Branch: MECHANICAL ENGINEERING

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Subject: ADVANCE MANUFACTURING PROCESS

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1ST CHAPTER
MODERN MANUFACTURING PROCESS

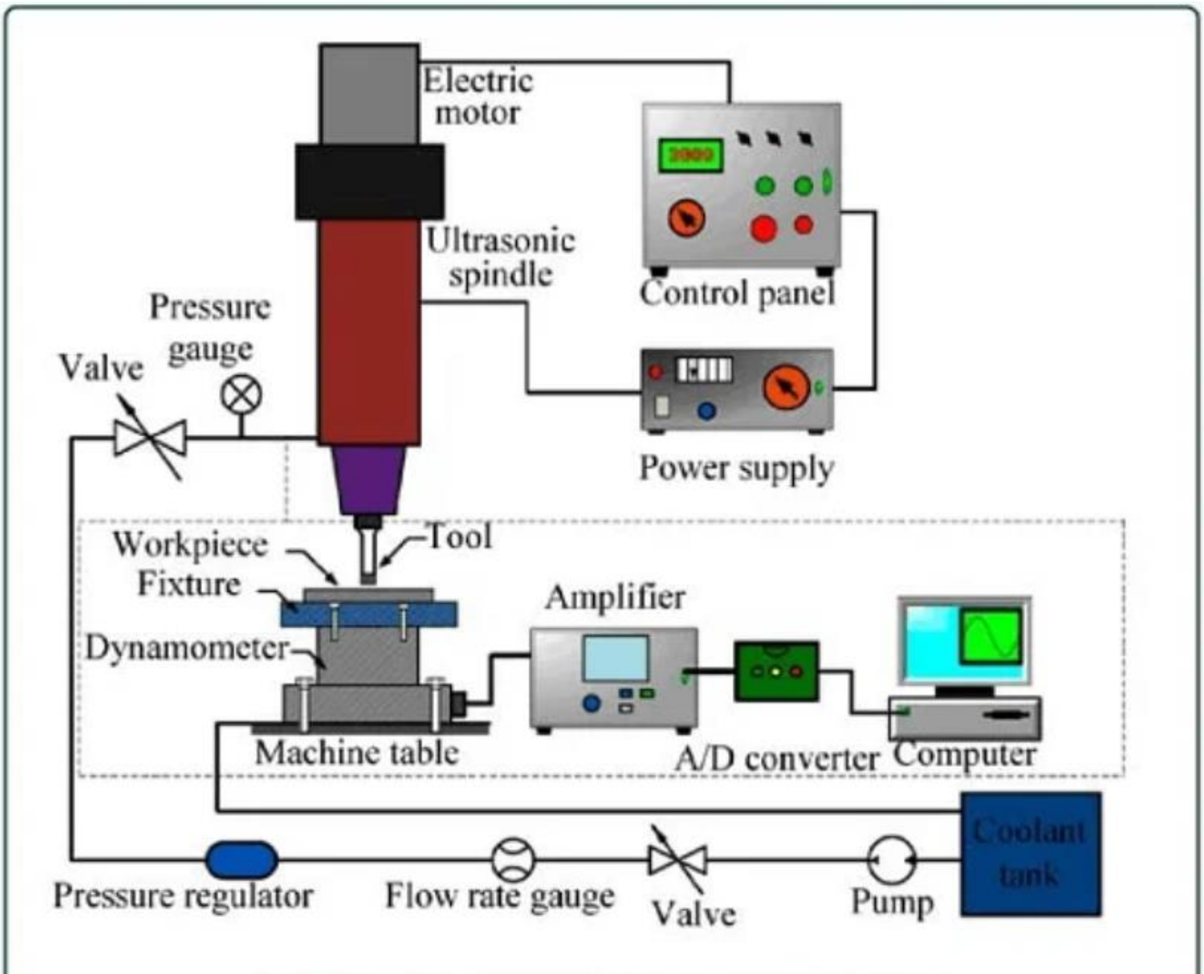
Non-traditional machining, also known as the modern machining method, is a machining method that uses electricity, heat energy, light energy, electrochemical energy, energy, chemical energy, sound energy, and special mechanical energy to remove, deform, change properties, or plate materials.

Extremely hard and brittle materials are difficult to machine by traditional machining processes such as turning, drilling, shaping and milling. Non- traditional machining processes, also called advanced manufacturing processes, are employed where traditional machining processes are not feasible, satisfactory or economical due to special reasons as outlined below.

- Very hard fragile materials difficult to clamp for traditional machining.
- When the workpiece is too flexible or slender.
- When the shape of the part is too complex.

Conventional	Non-Conventional
Direct contact of tool and workpiece.	Tools are non-conventional technique like Laser beam, electric arc, etc.
Cutting tool is always harder than w/p.	Tool may not be harder and it may not be physical presence.
Tool life is less due to high wear.	Tool life is more.
Generally Macroscopic chip formation.	Material removal occurs with or without chip formation.
Material removal takes place due to application of cutting force.	It uses different energy like electrical, Thermo-Chemical etc. to provide machining.
Suitable for all material.	Not suitable for all material.
It cannot be used to make a prototype parts very effectively.	It can be used to produce a prototype parts very effectively.

ULTRASONIC MACHINING(USM):



Working Principle of Ultrasonic Machining

Ultrasonic Machining is process in which the Harder material is machined. These machines have great properties like

- A high degree of accuracy and Surface texture.
- The high rate of metal removal and so on.

Parts of Ultrasonic Machining:

The **Parts of Ultrasonic Machine** are as follows

- Power Supply
- Electro-mechanical transducer
- Velocity Transformer
- Tool
- Abrasive Slurry
- Abrasive gun
- Workpiece

Working Principle of ultrasonic Machining

It consists of an electromechanical transducer connected to the AC supply. Velocity transformer which holds the tool firmly. An abrasive gun is used to supply an abrasive slurry, which is a mixture of abrasive grain and the water in between the tool-workpiece interface under a definite pressure.

When the AC power is supplied with high frequency, the transducer starts vibrating longitudinally by magnetostriction, which is transmitted to the penetrating tool through a mechanical focusing device called a Velocity transformer. As the tool vibrates it is pressed on the work surface with light force and allowing the abrasive slurry to flow through between the tool-workpiece interface.

The Impact force arising out of the vibration of the tool end and the flow of abrasive slurry causes thousands of microscopic grains to remove from work material by abrasion. Abrasive like Aluminium Oxide, Silicon Carbide can be used. The tool is made of soft ductile material like copper or brass, soft steel or stainless steel.

Applications of ultrasonic Machining

- Machining very precise and intricately shaped articles.
- Drilling the round holes of any shape.
- Grinding the brittle materials.
- Profiling the holes.
- Engraving
- Trepanning and coining
- Threading
- Slicing and broaching hard materials.
- Machining the glasses, and ceramics.

