
KTU
NOTES

MODULE 6
MANUFACTUING PROCESSES

Introduction:
Manufacturing involves turning raw material to finished products, to be used for various purposes. The branch of engineering which deals with the manufacturing is known as manufacturing engineering (or science). There are a large number of processes available. These processes can be broadly classified into four categories.
1: Casting processes
2: Forming processes (Bending, forging, extrusion, rolling etc.)
3: Machining processes (Drilling, boring, grinding, milling, reaming, threading etc.)
4: Joining process (Welding, riveting, brazing, soldering, adhesive bonding etc.)

Casting Process
These processes only processes where the liquid metal is used. Casting is also the oldest known manufacturing process. Casting is a 6000 year old process. The oldest surviving casting is copper frog from 3200 BC. Basically it consists of inducing the molten metal into a cavity of mould of the required form and allowing the metal to solidify. The object after solidification removed from the mould. Casting processes are universally used to manufacture a wide variety of products. Casting is the most flexible and cheapest method and given high strength of rigidity to the parts which are difficult to produce by other manufacturing processes.

Casting is usually performed in a foundry. Foundry is a factory equipped for making moulds, melting and handling molten metal, performing the casting process and cleaning the finished casting. Workers who perform casting are called foundry men.
The principle process among this is sand casting where sand is used as the raw material. The process is equally suitable for the production of a small batch as well as on a large scale. Some of the other classified casting processes for specialized need are-

- Shell mould casting
- Precision mould casting
- Plaster mould casting
- Permanent mould casting
- Die casting
- Centrifugal casting

Advantages of casting:

1. Complex shapes can be developed
2. Economical method
3. Mass production
4. Large products can be developed
5. Flexible process

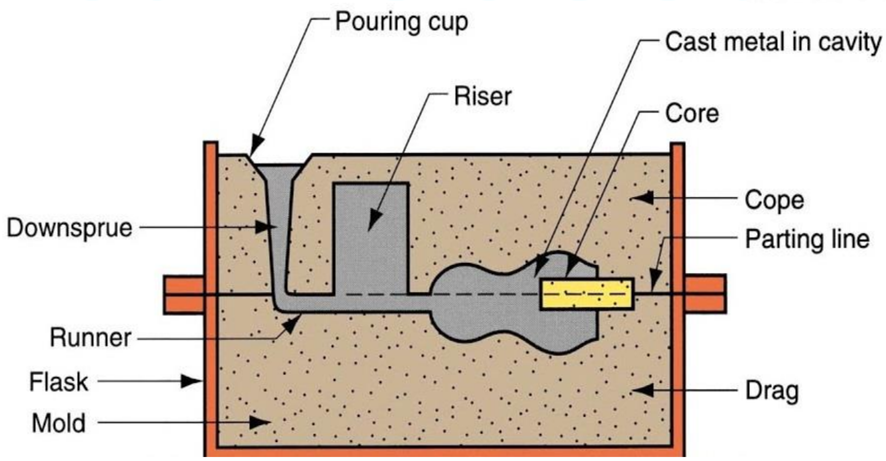
Disadvantages of casting are:

1. Mechanical properties are limited
2. Poor dimensional accuracy
3. Safety hazards to workers
4. Environmental issues

Sand casting:

Sand casting, also known as sand molded casting, is a metal casting process characterized by using sand as the mold material. The term "sand casting" can also refer to an object produced via the sand casting process. Sand castings are produced in specialized factories called foundries. Over 60% of all metal castings are produced via sand casting process.

Molds made of sand are relatively cheap, and sufficiently refractory even for steel foundry use. In addition to the sand, a suitable bonding agent (usually clay) is mixed or occurs with the sand. The mixture is moistened, typically with water, but sometimes with other substances, to develop the strength and plasticity of the clay and to make the aggregate suitable for molding. The sand is typically contained in a system of frames or mold boxes known as a flask. The mold cavities and gate system are created by compacting the sand around models called patterns, by carving directly into the sand, or by 3D printing.



Steps involved in sand casting:

1. Placing of the pattern having the shape of the desired casting in sand to make the imprint
2. Incorporating gating, runner and riser systems
3. Filling the resultant cavity with molten metal
4. Allowing solidification and cooling
5. Breaking the sand mould and removing the casting
6. Heat treatment for the casting to relieve the stresses
7. Cleaning and finishing the casting
8. Inspection for defects

Parts involved in casting operation:

- **Cope/drag –** The mould is made up of two parts, the top half is called cope and bottom is the drag.
- **Mould cavity –** The liquid flows into the gap between the two parts, called the mould cavity.
- **Pattern –** The geometry of the cavity is created by the use of a wooden shape, called the pattern. The shape of pattern is almost identical to the shape of the part we need to make.
- **Pouring cup-** The large funnel shaped cavity/opening where the molten metal is fed.
- **Sprue –** A pipe shaped neck of the funnel that connects pouring cup and runner is termed as sprue. The downward flow of the molten metal takes place with the help of sprue.
- **Runner –** The runners are the horizontal hollow channels that connect the bottom of the sprue to mould cavity. The region where the runner joins with the cavity is called the gate.
- **Riser –** Some extra cavities are made connecting to the top surface of the mould. Excess metal poured into the mould flows into these cavities called risers. They act as reservoirs, as the metal solidifies inside the cavity, it shrinks and the extra metal from the risers flows back down to avoid holes in the cast part.
- **Vents –** Vents are narrow holes connecting the cavity to the atmosphere to allow the gas and the air in the cavity to escape.
- **Cores –** Many cast parts have interior holes (hollow parts) or other cavities in their shape that are not directly accessible from either piece of the mould. Such interiors are generated by inserts called cores.
- **Chaplets –** Chaplets are metal pieces inserted in the mould to prevent shifting of the mould or to locate core surface.

Advantages of sand casting:

1. Low cost of mould materials
2. Large casting dimensions may be obtained
3. Wide variety of metals and alloys can be used

Disadvantages of sand casting:

1. Rough surface
2. Poor dimensional accuracy
3. Coarse grain structure
4. Time consuming process

Metal Forming Processes:

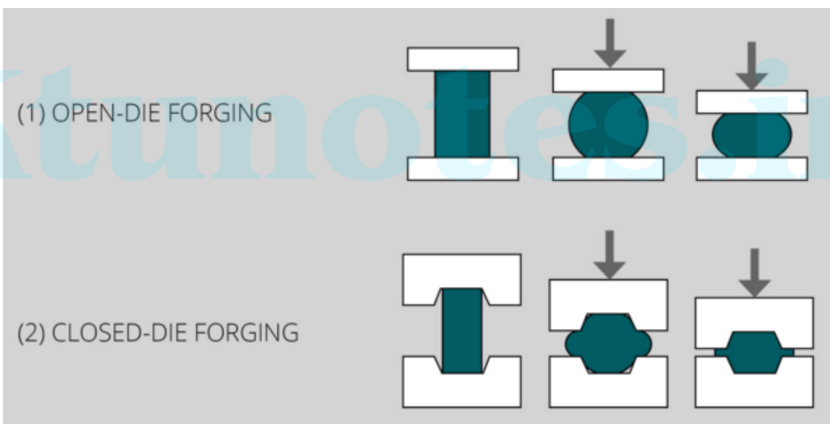
These are solid state manufacturing processes involve minimum amount of material wastage. Metal forming processes, also known as mechanical working processes, are primary shaping processes in which a mass of metal or alloy is subjected to mechanical forces. Under the action of such forces, the shape and size of metal piece undergo a change. By mechanical working processes, the given shape and size of a machine part can be achieved with great economy in material and time. Metal forming is possible in case of such metals or alloys which are sufficiently malleable and ductile. Mechanical working requires that the material may undergo "plastic deformation" during its processing. Frequently, work piece material is not sufficiently malleable or ductile at ordinary room temperature, but may become so when heated. Thus we have both hot and cold metal forming operations.

Forging

Forging can be defined as the working of metal, mostly in hot condition, by the application of sudden blows (hammering) or steady pressure (pressing) to obtain useful shape and improve its mechanical properties. In impact or hammer forging the rapid blows are given to the surface of the metal. On the basis of operation forging is classified into two types (a) open die forging (b) close die forging

Open die forging: Open die forging is the process of deforming a piece of metal between multiple dies that do not completely enclose the material. The metal is altered as the dies “hammer” or “stamp” the material through a series of movements until the desired shape is achieved. Products formed through open forging often need secondary machining and refining to achieve the tolerances required for the finished specifications. Open die forging is widely used for the products in small quantity that are simple, rather than complex, such as discs, rings, sleeves, cylinders and shafts.

Closed die forging: Closed die forging (also known as as impression die forging) is a metal forming process that compress a piece of metal under high pressure to fill an enclosed die impression. For some special shapes, second forging operation is required to reach final shapes and dimensions.



