 2: Process & Machine Improvement. ...
- **Pillar** 3: Preventative Maintenance. ...
- **Pillar** 4: Early Management of New Equipment. ...
- **Pillar** 5: Process Quality Management. ...
- **Pillar** 6: Administrative Work. ...
- **Pillar** 7: Education & Training. ...
- **Pillar 8**: Safety & Sustained Success.

The main **objective of TPM** is to increase the **Overall** Equipment Effectiveness (OEE) of plant equipment. **TPM** addresses the causes for accelerated deterioration and production losses while creating the correct environment between operators and equipment to create ownership..

Total Productive Maintenance (**TPM**) is a set of strategic initiatives focusing on maintaining and improving production and quality systems through the machines, equipment, processes and employees that add value to an organization.

TPM (Total Productive Maintenance) is a holistic approach to equipment maintenance that strives to achieve perfect production:

No Breakdowns

No Small Stops or Slow Running

No Defects

In addition it values a safe working environment:

- No Accidents

TPM emphasizes proactive and preventative maintenance to maximize the operational efficiency of equipment. It blurs the distinction between the roles of production and maintenance by placing a strong emphasis on empowering operators to help maintain their equipment.

The implementation of a TPM program creates a shared responsibility for equipment that encourages greater involvement by plant floor workers. In the right environment this can be very effective in improving productivity (increasing up time, reducing cycle times, and eliminating defects).

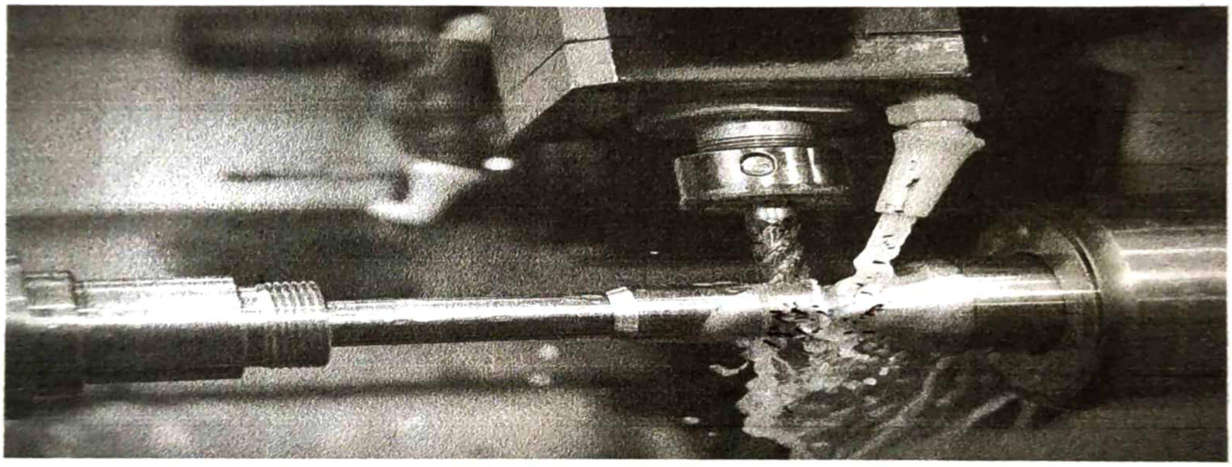
MAINTENANCE OF M/C TOOLS

In order to keep the machine tools accurate and durable, it is necessary to apply lubricants. It will minimise friction and tool wear. Lubrication is very important of machine tool.

Maintenance for Machine Tools

Maintenance is the systematic care and protection of tools also it consist of a series of elementary tasks such as data collections, visual inspections, cleaning, lubricating, and tightening screws.

- Keep them Dry.
- Keep them Lubricated.
- Keep them Sharpened. ...
- Keep them Clean. ...



Types of Maintenance

Preventive Maintenance.

Predictive Maintenance.

Corrective Maintenance.

Breakdown Maintenance.