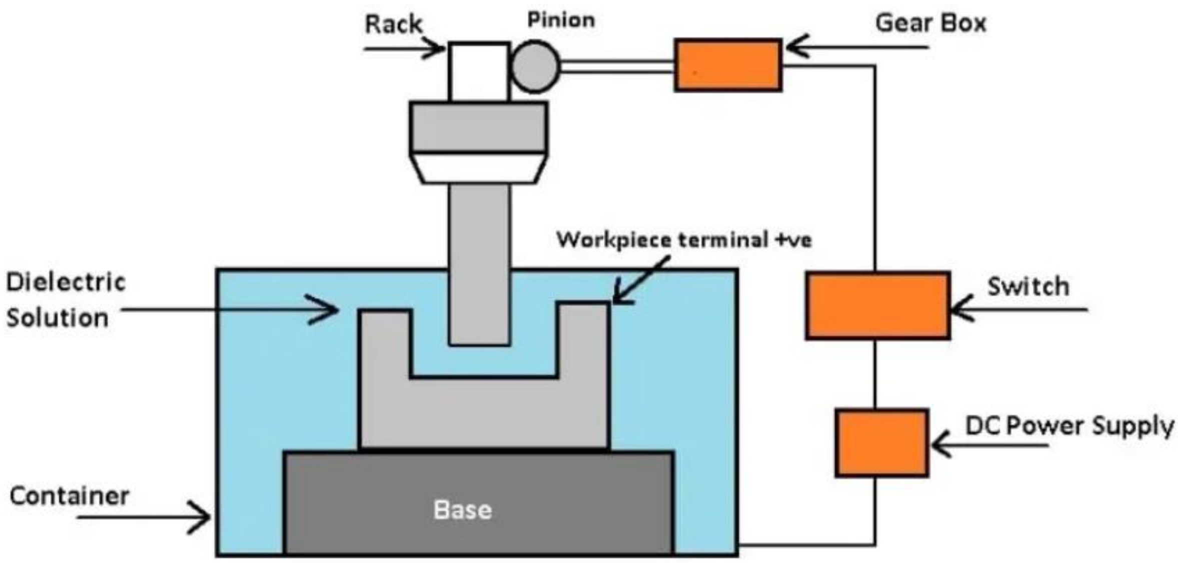
Advantages of ultrasonic Machining

- 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.
- Glass, Ceramic, and tungsten can be machined.
- A semi-skilled operator can operate the machine.
- Better efficiency can be achieved.
- Good surface finish.
- It is suitable for both conducting and non-conducting materials.
- High accuracy can be achieved.

Disadvantages of Ultrasonic Machining

- Low material cutting rate.
- High power consumption.
- Low penetration rate.
- The process is limited to the machined surface of a small size.
- Shorter tool life.

<u>ELECTRICAL DISCHARGE MACHINING(EDM):</u>



Electric discharge machining, also known as spark erosion, electro-erosion or spark machining, is a process of metal removal based on the principle of erosion of metals by an interrupted electric spark discharge between the electrode tool cathode and the working anode.

Fundamentally, the electric erosion effect is understood by the breakdown of electrode material accompanying any form of electric discharge.

The discharge is usually through a gas, liquid, or in some cases, through solids. A necessary condition for producing discharge is ionization of the dielectric, i.e., splitting up of its molecules into ions and electrons.

The main components are the electric power supply, the dielectric medium, the workpiece and the tool, and the servo control.

Working Principle of Electric Discharge Machining:

- The workpiece and the tool are electrically connected to dc electric power. The workpiece is connected to the +ve terminal. It becomes the anode. The tool is the cathode.
- A gap, known as the 'spark gap' in the ranges of 0.005 to 0.05 mm is maintained between the workpiece and the tool.
- When a suitable voltage in the range of 50 to 450 V is applied, the dielectric breaks down and electrons are emitted from the cathode, and the gap is ionized.
- In fact, a small, ionized fluid column is formed owing to the formation of an avalanche of electrons in the spark gap where the process of ionization collision takes place.
- When more electrons collect in the gap the resistance drops, causing the electric spark to jump between the workpiece and the tool.
- Each electric discharge causes a stream of electrons to move with a high velocity and acceleration from the cathode towards the anode and creates compression shock waves on both electrode surface.

- The formation of compression shock waves produces a rise in temperature. However, the temperature of the spot hit by the electrons is of the order of 10,000 °C.
- The forces of electric and magnetic fields caused by the spark produce a tensile force and tear off particles of molten and softened metal from this spot on the workpiece.

A part of the metal may vaporize and fill up the gap. The metal is thus removed in this way from the workpiece. The electric and magnetic fields on the heated metal cause a compressive force to act on the cathodic tool so that metal removal from the tool is slower than that from the workpiece.

Applications of Electric Discharge Machining

1. Electrical discharge machining is used for the manufacture of tools having complicated profiles and a number of other components.
2. The EDM provides an advantage for making stamping tools, wire drawing and extrusion dies, forging dies, header dies, intricate mold cavities, etc.
3. It has been extremely used to manufacture exotic materials used in aerospace industries, refractory metals, hard carbides, and hardenable steels.
4. Also, delicate workpieces like copper parts for fitting into the vacuum tubes can be produced by this method. The workpiece, in this case, is fragile to withstand the cutting tool load during conventional machining.

Advantages of Electric Discharge Machining

The extremely high popularity of the EDM process is due to the following advantages:

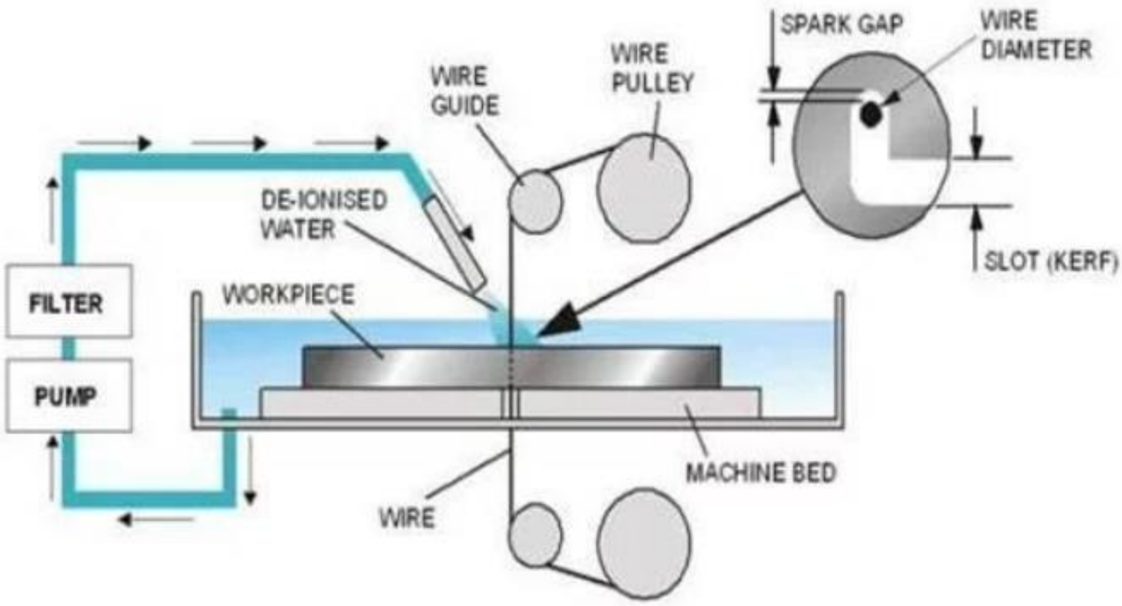
1. The process can be applied to all electrically conducting metals and alloys irrespective of their melting points, hardness, toughness or brittleness.
2. Any complicated shape that can be made on the tool can be reproduced on the workpiece.
3. Complicated shapes can be done by fabricating the tool with split sectioned shapes.
4. Time of machining is less than conventional machining processes.
5. EDM can be employed for the extremely hardened workpiece. Hence, the distortion of the workpiece arising out of the heat treatment process can be eliminated.
6. No mechanical stress is present in the process. It is due to the fact that the physical contact between the tool and the workpiece is eliminated. Thus, fragile and slender workpieces can be machined without distortion.
7. Hard and corrosion-resistant surfaces, essentially needed for die making, can be developed.

Disadvantages of Electric Discharge Machining

The following disadvantages of the process limit its application:

1. Profile machining of complex contours is not possible at required tolerances.
2. Machining times are too long.
3. Machining heats the workpiece considerably and hence causes a change in surface and metallurgical properties.
4. Excessive tool wear.
5. High specific power consumption.

WIRE-CUT ELECTRICAL DISCHARGE MACHINING:



Wire electrical discharge machining is a non-contact subtractive manufacturing process that uses an electrically charged thin wire with a dielectric fluid to cut a metal part into different shapes.