Advantages of forging

- Parts manufactured by forging are stronger
- It offers high ductility
- It is more reliable and less costly
- It offers more consistent and better metallurgical properties
- It refines structure of metal
- It offers broad size range of products

Disadvantages of forging

- It is limited to simple shapes
- Capital cost is more
- Very high man and material safety procedures need to be followed
- Forged metal surface is prone to rapid oxidation due to very high temperature
- It is difficult to maintain close tolerances

These processes are normally used for large scale production rates. These are generally economical and in many cases improve the mechanical properties. These are some of the metal forming processes.

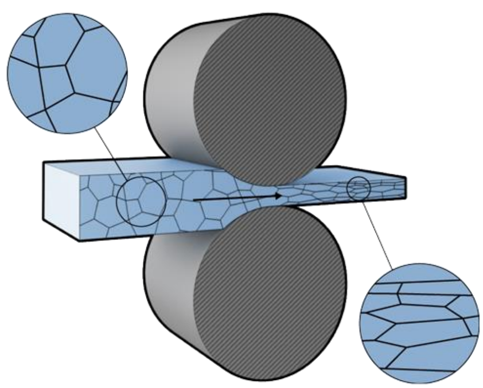
- Rolling forging
- Drop forging
- Press forging
- Upset forging
- Extrusion forging
- Wire forging

Rolling process

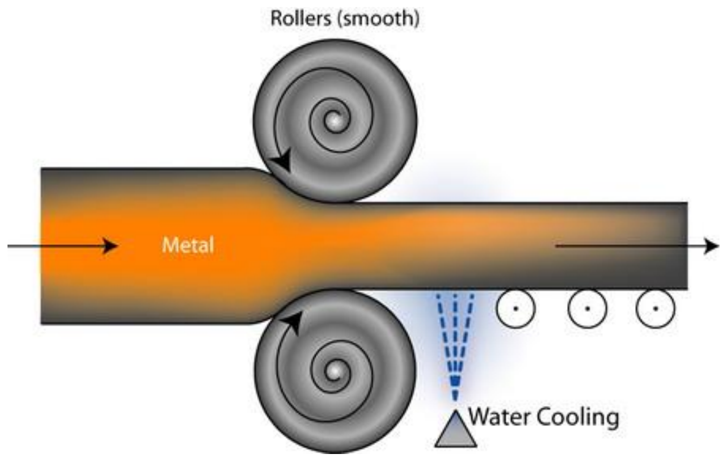
In metalworking, rolling is a metal forming process in which metal stock is passed through one or more pairs of rolls to reduce the thickness, to make the thickness uniform, and/or to impart a desired mechanical property. Rolling is classified according to the temperature of the metal rolled. If the temperature of the metal is above its recrystallization temperature, then the process is known as hot rolling. If the temperature of the metal is below its recrystallization temperature, the process is known as cold rolling.

Recrystallization: when a metal is heated and deformed under mechanical force, an energy level will be reached when the old grain structure starts disintegrating. Simultaneously an entirely new grain structure (equi axed and stress free) with reduced grain structure starts forming. This phenomenon is called recrystallization and the temperature at which this phenomenon happens is termed as recrystallization temperature.

Cold rolling: Cold rolling is the process of rolling metals and alloys below their recrystallization temperature, generally at room temperature. Cold rolling occurs with the metal below its recrystallization temperature (usually at room temperature), which increases the strength via strain hardening up to 20%. It also improves the surface finish and holds tighter tolerances. Commonly cold-rolled products include sheets, strips, bars, and rods; these products are usually smaller than the same products that are hot rolled. Because of the smaller size of the work pieces and their greater strength, as compared to hot rolled stock, four-high or cluster mills are used. Cold rolling cannot reduce the thickness of a work piece as much as hot rolling in a single pass.



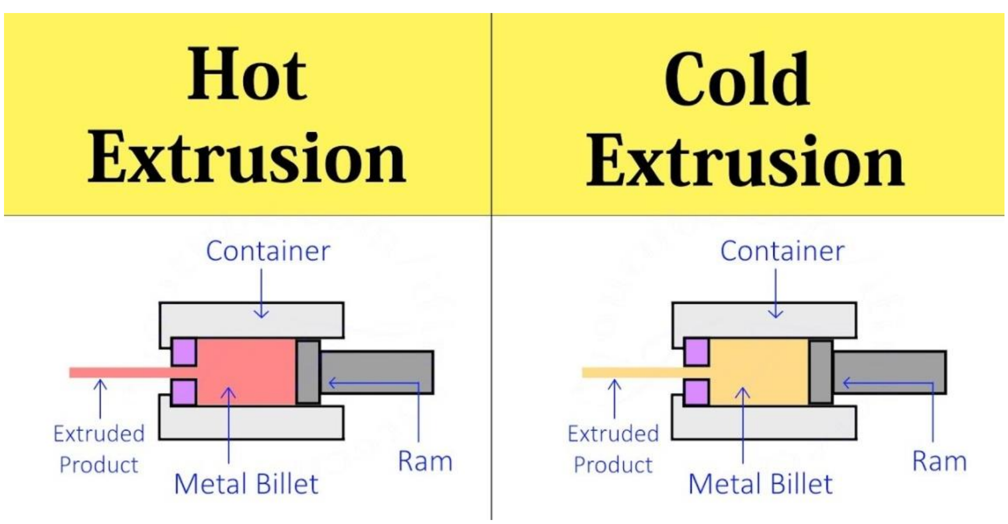
Hot rolling: Hot rolling is a metalworking process that occurs above the recrystallization temperature of the material. After the grains deform during processing, they recrystallize, which maintains an equiaxed microstructure and prevents the metal from work hardening. The starting material is usually large pieces of metal, like semi-finished casting products, such as slabs, blooms, and billets. If these products came from a continuous casting operation, the products are usually fed directly into the rolling mills at the proper temperature. In smaller operations, the material starts at room temperature and must be heated. This is done in a gas- or oil-fired soaking pit for larger work pieces; for smaller work pieces, induction heating is used. As the material is worked, the temperature must be monitored to make sure it remains above the recrystallization temperature. To maintain a safety factor a finishing temperature is defined above the recrystallization temperature; this is usually 50 to 100 °C (90 to 180 °F) above the recrystallization temperature. If the temperature does drop below this temperature the material must be re-heated prior to additional hot rolling.



Extrusion

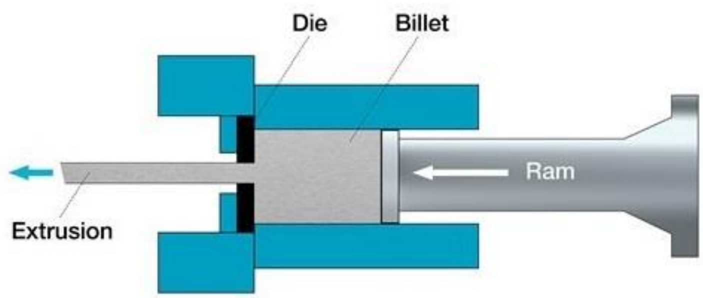
Extrusion is a process used to create objects of a fixed cross-sectional profile by pushing material through a die of the desired cross-section. Its two main advantages over other manufacturing processes are its ability to create very complex cross-sections; and to work materials that are brittle, because the material encounters only compressive and shear stresses. It also creates excellent surface finish and gives considerable freedom of form in the design process. Extrusion may be continuous (theoretically producing indefinitely long material) or semi-continuous (producing many pieces). It can be done with hot or cold material. Commonly extruded materials include metals, polymers, ceramics, concrete, modelling clay, and foodstuffs. Products of extrusion are generally called extrudates. On the basis of operational temperature, extrusion is broadly classified into two types, hot extrusion and cold extrusion.

Hot extrusion: Hot extrusion is a hot working process, which means it is done above the material's recrystallization temperature to keep the material from work hardening and to make it easier to push the material through the die. Most hot extrusions are done on horizontal hydraulic presses that range from 230 to 11,000 metric tons. Pressures range from 30 to 700 MPa.

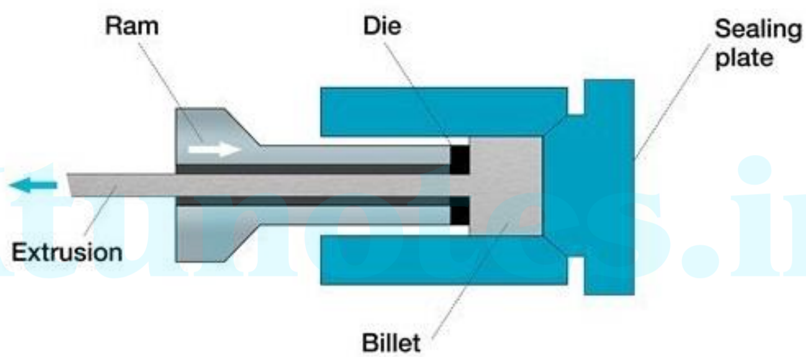


Cold extrusion: Cold extrusion is done at room temperature or near room temperature. The advantages of this over hot extrusion are the lack of oxidation, higher strength due to cold working, closer tolerances and better surface finish. Materials that are commonly cold extruded include: lead, tin, aluminum, copper, vanadium etc.

