MACHINE TOOLS

UNIT-4

PRESENTED BY

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INTRODUCTION

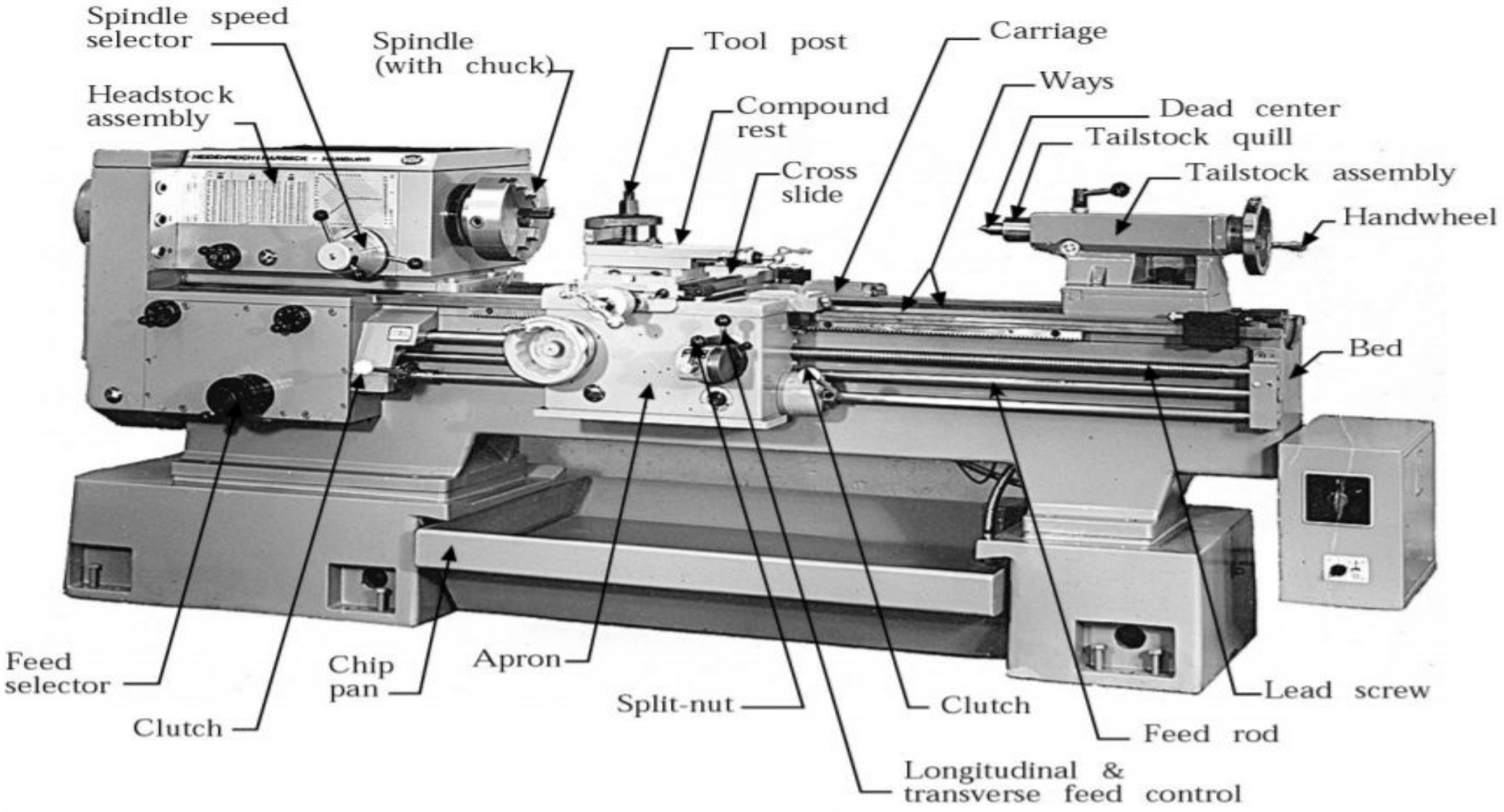
- A **machine tool** is a machine for handling or machining metal or other rigid materials, usually by cutting, boring, grinding, shearing, or other forms of deformation.
- All machine tools have some means of constraining the workpiece and provide a guided movement of the parts of the machine.
- Thus the relative movement between the workpiece and the cutting tool (which is called the **toolpath**) is controlled or constrained by the machine to at least some extent, rather than being entirely "offhand" or "freehand".

LATHE MACHINE

Lathe is a machine, which removes the metal from a piece of work to the required shape and size.

- Lathe is one of the most important machine tools in the metal working industry. A lathe operates on the principle of a rotating workpiece and a fixed cutting tool.
- The cutting tool is feed into the workpiece, which rotates about its own axis, causing the workpiece to be formed to the desired shape.
- Lathe machine is also known as “the mother/father of the entire tool family”.