The process produces small chips and precise cut lines by melting or vaporizing the material rather than cutting it. As a result, it can conveniently machine parts unsuitable for conventional machining techniques. However, the parts must be electrically conductive.

Machining a part using the process involves submerging the workpiece into a dielectric fluid, securing it with a machinist vice, and running the wire through it to produce sparks as it passes an electric current.

In other words, the wire carries one side of the charge, and the workpiece, which must be a conductive material, carries the other side of the charge. When the two get close, a hot electric charge jumps the gap and melts tiny pieces of the metal away.

The electric spark is the cutting tool to cut the material in the desired shape. Additionally, the wire EDM process involves deionized water to control the process and flush away tiny particles removed.

1. CNC Tools

The CNC tools control the entire operation of the Wire EDM machining process. Controlling the entire operations include being in control of the sequencing of the wire path and being able to manage the cutting process automatically.

Note: The CNC tool's sophistication determines the error level and the machining time.

2. Power Supply

The power supply unit is the component that delivers pulses (from 100V to 300V) to the wire electrode and the workpiece. Furthermore, it controls the frequency and strength of the electrical charges that pass through the wire electrode to interact with the workpiece.

It is necessary to use a highly developed power supply unit to deliver the necessary quality and type of charges during Wire EDM machining.

3. Wire

The wire serves as the electrode to create the electrical discharge. The shape and thickness of the workpiece directly influence the wire's diameter. Typically, one can use wires with diameters ranging from 0.05 to 0.25mm. The main types of wires used include

-Brass Wires

Brass is the most common EDM wire material because of its excellent conductive properties. It is an alloy of copper and zinc, and the higher the zinc content, the faster the wire cuts. However, there should be a balance because when the zinc content is over 40%, this decreases the corrosion rate of the brass wire.

-Zinc coated Wires

As the name implies, you obtain it by applying a coating of pure zinc or zinc oxide on the wire surface. Manufacturers use zinc-coated wires because it improves the machining speed.

-Diffusion-annealed Wires

The diffusion annealing process helps to create wires with higher zinc content (more than 40% zinc). It involves coating wires with layers of pure zinc. These wires are ideal for mass production and can machine many materials.

-How to Choose the Right Wire

- To choose the right EDM wire material for your project, consider the following
- Tensile Strength
- Fracture Resistance
- Conductivity
- Vaporization Temperature
- Hardness

4. Dielectric Medium

The wire-cut EDM process must be carried out in a tank filled with dielectric fluid. This liquid prevents the tiny particles from the workpiece from getting attached to the wire electrode. The most common medium is deionized water which cools the process and gives the workpiece a good surface finish.

5. Electrodes

The electrodes in the machine are the wire (cathode) and the workpiece (anode). The servo motor controls the wire electrode, ensuring it does not come in contact with the workpiece at any point during the wire EDM cutting process.

Advantages of Wire EDM

- **Cost-Effective:** Since the electrode in an EDM-wire cut machine is just a simple wire, the tool's cost is relatively modest. With wire EDM, there is no need for expensive equipment or molds because workpieces are cut directly. As a result, it can rapidly and precisely cut hard and delicate materials with quick turnaround times and much fewer human resources than conventional manufacturing processes. Additionally, wire EDM uses less material and generates less waste.
- **Very Little Distortion:** Hard and delicate materials can be cut with wire EDM without causing damage to the cutting tools or deforming the material's surface or edges.
- **Rapid Rate of Manufacturing:** Wire EDM equipment may be set up and programmed quickly. In addition, it removes the need for further tooling and finishing operations because final components have smooth edges and clean surfaces, greatly decreasing lead times.
- **Exceptional Precision:** Due to the use of extremely fine wire in wire EDM, it may produce incredibly exact cuts and adhere to rigorous tolerances on even the most complicated shapes and designs.
- **Complexity in Part:** Producing tiny, delicate, and detailed components are best accomplished with wire EDM. This ability makes it a very well-liked production choice for sectors like healthcare and aerospace that need incredibly complicated and precise parts.

Disadvantages of Wire EDM

- **Slow Rate:** The most well-known drawback is that wire EDM cutting is still labor-intensive. Modern EDM equipment with AWT (automatic wire threading) and CNC capabilities can be designed to operate "lights out" to counteract the sluggish cutting speed. However, a technique like thin-wheel abrasive cutting might be chosen for extremely high volumes of items with diameters larger than 0.020′′ (0.5 mm).
- **Only Conductive Materials:** Wire EDM cutting can only be used on materials that conduct electricity because of the nature of the process, which involves quickly repeating regulated electrical charges down a strand of metal wire. Therefore, it is not practical to use EDM on any material that is a composite or covered with a dielectric.
- **A Charged Environment's Effects:** The workpiece, deionized water, and the entire EDM environment are charged. The wire's repetitive electrical discharges can heat the workpiece's target area thousands of degrees. This heat could put nearby areas under temperature stress and generate some trash. In addition, damage to the wire causes the EDM machine to feed in the new wire constantly.
- Another drawback of wire EDM cutting is that an oxide layer may develop on the cut surface, depending on the metal being cut. This coating can call for additional cleaning, which raises the price.

Applications

- Small or delicate pieces that other conventional procedures might damage
- Larger items that need a fine polish or accuracy
- Complicated shapes

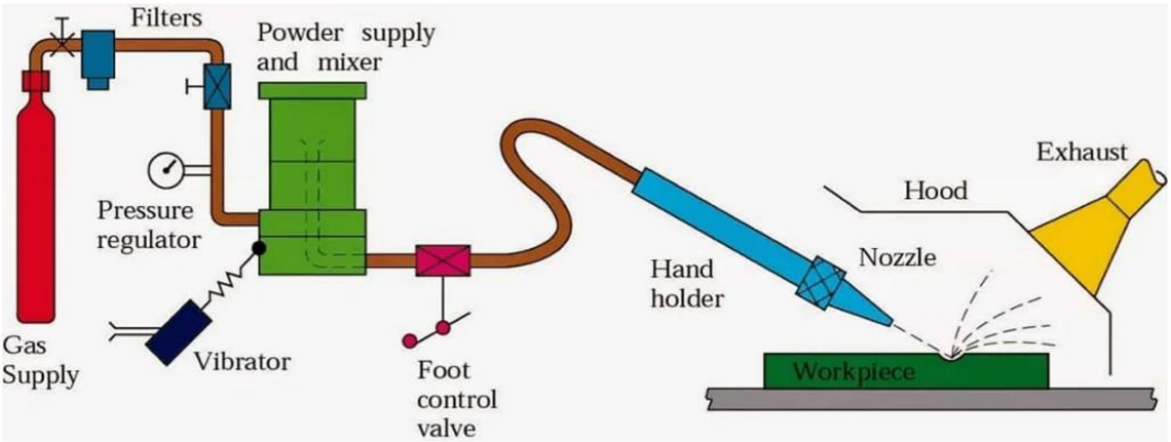
ABRASIVE JET MACHINING(AJM):

Abrasive jet machining is the process of impinging the high-speed stream of abrasive particles by high-pressure gas or air on the work surface through a nozzle and metal removal occurs due to erosion caused by high-speed abrasive particles. Because of repeated impacts small bits of material get loosened which is carried away by jet and exposes the fresh surface to the jet.

Parts or Construction

Abrasive Jet machining Consists of the following parts

- Gas Supply
- Filter
- Pressure Gauge
- Regulator
- Mixing chamber
- Nozzle



Working Principle of Abrasive Jet Machining:

The figure shown is the above Abrasive jet Machining. It consists of a mixing chamber, gas filter, pressure gauge, regulator, and nozzle. The filtered gas at a pressure of 2 to 8 kgf/cm^2 is supplied to the mixing chamber containing the abrasive powder and vibrating at 50 Hz, where it mixes with abrasive particles and then enters into the connecting hose.