Other methods of extrusion are:
Direct extrusion: In direct extrusion or forward extrusion the flow of metal through the die is in the same direction as the movement of ram. Hot billet is placed within the container that has a die at one end. A ram forces the billet through the die opening, producing the extruded product. The die may be round or it may have various shapes.



Indirect extrusion: In indirect or backward extrusion, the metal flows in the opposite direction to the movement of ram. Ram used is hollow and the die is mounted over the bore of ram. Billet remains stationery while die is pushed into the billet by the hollow ram. Indirect extrusion does not require much force as compared to direct extrusion as it involves no friction between billet metal and container walls.



Joining process
Manufacturing as a single unit is sometimes impossible since the part may be made up of many intricate shapes. In such situations, different methods are used by the manufacturing systems to join the parts to obtain the complete unit. The processing techniques used to fabricate a given shape are called joining process.

Welding
Welding is a fabrication process whereby two or more parts are fused together by means of heat, pressure or both forming a join as the parts cool. The parts that are joined are known as a parent material. The material added to help form the join is called filler or consumable.

Unlike brazing and soldering, which do not melt the base metal, welding is a high heat process which melts the base material. Heat at a high temperature causes a weld pool of molten material which cools to form the join, which can be stronger than the parent metal. Pressure can also be used to produce a weld, either alongside the heat or by itself. It can also use a shielding gas to protect the melted and filler metals from becoming contaminated or oxidized.

Advantages

- Strong joints (stronger than parent metal)
- Large parts can be joined
- Permanent joints
- High load carrying capacity
- Applicable for different metals and alloys

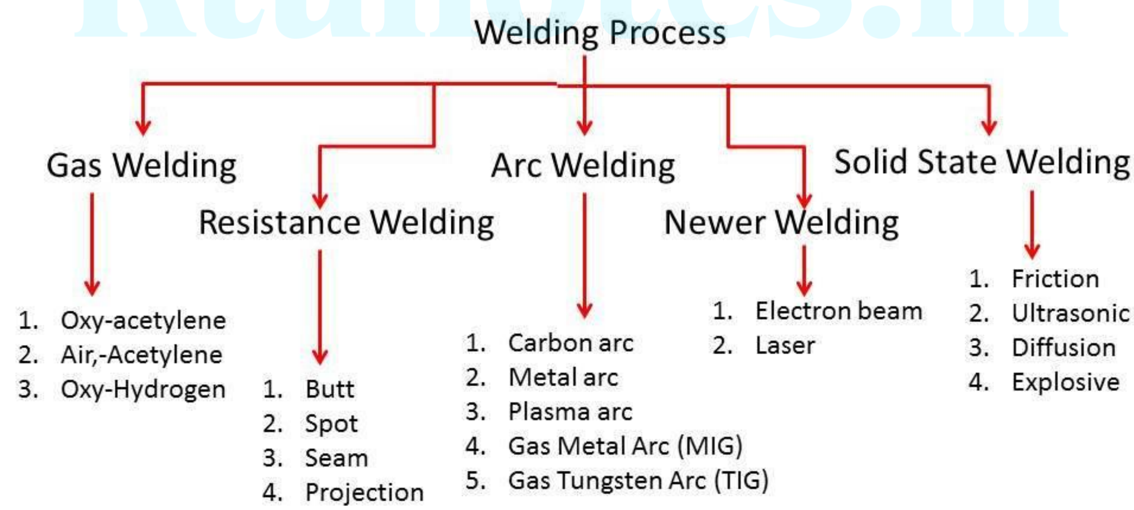
Disadvantages

- Expensive process
- Skilled labours are required
- High energy consumptions
- Difficult to disassemble

Applications

- Maintenance and repair industries
- Naval industries
- Offshore platforms
- Structural constructions
- Pipelines

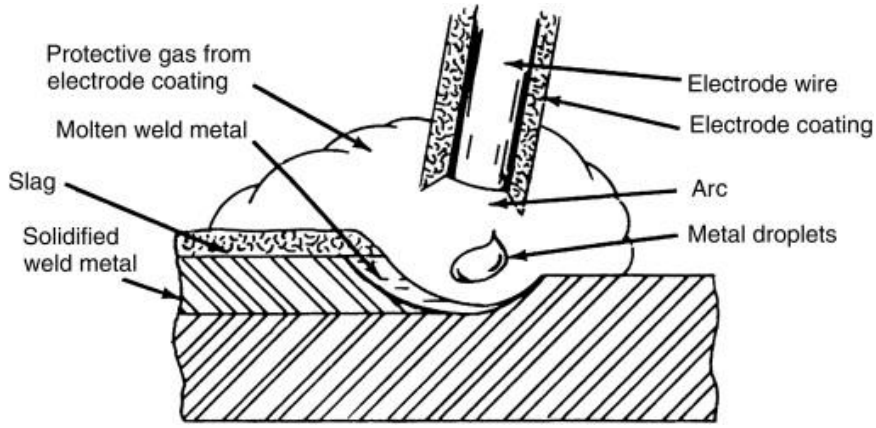
Classification of welding process



Arc Welding Process

The important components in arc welding are:

1. Power source (AC/DC)
2. Two cables
3. Electrode holder
4. Electrode
5. Protective shield
6. Gloves, wire brush, chipping hammer, goggles

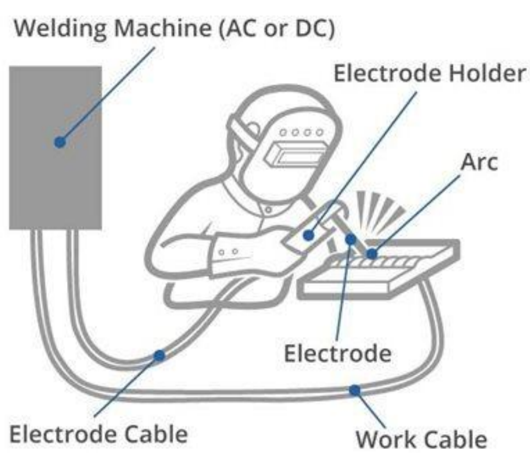


Arc welding is a fusion welding process used to join metals. An electric arc from an AC or DC power supply creates an intense heat of around 6500°F which melts the metal at the join between two work pieces. It uses the power of an electric current to join two metals. The power supply for the electric current is transferred from a welding electrode (or a "metal stick") to the base metal, creating an "arc" that melts the metals upon contact. The arc can be either manually or mechanically guided along the line of the join, while the electrode either simply carries the current or conducts the current and melts into the weld pool at the same time to supply filler metal to the join.

Because the metals react chemically to oxygen and nitrogen in the air when heated to high temperatures by the arc, a protective shielding gas or slag is used to minimise the contact of the molten metal with the air. Once cooled, the molten metals solidify to form a metallurgical bond. The electrodes (or "sticks" or "rods") used in arc welding can be either consumable or non-consumable.

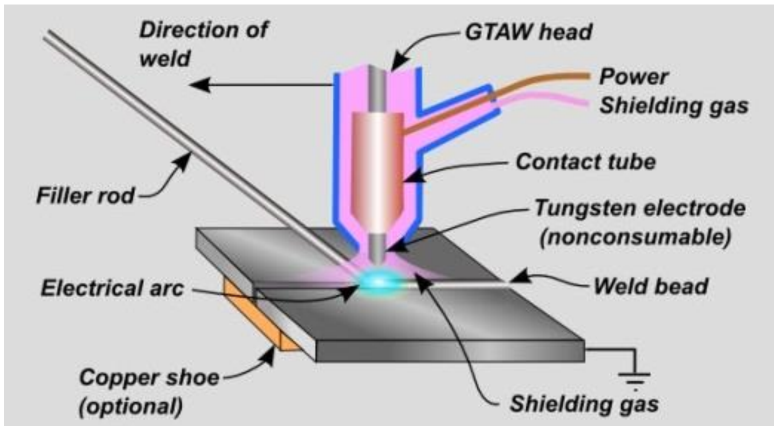
Consumable electrode: A consumable electrode not only conducts the current but also supplies filler metal to the joint. This means the electrode is made of a type of metal that melts along with the metals being welded together. This type of welding is often used in the manufacture of steel products. (Examples are: MIG/ Metal Inert Gas, SMAW/Shielded Metal Arc Welding, FCAW/Fluxed Core Arc Welding etc.)