Preventive Maintenance

- Keep them Dry.
- Keep them Lubricated.
- Keep them Sharpened. ...
- Keep them Clean. ...
- Don't Forget Accessories

Predictive Maintenance Tools

- Infrared Analysis Sensors. Sensor data is vital in a predictive maintenance program. ...
- Motor Circuit Analyzers. A motor circuit analyzer is a PdM tool that helps get a complete picture of an equipment's .
- Vibration Analysis Sensors. ...
- Ultrasonic Analysis Microphone. ...
- Laser-shaft alignment tool.

Corrective Maintenance

Corrective maintenance is the category of maintenance tasks that performed to rectify and repair faulty systems and equipment. The purpose of corrective maintenance is to restore systems that have broken down. Corrective maintenance can be synonymous with breakdown or reactive maintenance.

Examples

Corrective maintenance may be performed on a wide variety of equipment, systems, and processes. Here are a few examples:

- **Production line.** A technician is performing preventive maintenance on a line of production equipment and notices significant wear on a critical part or component. A corrective maintenance order can be initiated to repair or restore that part immidiatly.
- **Public works.** While performing routine roadway repairs, a technician may notice some damage . A corrective maintenance order to restore that can be entered so the work is performed at a later date.

Benefits of Corrective Maintenance

Since the focus of corrective maintenance is to restore an asset so it can be functioning properly and efficiently...:

- **Reduce emergency maintenance orders.** If corrective orders can be executed in a timely manner once they are initiated, it's likely that a company can reduce the number of emergency maintenance orders it generates. In general, corrective maintenance is less expensive than emergency maintenance.
- **Increase employee safety.** In some cases, the issues identified and tagged as corrective maintenance may have significant safety for employees .
- **Reduce service interruptions.** Since corrective maintenance work orders are scheduled and prior to that it reduces interruption.
- **Extend asset lifetime.** Corrective maintenance with good preventive maintenance extends the lifetime of its assets.
- **Decreases downtime.** In some cases, corrective maintenance may help companies decrease downtime. For example, if a maintenance technician is performing routine maintenance on a piece of equipment and sees that a part is worn down, a corrective maintenance order can be

placed immediately. Ideally, that task gets scheduled and completed before breakage or downtime occurs.

Breakdown Maintenance

Breakdown maintenance is maintenance performed on a piece of equipment that has broken down, unusable, faulted, or otherwise cannot be operated.

Generally two types of breakdown maintenance:

- Run-to-Failure Maintenance. This type of maintenance refers to equipment failure that is expected to happen. ...
- Emergency Maintenance. Emergency maintenance is conducted when an important piece of equipment stops working unexpectedly and needs to be replaced immediately.

Effect of Breakdown Maintenance

Increased chances of accidents or injuries.

Faster plant deterioration.

Breakdown generally occurs inappropriate times leading to poor and hurried maintenance

Longer Repair time in comparison to other maintenance.

Single spindle

Numerically controlled lathe with a single main spindle is known as a single-spindle lathe. A single spindle automatic lathe is a modified form of turret lathe.The cams are mounted on a shaft which draws the power from the main spindle through a set of gears called cyclic time change gears. Turret operation is also synchronized with the cross slide operation and is driven by another cam called main cam.

Multi Spindle Automatic Lathe

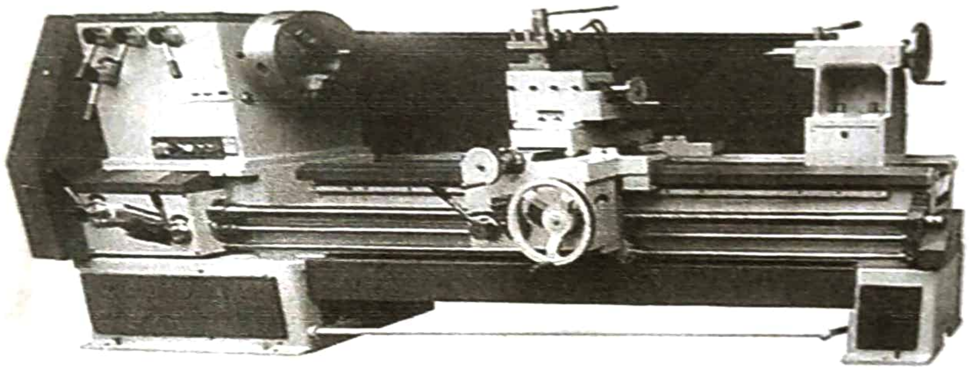
The multi-spindle lathe has six to eight main spindles working simultaneously. This type of machine has the ability to provide various types of operations which include boring holes, turning, chamfering, threading, grooving as well as drilling and this is done by moving the piece that is being worked on between six to eight positions in the machine.