The abrasive and gas mixture comes out from the nozzle at a high velocity ranging from 150 to 300 meters/minute and impinges over the work surface causing abrasion action by repeated impacts and the material is removed by erosion. The abrasive power feed rate can be controlled by the amplitude of vibration of the mixing chamber. A pressure regulator controls the gas flow and pressure.

To control the size and shape of the cut, either the workpiece or nozzle is moved by cams, pantographs, or any other suitable mechanism. The carrier gas should be cheap and non-toxic and easily available, It is generally air or nitrogen. Abrasive generally used are Aluminum oxide, Silicon carbide, or glass powder.

The nozzle is generally made of harder material such as ceramic or tungsten carbide to reduce abrasion wear. The material removal rate depends on the diameter of the nozzle, jet pressure, composition of mixtures, Hardness of abrasive particles and workpiece, Particle size, the velocity of the jet, and distance between work and nozzle.

Applications

- Cutting slots and thin sections.
- Contouring and drilling operation.
- Producing shallow crevices and deburring.
- Producing intricate hole shapes in a hard and brittle material.
- Cleaning and polishing the plastic, nylon, and Teflon components.
- Frosting of the interior surface of glass tubes.
- Etching of marking of glass cylinders.
- Machining super-alloys and refractory material.

Advantages

- The surface finish can be obtained smooth.
- The cost of equipment is low.
- Ability to cut fragile and heat-sensitive material without damage.
- Ability to cut intricate hole shapes in hard and brittle material.
- The main advantages are its flexibility, and low heat production.

Disadvantages

- The material removal rate is low.
- Poor machining accuracy.
- High nozzle wear rate.
- The soft material cannot be machined.
- Additional cleaning of the work surface is required due to the sticking of abrasive grains in softer material.

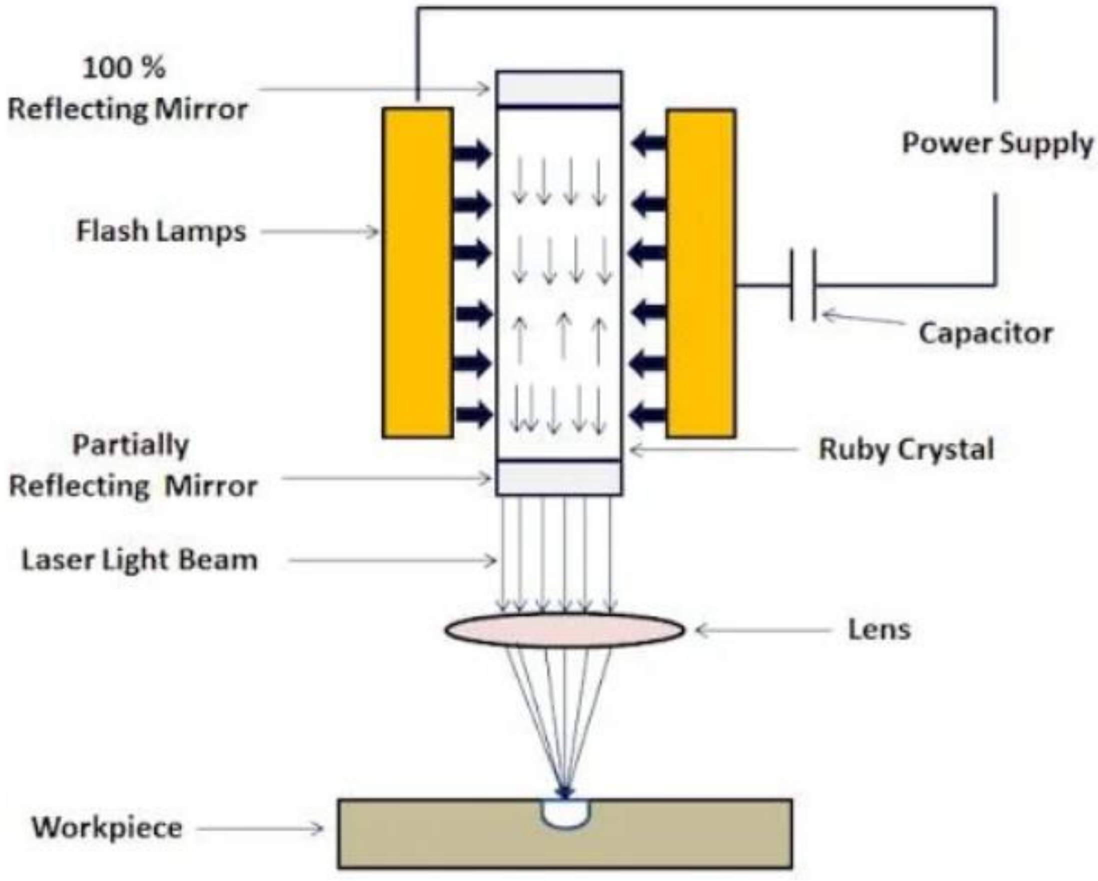
LASER BEAM MACHINING(LBM):

Laser Beam Machining is a non-conventional machining process in which the workpiece is being holed by the laser machining process. To remove the material from the workpiece the process used thermal energy.

Parts or Construction:

Laser Machining consists of the following Main Parts:

- Power Supply
- Capacitor
- Flash Lamps
- Reflecting Mirror
- Laser Light Beam
- Ruby Crystal
- Lens
- Workpiece



Laser Beam Machining Working Principle:

Laser Machining is based on the LASER and conversion or process of Electric Energy into Light Energy and into Thermal Energy.

Negatively charged electrons in the atomic model rotate around the positively charged nucleus in orbital paths. It depends on the number of electrons, electron structure, neighboring atoms, and the electromagnetic field.

Every orbital of electrons is associated with different energy levels. An atom is considered to be at ground level at absolute zero temperature at this, all electrons occupy their lowest potential energy.

The electrons at the ground state move to a higher state of energy by absorbing energy like an increase in electronic vibration at elevated temperatures.

Uses or Applications of Laser Beam Machining are:

- Laser Machining is used for making very small holes, Welding non-conductive and refractory material.
- It is best suited for brittle material with low conductivity and Ceramic, Cloth, and Wood.
- Laser Machining is also used in surgery, micro-drilling operations.
- Spectroscopic Science and Photography in medical science.
- It is also used in mass macro machining production.
- Cutting complex profiles for both thin and hard materials.
- It is used to make tiny holes. Example: Nipples of the baby feeder.

The following advantages of Laser Beam Machining are:

- In Laser Beam Machining any material including non-metal also can be machined.
- Extremely small holes with good accuracy can be machined.
- The tool wear rate is very low.
- There is no mechanical force on the work.
- Soft materials like plastic, rubber can be machined easily.
- It is a very flexible and easily automated machine.
- The heat-affected zone is very small.
- Laser Machining gives a very good surface finish.
- Heat treated and magnetic materials can be welded, without losing their properties.
- The precise location can be ensured on the workpiece.

Disadvantages of Laser Beam Machining are:

- Laser Machining cannot be used to produce a blind hole and also not able to drill too deep holes.
- The machined holes are not round and straight.
- The capital and maintenance cost is high.
- There is a problem with safety hazards.
- The overall efficiency of the Laser beam machining is low.
- It is limited to thin sheets.
- The metal-removing rate is also low.
- The flash lamp life is short.
- There is a limited amount of metal removing during the process.

PLASMA ARC MACHINING(PAM):

Plasma arc machining is a non traditional **process of metal removal** that involves focusing a high-velocity jet of high-temperature (11,000°C to 30,000°C) ionized gas on a workpiece.

Plasma Arc Machining is a technique for removing material from a workpiece. A high-velocity jet of high-temperature gas is used in this process to melt and remove material from the workpiece. This fast-moving hot gas is also known as a plasma jet.