Non-consumable electrode: A non-consumable electrode, on the other hand, is made of material that is not melted during the weld, such as tungsten, which has an extremely high melting point. (Examples are: TIG/Tungsten Inert Gas, PAW/Plasma Arc Welding etc.)

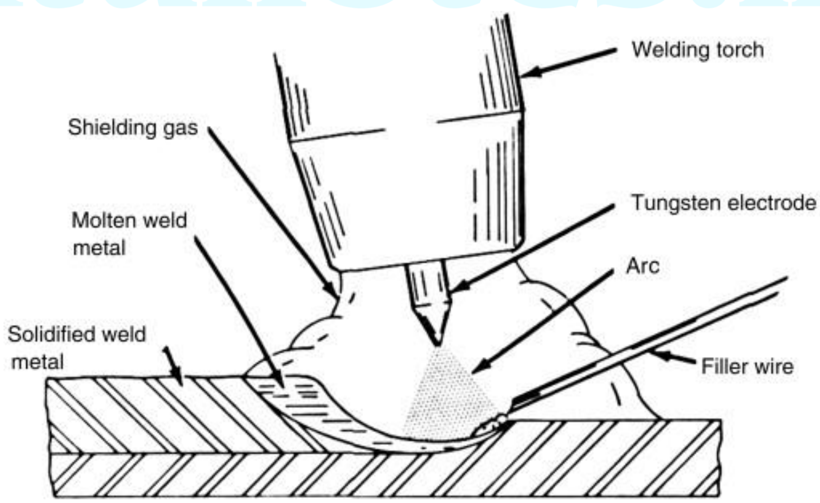


Gas tungsten arc welding (GTAW)

Gas tungsten arc welding (GTAW), also known as tungsten inert gas (TIG) welding, is an arc welding process that uses a non-consumable tungsten electrode to produce the weld. The weld area and electrode are protected from oxidation or other atmospheric contamination by an inert shielding gas (argon or helium). A filler metal is normally used, though some welds, known as autogenous welds, or fusion welds do not require it. When helium is used, this is known as heliarc welding. A constant-current welding power supply produces electrical energy, which is conducted across the arc through a column of highly ionized gas and metal vapors known as a plasma.



GTAW is most commonly used to weld thin sections of stainless steel and non-ferrous metals such as aluminum, magnesium, and copper alloys. The process grants the operator greater control over the weld than competing processes such as shielded metal arc welding and gas metal arc welding, allowing for stronger, higher quality welds. However, GTAW is comparatively more complex and difficult to master, and furthermore, it is significantly slower than most other welding techniques.



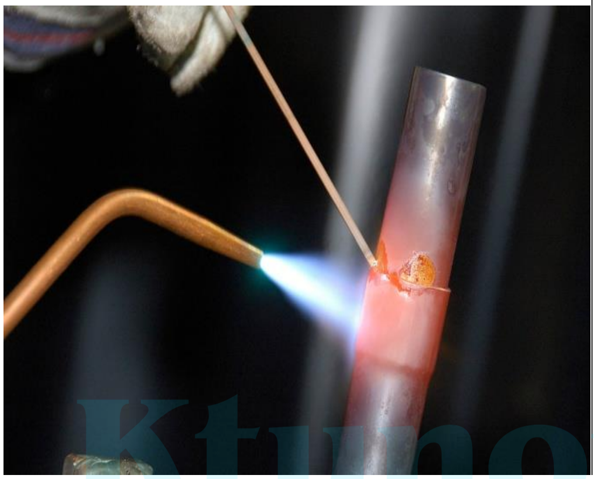
Advantages

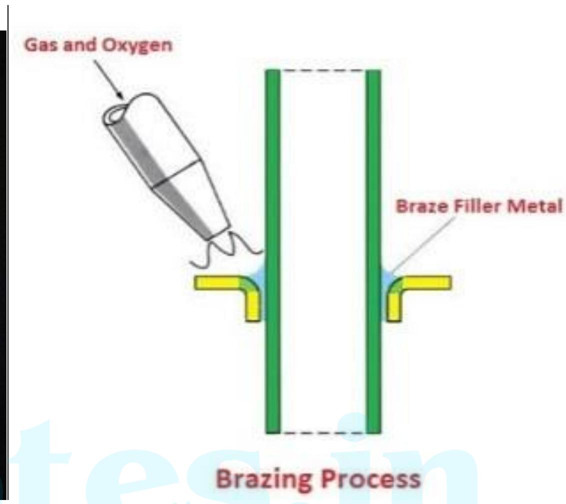
- Clean weld
- High surface finish
- Deep penetration
- Variety of metals can be used

Brazing

Brazing is a metal-joining process in which two or more metal items are joined together by melting and flowing a filler metal into the joint, with the filler metal having a lower melting point than the adjoining metal.

Brazing differs from welding, that it does not involve melting the work pieces. Brazing differs from soldering through the use of a higher temperature and much more closely fitted parts than soldering. During the brazing process, the filler metal flows into the gap between close-fitting parts by capillary action. The filler metal is brought slightly above its melting (liquidus) temperature while protected by a suitable atmosphere, usually a flux. It then flows over the base metal (in a process known as wetting) and is then cooled to join the work pieces together. A major advantage of brazing is the ability to join the same or different metals with considerable strength.





Advantages

- Dissimilar metals can be joined by a brazing process
- The metals which cannot join by welding, in terms of thickness, can join by means of a Brazing process like Radiators, pipe fittings, containers, and heat exchangers.
- The leak-proof joints can be prepared by means of a brazing process.

Disadvantages

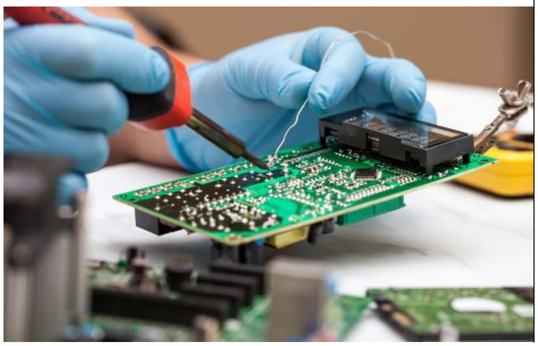
- Skilled labor is required to do a brazing process.
- The joints produced due to brazing exhibit less strength than welding.

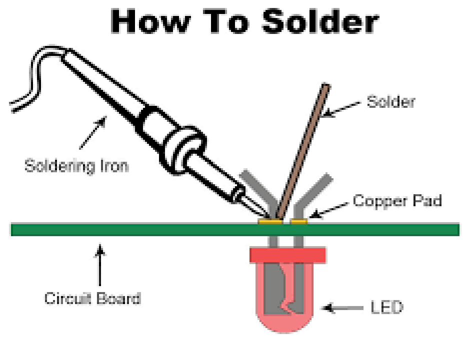
Applications of Brazing

- Brazing is used for the fastening of pipe fittings, carbide tips on tools, heat exchangers, electrical parts, radiators, axles, etc.
- It can join cast metals to wrought metals, dissimilar metals, porous metal components, etc.
- It is used to join parts of the bicycle such as frame and rims

Soldering

Soldering is a metal joining process with the help of low melting point metal by the use of heat and filler material. In soldering the melting point of the filler metal is less than 427^{o} C. Generally the solders used to have a melting temperature between 180-270^{o} C.





Types of soldering:

- **Hard soldering** – In hard soldering filler metal is silver. It is also known as silver soldering and expensive in nature.

- **Soft soldering** – It is the common method used. Here the filler metal is copper.

- **Dip soldering** - In this method large solder is melted in a closed tank. Then the parts to be soldered are cleaned and properly dipped in the flux bath as per the requirements.

- **Wave soldering** – The wave generated in the flux bath tank is allowed to come in contact with the required area.

Advantages

- Joints prepared using the soldering process will be dismantled easily.
- Soldering can be done at a low temperature.
- The soldering cost is very less.
- It's simple in design and economical.