SEMI AUTOMATICS

These are turning machines used for chucking work. In this type of lathes although all movements of w/p (or) tools are automatically controlled, but w/p has to be loaded into & removed from chuck at beginning & end of each cycle of operation.

Example

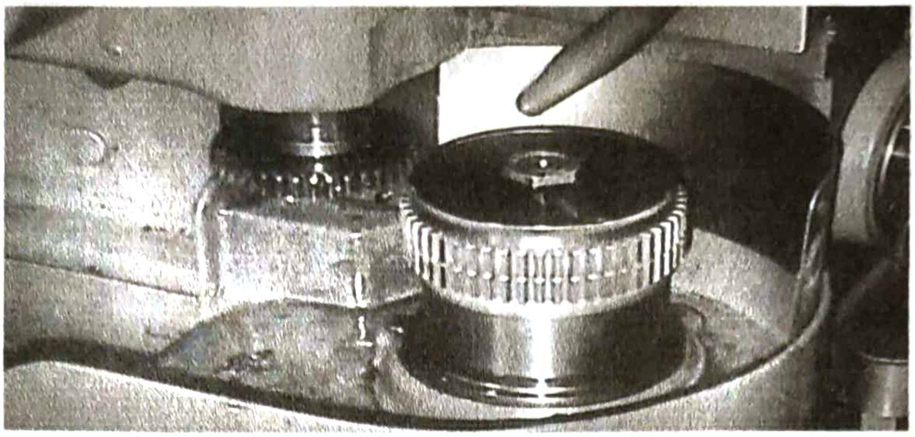
The semiautomatic lathes, capstan lathe and turret lathe are very similar in construction, operation and application.



The difference between automatic lathe and semi-automatic lathe is that the fully automatic lathe is controlled by computer, while the semi-automatic lathe is controlled by computer and manual.

GEAR SHAPING

Gear shaping is a machining process for creating teeth on a gear using a cutter. Gear shaping is a convenient and versatile method of gear cutting. It involves continuous, same-plane rotational cutting of gear. It is a machine tool for cutting the teeth of internal or external gears, it is a specialised application of the general shaper machine.



Gear shaping is a precise machining process used to create teeth or splines on a gear using highly accurate and precise cutting tool. It is a convenient method of gear cutting used to produce well-polished gears with perfect cuts of splines or teeth.

Advantages of gear Shaping

Spur, helical, rack and internal gears can be cut by this process. Cutter having same module can cut gears having different numbers of teeth, hence cutter is universal and not dependent on number of teeth on the gear. It is useful for medium and batch production.