Working of Plasma Arc Machining

When DC power is given to the circuit, a strong arc forms between the cathode (electrodes) and anode (nozzle).

Following that, the chambers are filled with gas. This gas may be a mixture of hydrogen, nitrogen, argon, or other gases selected based on the metal being worked.

The gas used in the process is heated by an arc formed between the cathode and the anode. This gas heats at extremely high temperatures ranging from 11000 ° C to 28000 ° C.

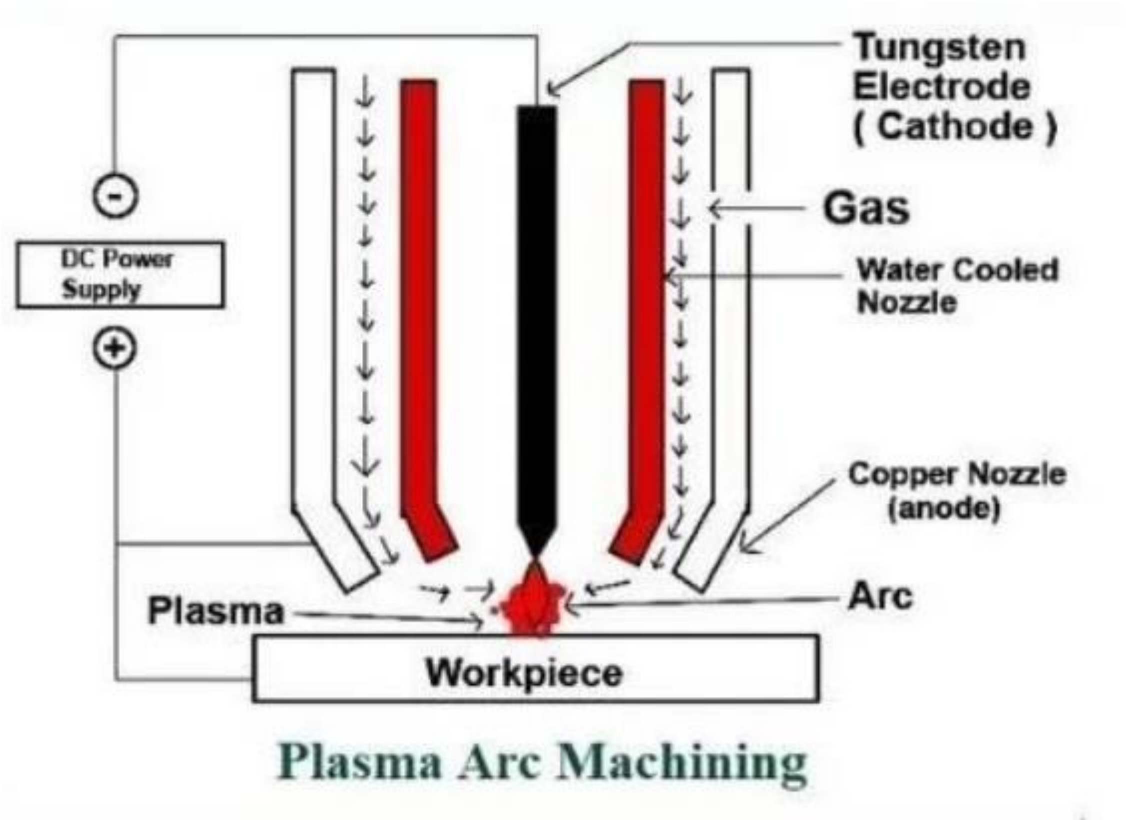
When the arc makes contact with the gas, the electrons of the arc collide with the molecules of the gas, causing the gas molecules to separate into different atoms.

Because of the high temperatures produced by the arc, electrons from some atoms are displaced, the atoms are ionized (electrically charged), and the gas is converted into plasma. A significant amount of thermal energy is released as the gas is ionized.

After the gas has been ionized, the high temperature ionized gas is directed with high velocity towards the workpiece.

Other advantages of using an electric arc include increasing the temperature of the ionized gas, making the beam approximately parallel, and increasing the velocity of the gas.

As the plasma jet approaches the workpiece, the plasma melts it and the molten metal is blown away by the high-velocity gas. Plasma arc machining is used in this manner to remove material from the workpiece.



ADVANTAGES:

1. Requires no complicated chemical analysis or maintenance
2. Uses no harmful chlorinated fluorocarbons, solvents, or acid cleaning chemicals
3. Operates cleanly, often eliminating the need for vapor degreasing, solvent wiping, ultrasonic cleaning, and grit blasting
4. Requires no worker exposure to harmful chemicals
5. Needs less energy to operate.

6. This method can be used to machine both hard and brittle metals.
7. Plasma Arc Machining provides a faster rate of production.
8. This process can machine small cavities with high dimensional accuracy.
9. It is suitable for rough turning of extremely hard materials.
10. It's also found in machines that repair jet engine blades.

DISADVANTAGES:

1. The large power supplies needed (220 kW) are required to cut through 12-mm-thick mild steel plate at 2.5 m/min.
2. The process also produces heat that could spoil the workpiece and pro-duce toxic fumes.

3. The equipment used in Plasma Arc Machining is very expensive (costly).
4. Metallurgical changes occur on the surface of the workpiece.
5. Inert gas consumption is high.
6. Shielding is required as oxidation and scale formation occur.

2ND CHAPTER
PLASTIC PROCESSING

It is defined as the process of converting the Plastics raw materials in to semi-finished or finished products.

Examples

Buckets, Mugs, Soap boxes, Crates, Tanks, Pipes, Shampoo, bottles, etc.

Moulding process:

Molding is a manufacturing process that involves shaping a liquid or malleable raw material by using a fixed frame; known as either a mold or a matrix. The mold is generally a hollow cavity receptacle, commonly made of metal, where liquid plastic, metal, ceramic, or glass material is poured.

(1) Injection moulding:

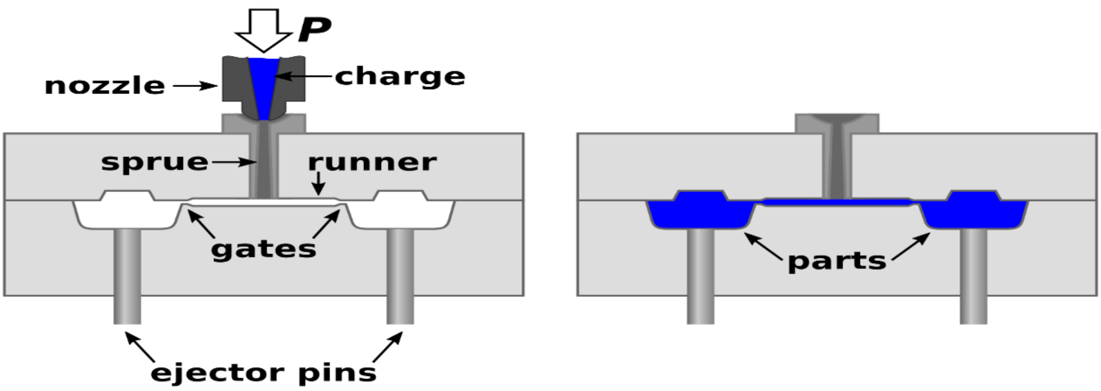
Injection moulding is a manufacturing process for producing parts by injecting molten material into a mould, or mold.

Injection moulding can be performed with a host of materials mainly including metals (for which the process is called die-casting), glasses, elastomers, confections, and most commonly thermoplastic and thermosetting polymers.

Material for the part is fed into a heated barrel, mixed (using a helical screw), and injected into a mould cavity, where it cools and hardens to the configuration of the cavity.