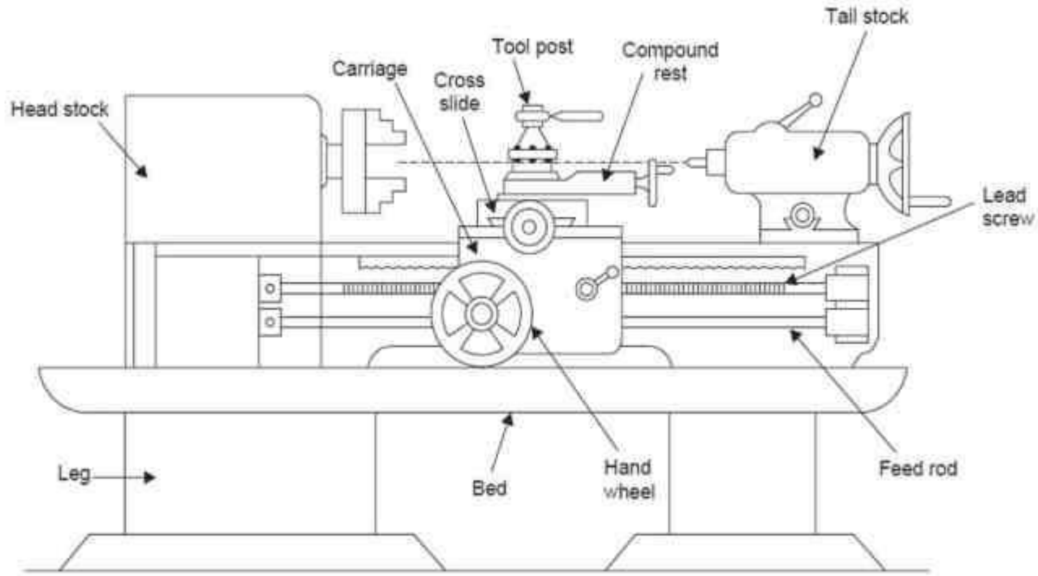
Disadvantages

- Skilled worker is required to make a perfect and stronger joint.
- Solders are costlier.
- Soldering can be applied only for small joints but it cannot be applied for heavy parts.
- Prior cleaning is a mandatory requirement.

Applications of Soldering

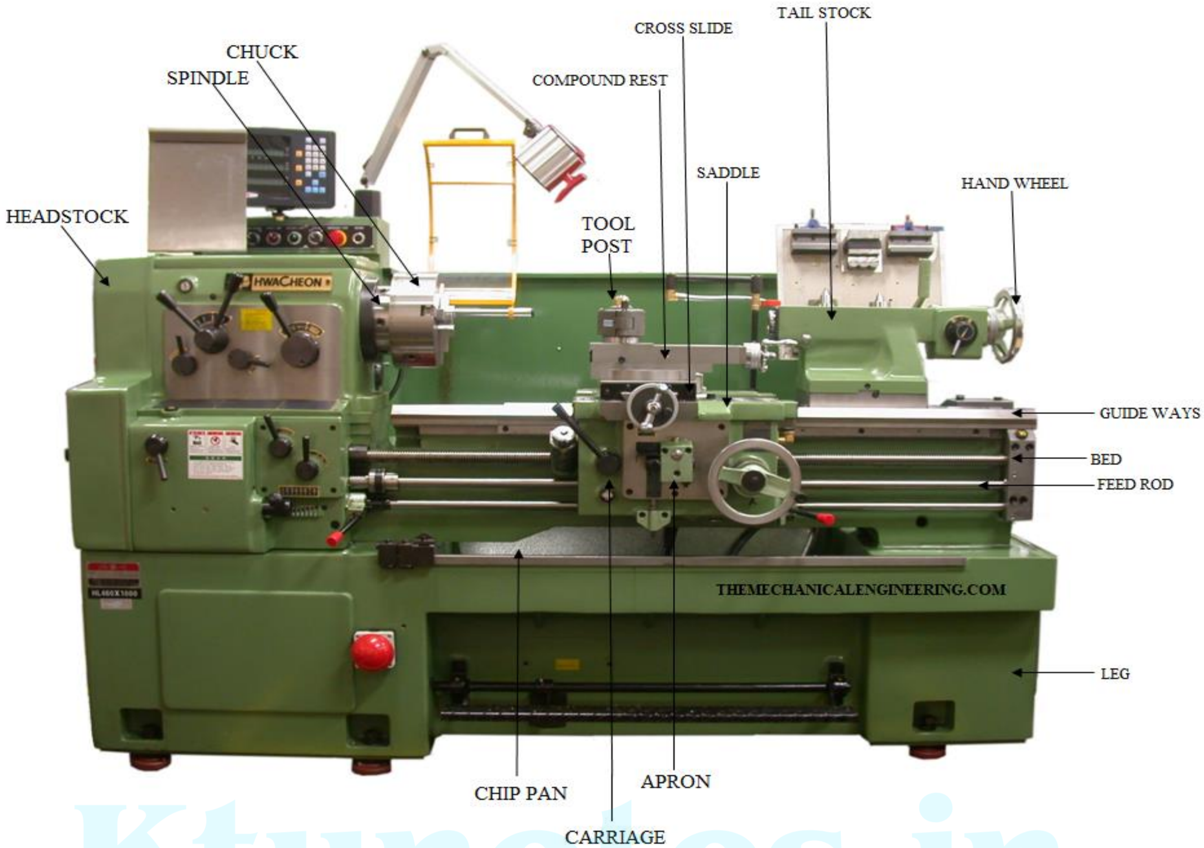
- Mostly used to solder the wires on the Printed Circuit Boards(PCB)

Lathe Machine



The Lathe Machine consists of following Main Parts:

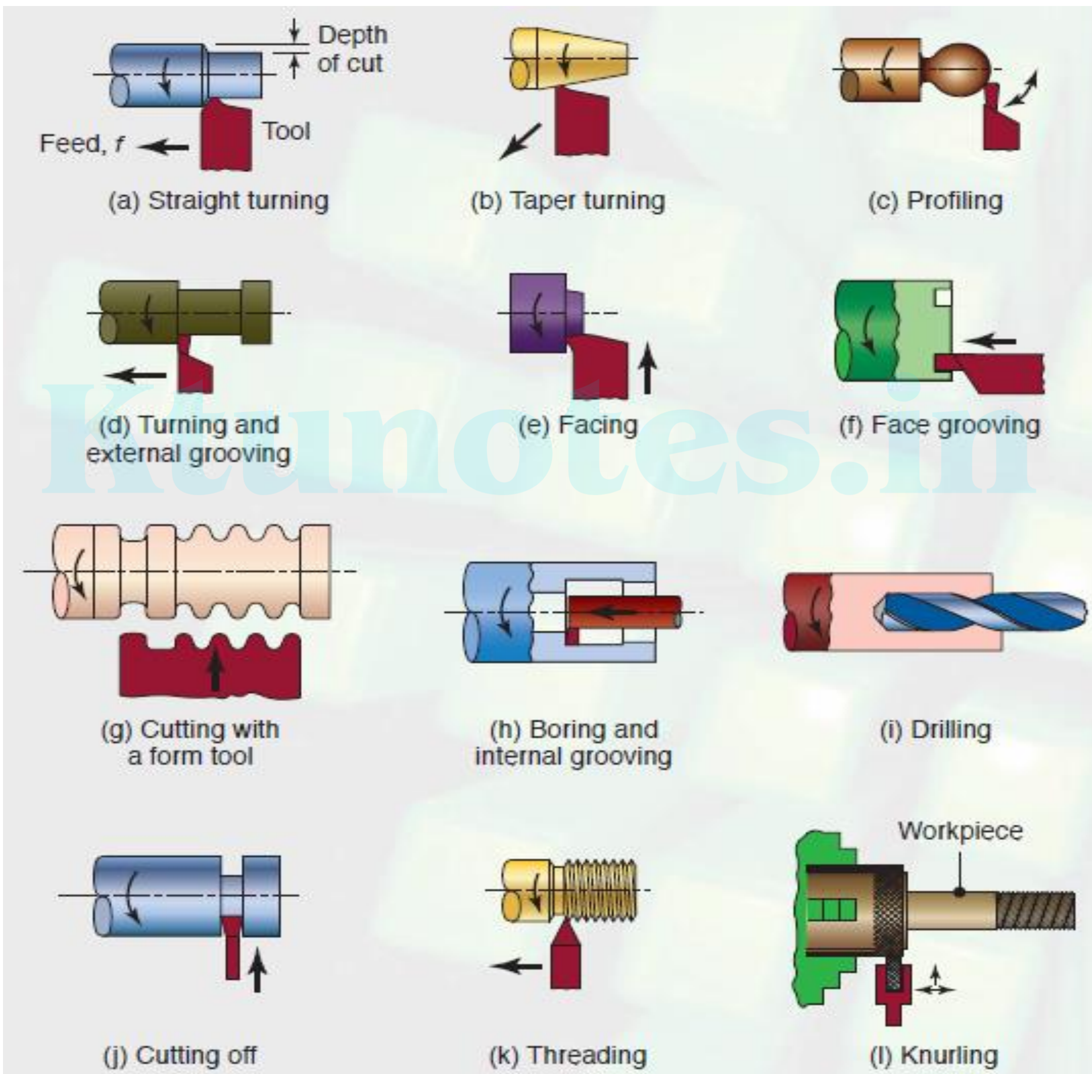
- **Bed** : The bed of the lathe machine is the base on which all the other parts of the lathe are mounted. The bed is made from Cast iron
- **Headstock**: The headstock is present on the left end of the bed. The main function of the headstock is to transmit power to the different parts of the lathe.
- **Tailstock**: The tailstock is a movable casting located opposite to the headstock on the way of the bed. It supports the other end of the work when being machined. It holds a tool for performing operations like drilling, reaming, tapping, etc
- **Carriage**: Carriage is located between headstock and tailstock. The basic function of the carriage is to support, guide, and feed the tool against the job during operation.
- **Saddle**: It is an H-shaped casting mounted on the top of the lathe ways. It provides support to cross-slide, compound rest, and tool post.
- **Cross Slide**: Cross slide is provided with a female dovetail on one side and assembled on the top of the saddle with its male dovetail.
- **Compound rest**: Compound rest is present on the top of the cross slide. It supports the tool post and cutting tool in its various positions. Compound rest is necessary for turning angles and boring short tapers and forms on forming tools.
- **Tool Post**: The tool post is mounted on the compound rest. It is used to hold various cutting tool holders.
- **Apron**: The Apron is fastened to the saddle and hangs over the front of the bed. Apron consists of the gears and clutches for transmitting motion from the feed rod to the carriage, and the split nut which engages with the lead screw during cutting threads.
- **Chuck:** Chuck is basically used to hold the workpiece, particularly of short length and large diameter or of irregular shape which can't be conveniently mounted between centers.
- **Lead Screw**: The lead screw is used mostly in the case when the threading operation is to be performed on a lathe.