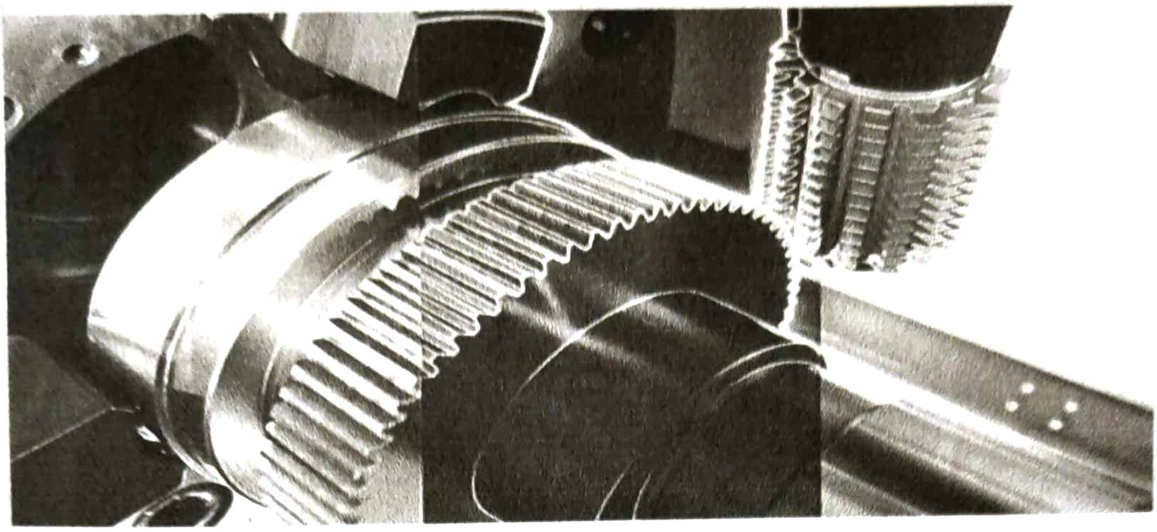
Gear Hobbing

Gear-hobbing machines is a rotating, multiple-tooth cutting tool called hob for generating teeth on spur gears, worm gears, helical gears, splines, and sprockets splines in almost any material (ferrous and nonferrous metals and plastics).. More gears are cut by hobbing than by other methods because the hobbing cutter cuts continuously and produces accurate gears.

A hob resembles a worm gear; it has a number of flutes around its periphery, parallel to the axis, to form cutting edges.

During hobbing, both the hob and the workpiece rotate in a continual, timed relationship. For a spur gear being cut with a single- start hob, the workpiece will advance one tooth for each revolution of the cutter. When hobbing a 20-tooth gear, the hob will rotate 20 times, while the workpiece will rotate once.

Hobbing is a machining process for gear cutting, cutting splines, and cutting sprockets on a hobbing machine, which is a special type of milling machine. The teeth or splines of the gear are progressively cut into the material (a flat, cylindrical piece of metal) by a series of cuts made by a cutting tool called a hob.



Difference

Gear hobbing is more productive than gear shaping.That scenario occurs when the gear is smaller in size and the teeth have a large and small-tooth width. As per accuracy and productivity gear hobbing is better.

Advantages of this process

1. **Speed.** Some gear manufacturing processes take a long time, but gear hobbing is relatively fast. The machine is simple, so it doesn't require as much operational attention.
2. **Precision.** Hobbing can be highly precise, resulting in high quality gears.
3. **Flexibility.** There's more than one type of hob—and more than one type of hobbing machine.
4. **Applications.** While hobbing is often used for spur gears, the process can be used for a variety of other gears, such as cycloid gears, helical gears, worm gears, ratchets, splines, and sprockets (as long as you have the right tools for the job).
5. **Related processes.** One of hobbing's only weaknesses is that it does not work for internal gears (with inward-facing teeth). However, there's a related process called shaping that can be used instead—with all the same advantages of hobbing.

COPYING LATHE

A machine used for the reproduction of plane and curved surfaces from a master (template, pattern, model, or blueprint) on products made of various materials.

Copy turning is carried out on special lathes that control the cutting tool in some manner to produce identical items. The copy lathe uses a template to guide the cutter. They are capable of creating good quality components for little expense in patterns and setting up. Sanding is usually carried out by hand.

TRANSFER MACHINE

Transfer machines. Combination of individual machines or machining heads arranged in the required sequence, connected by work transfer .

In this arrangement, several machining heads are arranged across the straight line on the sides and components flow in the middle of two rows of machines along guide rails.

Transfer machines come in three main types, including:

- Rotary: ....These machines move workpieces between stations in a circular path. ...
- In-line or linear:..... Workpieces follow a linear path from one workstation to the other. ...
- Trunnion:...... Parts are indexed around a horizontal shaft, known as the trunnion.

INLINE TRANSFER MACHINES: in this arrangement, several machining heads are arranged across the straight line on the sides a pitch of nearly 1 meter and components flow in the middle of two rows of MACHINES along guide rails.

A rotary transfer machine is a machine tool, typically for metal working by machining, comprising a large indexing table with machining stations surrounding the table. Such rotary transfer machines are used for producing a large number of parts in fairly short cycle times.