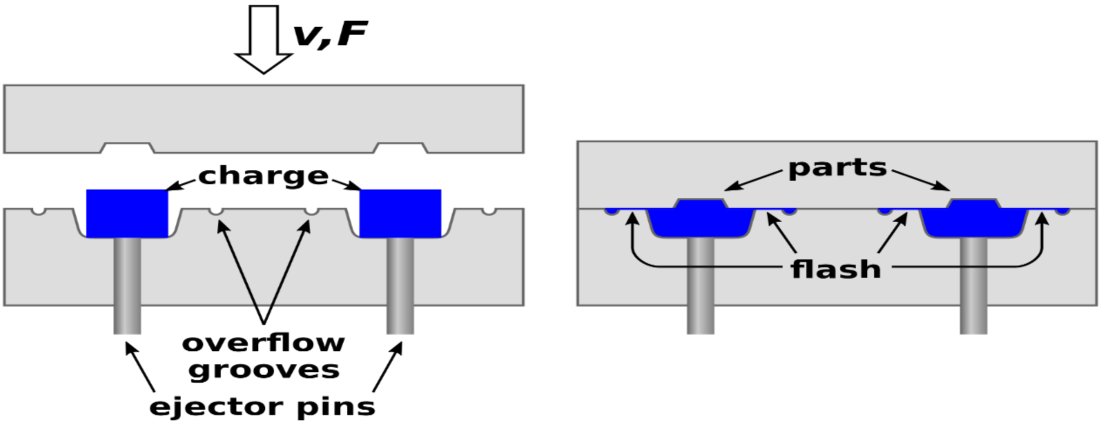
After a product is designed, usually by an industrial designer or an engineer, moulds are made by a mould-maker (or toolmaker) from metal, usually either steel or aluminium, and precision-machined to form the features of the desired part. Injection moulding is widely used for manufacturing a variety of parts, from the smallest components to entire body panels of cars.

Advances in 3D printing technology, using photopolymers that do not melt during the injection moulding of some lower-temperature thermoplastics, can be used for some simple injection moulds.



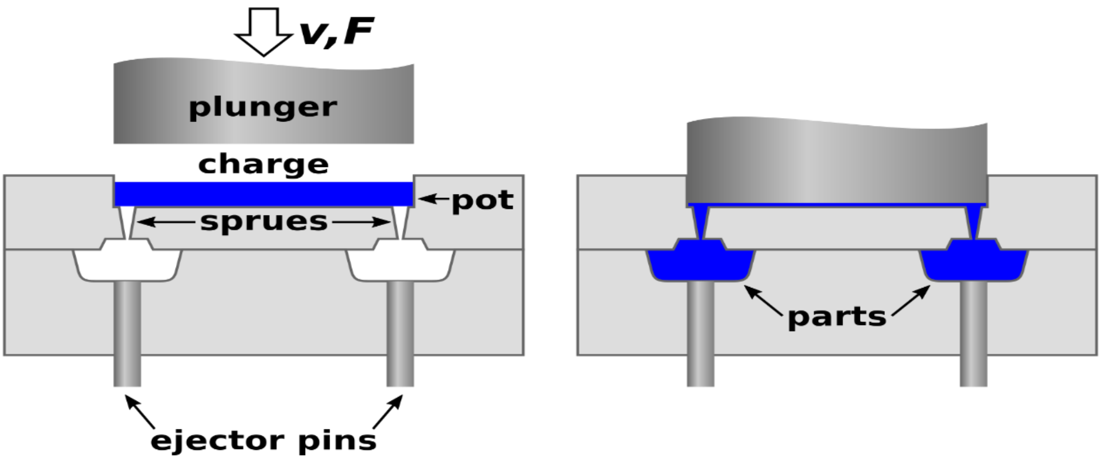
(2) Compression moulding:

Compression molding is a method of molding in which the molding material, generally preheated, is first placed in an open, heated mold cavity. The mold is closed with a top force or plug member, pressure is applied to force the material into contact with all mold areas, while heat and pressure are maintained until the molding material has cured; this process is known as compression molding method and in case of rubber it is also known as 'Vulcanisation'. The process employs thermosetting resins in a partially cured stage, either in the form of granules, putty-like masses, or preforms.



(3) Transfer molding:

Transfer molding is a manufacturing process in which casting material is forced into a mold. Transfer molding is different from compression molding in that the mold is enclosed rather than open to the fill plunger resulting in higher dimensional tolerances and less environmental impact. Compared to injection molding, transfer molding uses higher pressures to uniformly fill the mold cavity. This allows thicker reinforcing fiber matrices to be more completely saturated by resin. Furthermore, unlike injection molding the transfer mold casting material may start the process as a solid. This can reduce equipment costs and time dependency. The transfer process may have a slower fill rate than an equivalent injection molding process.



Extruding:

Extrusion is a process where a material undergoes plastic deformation by the application of a force causing that material to flow through an orifice or die. The material adopts the cross-sectional profile of the die and if the material has suitable properties, that shape is retained in the final extrudate.

Advantages of the extrusion process:

There are several advantages of the modern extrusion process

1. A variety of shapes are possible, especially with hot extrusion.
2. Grain structure and strength properties are enhanced in cold and warm extrusion.
3. Fairly close tolerances are possible, especially in cold extrusion.
4. Little or no wasted material is created.

Casting:

Casting may be defined as a metal object obtained by pouring molten metal into a mould and allowing it to solidify.

Casting process is based on the property of liquids to take up the shape of the vessel containing it.

The section of the workshop where metal castings are produced is known as the foundry or foundry shop.

Calendering:

• Calendaring is the process of squeezing plastic melting between two or more counter rotating cylinders or rolls to form a continuous film and sheet.

• The art of forming a plastic sheet has been adopted from the technique of making paper, metal and rubber in industries.

• Both rigid and plasticized compounds of PVC resin can be used in calendaring process.

• The sheet is formed in the range of 0.1 to 1.0 mm and above thickness. The sheet can be transparent, colored, embossed, printed or laminated form.

Fabrication method:

Plastic fabrication is the process of designing, manufacturing, and assembling a product made out of plastic material or composites that contain plastic.

There is a wide variety of plastic fabrication processes depending on the distinctive characteristics and the resulting product. The most common plastic fabrication methods are:

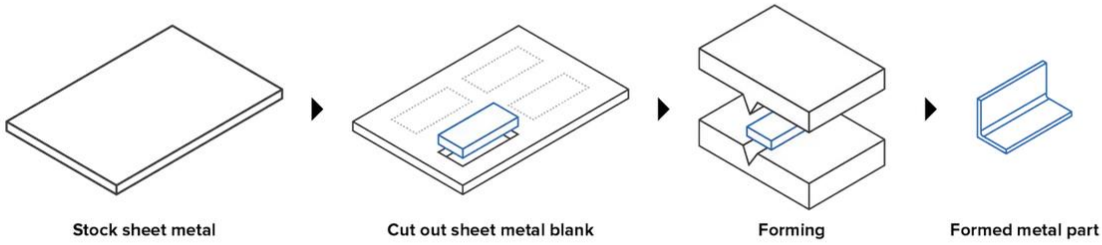
- Plastic Welding
- Compounding
- Plastic Lamination
- Molding
- Plastic Extrusion
- Thermoforming
- Die Cutting
- Pultrusion
- Forging
- Vacuum Casting

Sheet forming:

Sheet metal forming includes treatments such as **bending, spinning, drawing, or stretching implemented by dies or punching tools**. Forming is mostly performed on a press and parts are formed between two dies.

The sheet metal forming process is straightforward:

1. A sheet of metal is cut out from a stock metal to create individual blanks.
2. The blank is placed in the forming machine in between two tools.
3. Subjected to the high forces of the machine, the upper die (also known as the punch) pushes the sheet metal around the matching lower tool and bends it in the desired shape.