Lathe operations

- **Facing:** During the machining, the length of the workpieces is slightly longer than the final part should be. Facing is an operation of machining the end of a workpiece that is perpendicular to the rotating axis.
- **Grooving:** It is a turning operation that creates a narrow cut, a "groove" in the workpiece. The size of the cut depends on the width of a cutting tool.
- **Threading**: It is a turning operation in which a tool moves along the side of the workpiece, cutting threads in the outer surface.
- **Knurling:** This operation produces serrated patterns on the surface of a part. Knurling increases the gripping friction and the visual outlook of the machined part.
- **Drilling**: It removes the material from the workpiece.
- **Reaming:** It is a sizing operation that enlarges the hole in the workpiece. Reaming removes a minimal amount of material and is often performed after drilling to obtain both a more accurate diameter and a smoother internal finish.
- **Boring:** In boring operation, a tool enters the workpiece axially and removes material along the internal surface to enlarge an existing hole.
- **Tapping:** It is the process in which a tapping tool enters the workpiece axially and cuts the threads into an existing hole.
- **Turning:** It is the most common lathe machining operation. During the turning process, a cutting tool removes material from the outer diameter of a rotating workpiece. The main objective of turning is to reduce the workpiece diameter to the desired dimension.

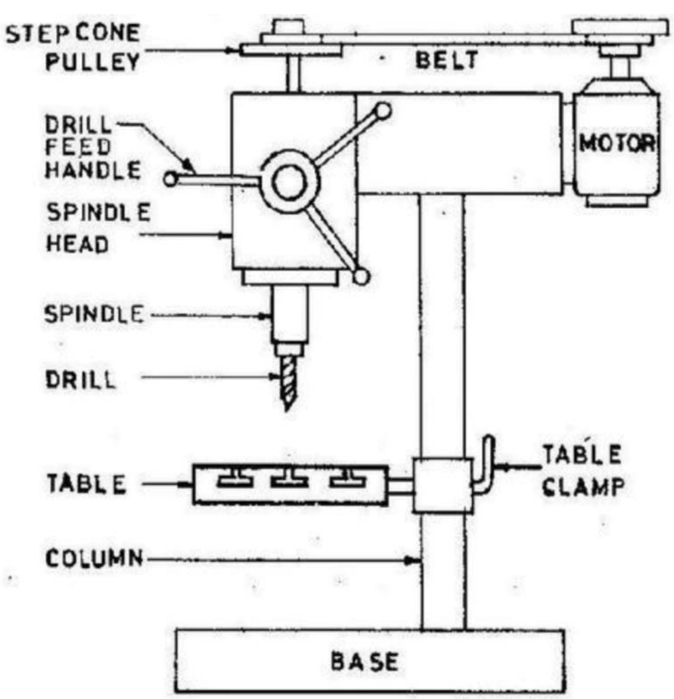
- **Rough turning:** Rough turning operation aims to machine a piece to within a predefined thickness, by removing the maximum amount of material in the shortest possible time, disregarding the accuracy and surface finish.
- **Finish turning:** Finish turning produces a smooth surface finish and the workpiece with final accurate dimensions.
- **Step turning:** Step turning creates two surfaces with an abrupt change in diameters between them. The final feature resembles a step.
- **Taper turning:** Taper turning produces a ramp transition between the two surfaces with different diameters due to the angled motion between the workpiece and a cutting tool
- **Chamfer turning:** Similar to the step turning, chamfer turning creates angled transition of an otherwise square edge between two surfaces with different turned diameters



Drilling machine

It is a simple and accurate machine, which is used in production shop. It is designed specifically to perform the operation of drilling and similar operations. The workpiece is held stationary in position on the table and drill bits rotate to make a hole. Drill bits are also called as drills. Drilling machine is one of the most important machine tools in a workshop. It was designed to produce a cylindrical hole of required diameter and depth on metal workpieces. Though holes can be made by different machine tools in a shop, drilling machine is designed specifically to perform the operation of drilling and similar operations. Drilling can be done easily at a low cost in a shorter period of time in a drilling machine. Drilling can be called as the operation of producing a cylindrical hole of required diameter and depth by removing metal by the rotating edges of a drill. The cutting tool known as drill is fitted into the spindle of the drilling machine. A mark of indentation is made at the required location with a centre punch. The rotating drill is pressed at the location and is fed into the work. The hole can be made upto a required depth.

- **Drill Base:** It is the most important part of the drilling machine because it carries a whole weight of the drilling machine.
- **Column:** Column provides supports for the different parts of a drilling machine. It also helps in the upward and downward movement of table.
- **Spindle:** It is used to hold and rotate the drill bits tool. It is fitted with the head of drilling machine.
- **Table:** The table is used to hold the workpiece or a job and can be adjusted by moving it upward or downward direction.
- **Head:** The top part of the drilling machine is called the head, which has a spindle that moves in the upward and downward directions
- **Motor:** Motor converts the electrical energy to mechanical energy and transfers with the help of belt drive.