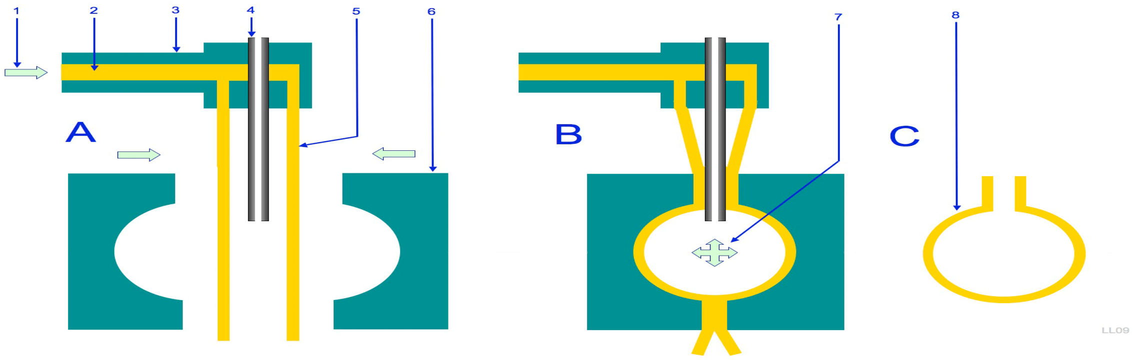
Blow moulding:

Blow molding (or moulding) is a manufacturing process for forming hollow plastic parts. It is also used for forming glass bottles or other hollow shapes.

In general, there are three main types of blow molding: extrusion blow molding, injection blow molding, and injection stretch blow molding.

The blow molding process begins with softening plastic by heating a preform or parison. The parison is a tube-like piece of plastic with a hole in one end through which compressed air can enter.

The plastic workpiece is then clamped into a mold and air is blown into it. The air pressure inflates the plastic which conforms to the mold. Once the plastic has cooled and hardened the mold opens and the part is ejected. Water channels within the mold assist cooling.

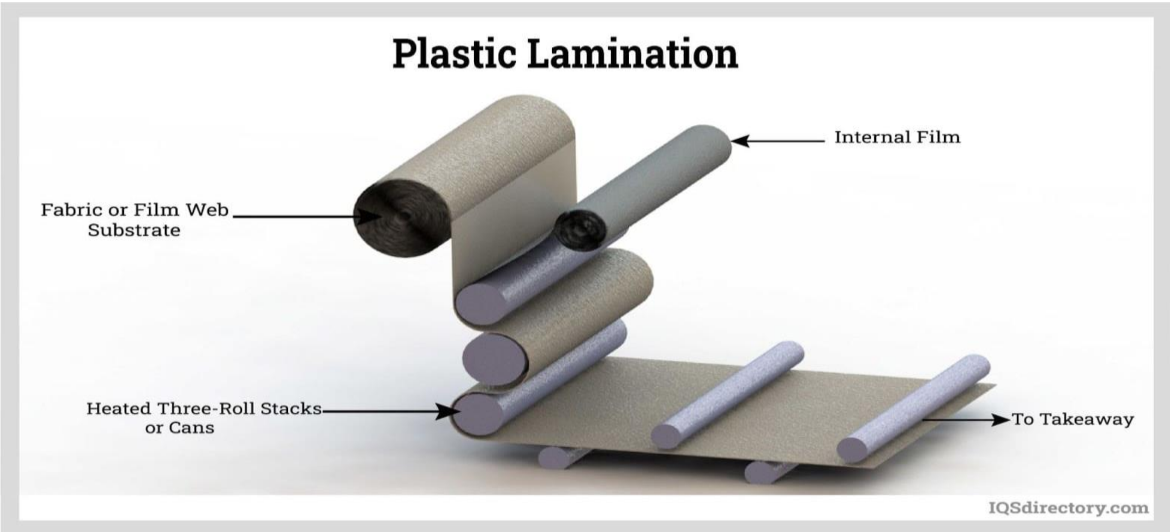


Laminating plastic:

In the plastic lamination method, various layers of plastic are held together creating a barrier along the surface of another material. This technique not only improves the durability and aesthetics of the product but reduces the potential need for maintenance by shielding the sensitive and deterioration-prone material.

There are two common types of plastic lamination, film, and resin. In both types, heat and pressure are applied to create the barrier. Film lamination on the other hand is considered to be more effective than resin lamination. Although the resin application is frequently used to create adhesive layers between common materials such as papers, fabrics, etc.

A major drawback of this process is that this is a time-consuming process hence the production rate is very low as compared to other plastic fabrication methods. However, this method produces plastic with properties like strength, stiffness, and temperature resistance much superior to others.



Reinforcing:

Reinforcement fabrication is **the process of assembling reinforcing steel bars into mats or cages prior to concreting at the site**.

Application of plastic:

Plastic is used across almost every sector, including to **produce packaging, in building and construction, in textiles, consumer products, transportation, electrical and electronics and industrial machinery**.

3RD CHAPTER

Additive manufacturing process

Additive manufacturing (AM) or additive layer manufacturing (ALM) is the industrial production name for 3D printing, a computer controlled process that creates three dimensional objects by depositing materials, usually in layers.

Types:

There are number of distinct AM processes with their own standards, which include:

1. Binder Jetting

This technique uses a 3d printing style head moving on x, y and z axes to deposit alternating layers of powdered material and a liquid binder as an adhesive.

2. Directed Energy Deposition

Direct energy deposition additive manufacturing can be used with a wide variety of materials including ceramics, metals and polymers. A laser, electric arc or an electron beam gun mounted on an arm moves horizontally melting wire, filament feedstock or powder to build up material as a bed moves vertically.

3. Material Extrusion

This common AM process uses spooled polymers which are either extruded or drawn through a heated nozzle which is mounted on a movable arm. This builds melted material layer by layer as the nozzle moves horizontally and the bed moves vertically. The layers adhere through temperature control or chemical bonding agents.

4. Powder Bed Fusion

Powder bed fusion encompasses a variety of AM techniques including direct metal laser melting (DMLM), direct metal laser sintering (DMLS), electron beam melting (EBM), selective laser sintering (SLS) and selective heat sintering (SHS). Electron beams, lasers or thermal print heads are used to melt or partially melt fine layers of material after which excess powder is blasted away.

5. Sheet Lamination

Sheet lamination can be split into two technologies; laminated object manufacturing (LOM) and ultrasonic additive manufacturing (UAM). Laminated object manufacturing is suited to creating items with visual or aesthetic appeal and uses alternate layers of paper and adhesive. UAM uses ultrasonic welding to join thin metal sheets; a low energy, low temperature process, UAM can be used with various metals such as aluminium, stainless steel and titanium.

6. Vat Polymerisation

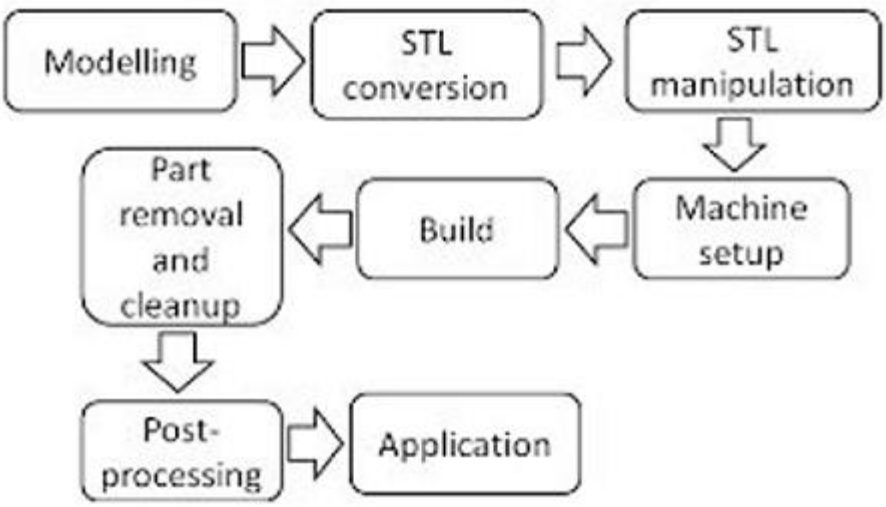
This process uses a vat of liquid resin photopolymer to create an object layer by layer. Mirrors are used to direct ultraviolet light which cures the successive layers of resin through photopolymerisation.