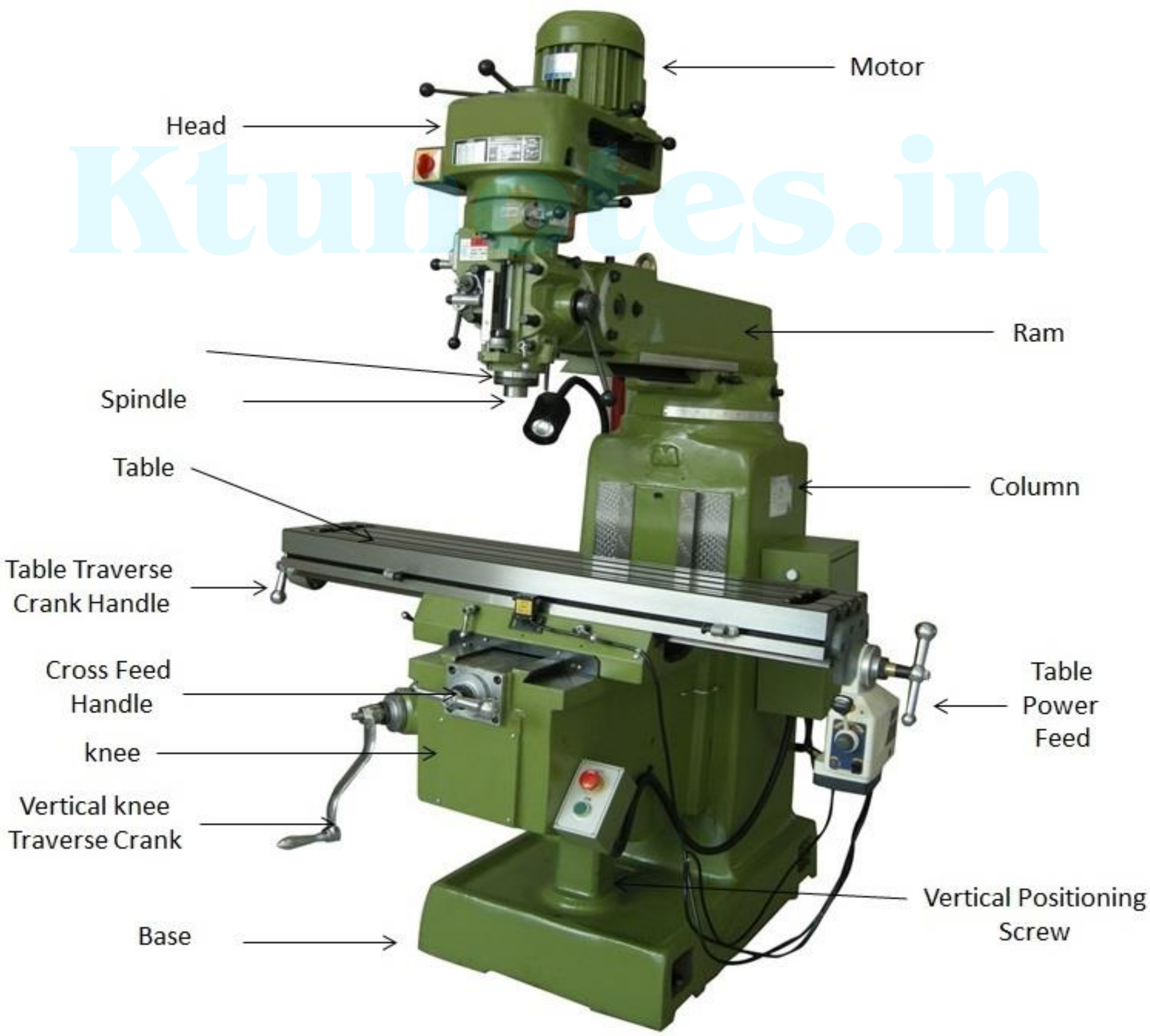
Pillar Type Drilling Machine

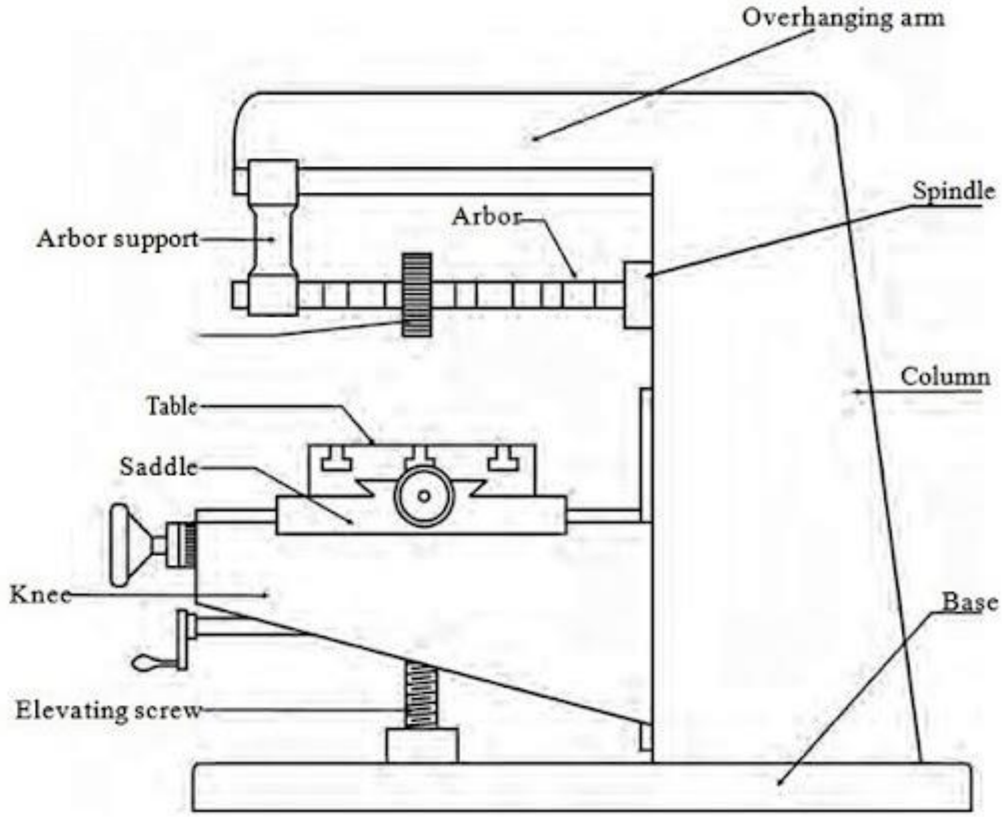
Milling machine

A milling machine is a device that rotates a circular tool that has a number of cutting edges symmetrically arranged about its axis and the workpiece is commonly held in a vise or similar device clamped to a table that can move in three perpendicular directions. Milling Machines are used for machining solid materials, including metal, plastic, and wood, and are commonly used to machine irregular and flat surfaces. The cutter is designed to rotate during the operation as opposed to a lathe, where the part itself rotates during the cutting operation.

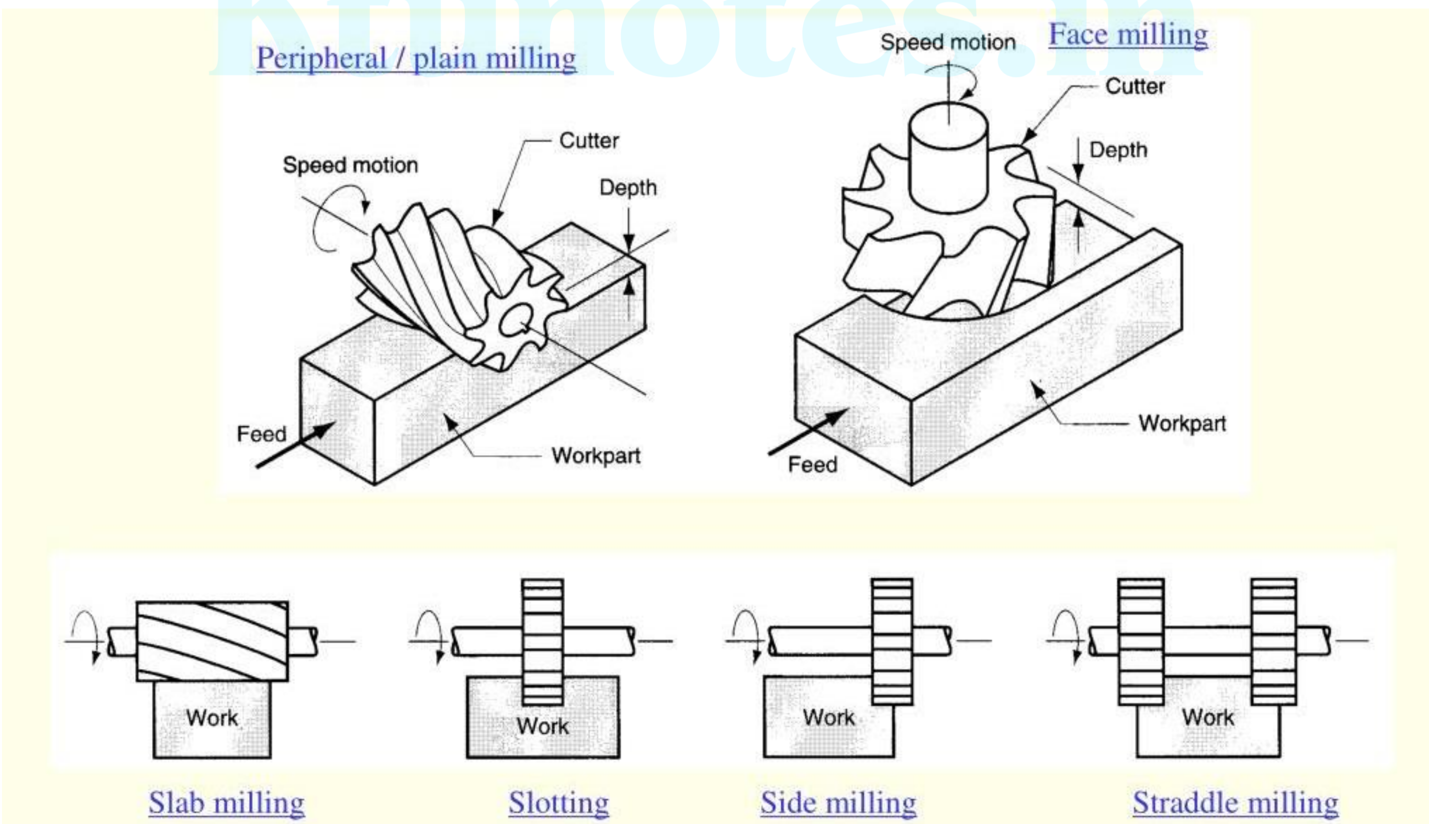
Components:

- **Column and base:** Column and base provide supports for the other parts of a milling machine.
- **Knee:** The gearing mechanism is enclosed within a knee. It is supported and adjusted by a vertical positioning screw also known as an elevating screw.
- **Power Feed Mechanism:** The power feed mechanism is in the knee. The power feed mechanism is used to control in longitudinal (left and right), transverse (in and out), and vertical (up and down) feeds.
- **Table:** A table is a rectangular casting that is presented on the top of a saddle. The table is used to hold the work or for work holding devices.
- **Spindle:** The spindle is used to hold and drive the cutting tools of a milling machine.
- **Ram:** The ram is an overhanging arm in a vertical milling machine. The one end of the ram is mounted on the top of the column and the milling head is attached to another.