7. Wire Arc Additive Manufacturing (Now known as Directed Energy Deposition-Arc (DED-arc))

Wire arc additive manufacturing uses arc welding power sources and manipulators to build 3D shapes through arc deposition. This process commonly uses wire as a material source and follows a predetermined path to create the desired shape. This method of additive manufacture is usually performed using robotic welding equipment.

AM process chain:

From CAD description to physical result, AM involves several steps. The process will vary depending on the product. It is likely that smaller, simpler products make use of AM only for visualization purposes, whereas larger, more complex products may incorporate AM at multiple stages and iterations throughout the development process. Also, in the early stages of product development, rough parts may be needed, and AM is generally used due to its rapid fabrication capability. As parts advance through the process, they may need cleaning and post-processing (such as coating and sanding) before they can be used; in this regard, rapid prototyping is useful due to the complexity of forms that can be created without involving tooling.



Step 1: CAD

CAD models that fully describe the external geometry are required for all AM parts. Any professional CAD solid modelling software can be used to create this, but the final product must be a 3D solid or surface model. To create such an image, reverse engineering equipment (for example, laser and optical scanning) can also be used.

Step 2: Conversion to STL

Upon completion of the digital model, the STL (Standard Tessellation Language) file format must be used to create the stereolithography. Nearly every CAD system supports this format, which is how AM machines communicate. The STL file serves as the basis for calculating the slices of the model.

Step 3: Transfer to Machine

In the third step, the STL file is transmitted to the AM machine. As a result of this step, it is possible to adjust the build so that it is positioned and sized correctly. A computer controls the AM machine. The AM machine is controlled by the computer, that computer only generates the required instruction in the form of G-codes and M-codes based on the given process parameters. It generates instructions automatically, if any correction is needed for the betterment of the part to be built it can be corrected.

Step 4: Setup

Before the building starts, the equipment has to be set up. The settings can constitute power, speed, layer thickness, and other several parameters related to material and process constraints, etc.

Step 5: Build

The fifth step is the actual building of the CAD model, melting layer by layer. This process can be semi or fully automated but some online monitoring is often conducted, so that the machine does not run out of material or that some software error occurs.

Step 6: Part Removal

Once the part is manufactured it has to be removed from the process, which is normally done manually. This may require interaction with the machine, which may have safety interlocks to ensure, for example, that the operating temperatures are sufficiently low or that there are no actively moving parts.

Step 7: Post-processing

After the build, the part might need some post-processing before it is completely finished. Of course, depending on the material and AM process used, some parts might need machining, cleaning, polishing, removal of support structures, hot isostatic pressing (HIP), and heat treatments.

Step 8: Application

At this stage, the part can be ready for use. Nevertheless, it could also need some additional treatments, like painting, or assembling with other components before it is fully usable. For example, they may require priming and painting to give an acceptable surface texture and finish. Treatments may be laborious and lengthy if the finishing requirements are very demanding. They may also be required to be assembled with other mechanical or electronic components to form a final model or product.

Advantages:

1. Reduced Time and Cost

One benefit of additive manufacturing is that it makes production faster and cheaper. Usually, when making a new product, you start by making a prototype, then the tools, and finally the finished product. This process could take a long time and cost a lot of money. But additive manufacturing makes the process go faster.

2. Complex Geometries

With additive printing, you can make things that would be hard to make in any other way. Additive manufacturing can be used to make structures with hollow channels inside and curved surfaces.

3. Customization and Personalization

Additive manufacturing makes it possible to change and personalize products. In traditional manufacturing, the same product is made over and over again, and there is no way to change it. Customers can use additive manufacturing to make one-of-a-kind items with their own specs, sizes, and shapes.

4. Reduced Material Waste

If additive manufacturing is used, there may be less need to throw away materials. With traditional ways of making things, like subtractive manufacturing, a lot of materials are wasted. In additive manufacturing, just the right amount of material is used. This cuts down on waste and saves money on materials.

5. Faster Prototyping:

One more benefit of additive manufacturing is that prototyping can be done more quickly. When standard production methods are used, prototyping can take a long time and cost a lot of money. Additive manufacturing can be used to make prototypes quickly and cheaply. You can easily change designs, try out new materials and shapes, and repeat the process. This makes it easier and cheaper to get products to market faster.

6. Simplified Supply Chains:

Since additive manufacturing makes it possible to make things only when they are needed, supply chains may be easier to run. Instead of making a lot of the same thing and storing it in warehouses, additive manufacturing lets people make things as they need them. This might make people need less storage space and be less likely to keep things they don't need.

Disadvantages:

1. Limited Materials

One problem with additive manufacturing is that it can only print with a certain number of materials at one time. Even though the number of materials is growing, it is still very small compared to conventional methods. This limitation could affect how well the final product works, how long it lasts, and how well it lasts.

2. Surface Quality

A glaring limitation of additive manufacturing is that the surface quality of the parts is still not very good. Especially, when complex structures are made, a smooth surface finish is difficult to achieve.

3. Size Limitations

With additive manufacturing, the size of objects may be limited. How big an item is depends on how big the printer is and how much room it has to work with. Larger things may need to be printed in parts before they can be put together. This will take time and make the process harder.

4. Complexity Limitations

Using additive manufacturing, you can make buildings with complex shapes, but the shapes can only be complicated. Complex designs can be hard to make because they often need more support structures or post-processing steps, which take more time and money.

5. Limited Scale

Another problem with additive manufacturing is that it can only make small quantities. Additive manufacturing is great for making small batches of goods, but it's not ready yet to make a lot of things at once. This is because additive manufacturing is a slow method that might take a long time to make a lot of parts.

6. Environmental Impact

When you use additive printing, it might be hard to get rid of things like support structures and failed prints. Also, if the materials used in additive manufacturing are not recycled or thrown away in the right way, they could hurt the environment.

Difference between AM and CNC:

Parameter	AM machining	CNC machining
Material	AM includes development of polymeric material, waxes and paper laminates.	CNC used for machining soft materials or medium density fiber board, machinable foams and machinable waxes etc.
Speed	Higher, takes few hours to make part.	Lower, takes weeks to develop same part.
Complexity	Complex operation	Easy operation
Efficiency	Higher	Lower
Accuracy	More accurate	Comparatively less
Programming	In AM machine the part won't be built properly if in correct programming is done	In correct programming can badly damage the machine and may even be safety risk.
Process	It is an additive process.	It is subtractive process.

Web based rapid prototyping system:

Rapid prototyping is the fast fabrication of a physical part, model or assembly using 3D computer aided design (CAD). The creation of the part, model or assembly is usually completed using additive manufacturing, or more commonly known as 3D printing.

Rapid prototyping (RP) includes a variety of manufacturing technologies, although most utilise layered additive manufacturing. However, other technologies used for RP include high-speed machining, casting, moulding and extruding.

While additive manufacturing is the most common rapid prototyping process, other more conventional processes can also be used to create prototypes.

These processes include:

- **Subtractive** - whereby a block of material is carved to produce the desired shape using milling, grinding or turning.
- **Compressive -** whereby a semi-solid or liquid material is forced into the desired shape before being solidified, such as with casting, compressive sintering or moulding.

Flexible manufacturing system:

A flexible manufacturing system (FMS) is a production method that is designed to easily adapt to changes in the type and quantity of the product being manufactured. Machines and computerized systems can be configured to manufacture a variety of parts and handle changing levels of production.