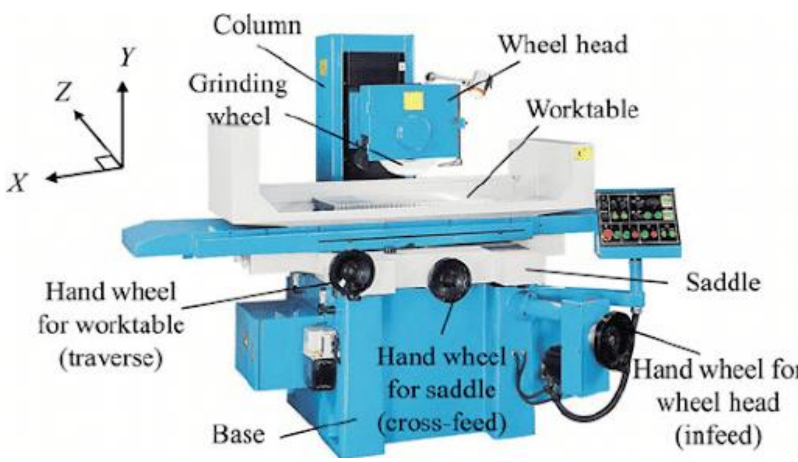
Milling operations



Grinding machine

A grinding machine is a production machine tool used in the manufacturing industry in which the grinding wheel is attached in the tool post and the workpiece is fixed to the work table and when the operation starts it removes the unwanted material to get the desired surface finish, correct size, and accurate shape of the workpiece. It is also known as the Abrasive Grinding Machining Process. Because the abrasives are placed on the surface of the grinding wheel and offers accuracy finishing. The grinding machine is widely used to finish the workpiece. Because the work removal rate is low (between 0.25 to 0.5 mm)

A grinding is metal cutting operation which is performed by means of a rotating abrasive wheel that acts as a tool. It works to the action of rubbing or friction between the abrasive particles and workpiece material. Due to this, workpiece is fed against the rotating abrasive wheel to remove material in the form of very small size of chips. These are mostly used to finish workpieces which must show a high surface quality, accuracy of shape and dimension.



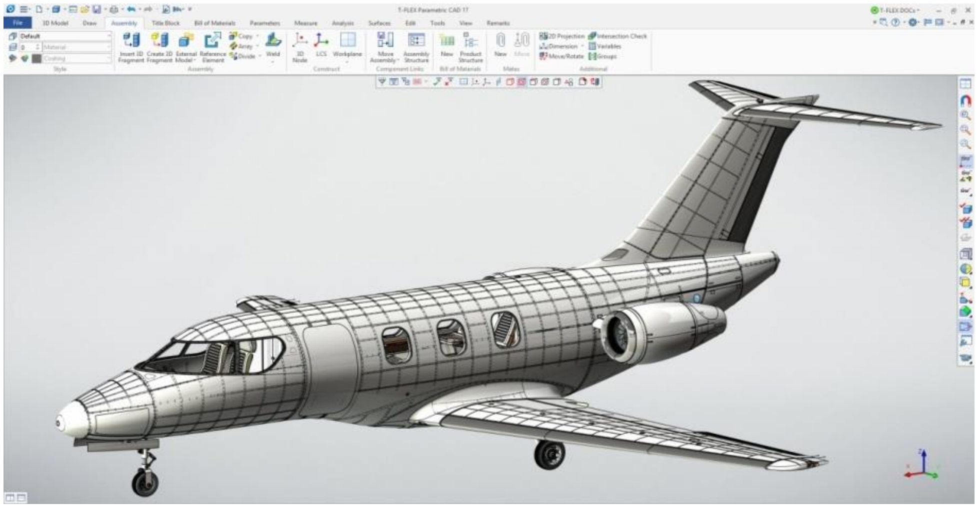
CNC machine

Computer numerical control (CNC) machines play an important role in the manufacturing industry. These complex machines are controlled by a computer and provide a level of efficiency, accuracy and consistency that would be impossible to achieve through a manual process. Operations that were impossible years ago are now easy with the help of CNC machines.

CNC machining can be defined as a process in which pre-programmed computer software dictates the movement of factory machinery and tools. As a result, manufacturers can produce parts in less time, reduce waste and eliminate the risk of human error. This manufacturing process is used to control a wide variety of complex machinery. All automated motion control machines have three primary components – a command function, a drive/motion system, and feedback system. CNC machining is the process of using a computer-driven machine tool to produce a part out of solid material in a different shape

CAD/CAM

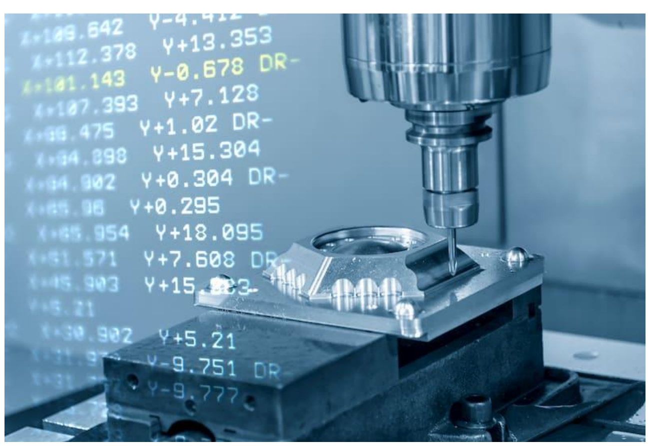
Computer-aided design (CAD) involves creating computer models defined by geometrical parameters. These models typically appear on a computer monitor as a three-dimensional representation of a part or a system of parts, which can be readily altered by changing relevant parameters. CAD systems enable designers to view objects under a wide variety of representations and to test these objects by simulating real-world conditions.



Commonly used software's are:

- Solid work
- Creo (Pro E)
- Autocad
- Revit
- Catia
- Inventor
- Ansys

Computer-aided manufacturing (CAM) uses geometrical design data to control automated machinery. CAM systems are associated with computer numerical control (CNC) or direct numerical control (DNC) systems. These systems differ from older forms of numerical control (NC) in that geometrical data are encoded mechanically. Since both CAD and CAM use computer-based methods for encoding geometrical data, it is possible for the processes of design and manufacture to be highly integrated. Computer-aided design and manufacturing systems are commonly referred to as CAD/CAM.



Advantages

- Flexible and modifiable
- Quick process
- Portable designs
- Error detection

Disadvantages

- Skilled people are required
- Energy consumption
- Expensive process

Rapid & Additive manufacturing

Additive manufacturing uses data computer-aided-design (CAD) software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes. As its name implies, additive manufacturing adds material to create an object.

The term "additive manufacturing" references technologies that grow three-dimensional objects one superfine layer at a time. Each successive layer bonds to the preceding layer of melted or partially melted material. Objects are digitally defined by computer-aided-design (CAD) software that is used to create .stl files that essentially "slice" the object into ultra-thin layers. This information guides the path of a nozzle or print head as it precisely deposits material upon the preceding layer. Or, a laser or electron beam selectively melts or partially melts in a bed of powdered material. As materials cool or are cured, they fuse together to form a three-dimensional object.

Additive manufacturing techniques are:

1. **Stereolithography (SLA)** - Very high end technology utilizing laser technology to cure layer-upon-layer of photopolymer resin (polymer that changes properties when exposed to light).
2. **Fused Deposition Modelling (FDM**) - Process oriented involving use of thermoplastic (polymer that changes to a liquid upon the application of heat and solidifies to a solid when cooled) materials injected through indexing nozzles onto a platform.
3. **Laminated Object Manufacturing (LOM)**
4. **3D printing**
5. **Selective Laser Sintering (SLS)** – It utilizes a high powered laser to fuse small particles of plastic, metal, ceramic or glass.

Advantages are

- Quick manufacturing
- Easy modifications
- Minimum wastage
- Automated process
- High precision & Dimensional accuracy
- Clean process

Steps involved in additive manufacturing