LATHE MACHINE



LATHE MACHINE WORKING PRINCIPLE

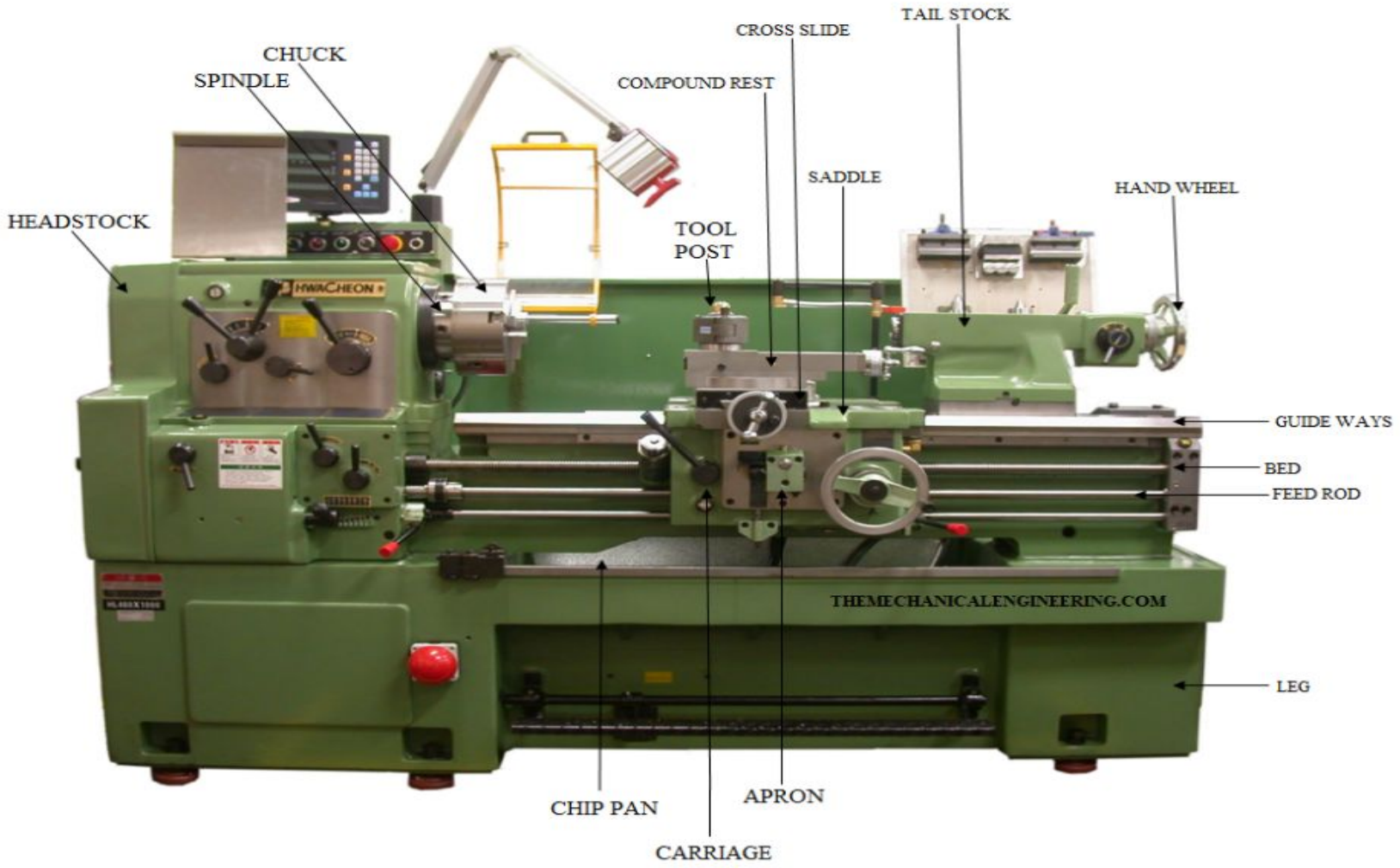
A Lathe works on the principle of rotating the workpiece and a fixed cutting tool.

- The workpiece is held between two rigid and strong supports called a center or in a chuck or in faceplate which revolves.
- Lathe removes the undesired material from a rotating workpiece in the form of chips with the help of a tool that is transverse across the work and can be fed deep in the work.
- The main function of the lathe is to remove the metal from a job to give it the required shape and size.
- The normal cutting operations are performed with the cutting tool fed either parallel or at right angles to the axis of the work.
- The cutting tool can be fed at an angle relative to the axis of the work for machining tapers and angles.

PRINCIPAL PARTS OF A LATHE

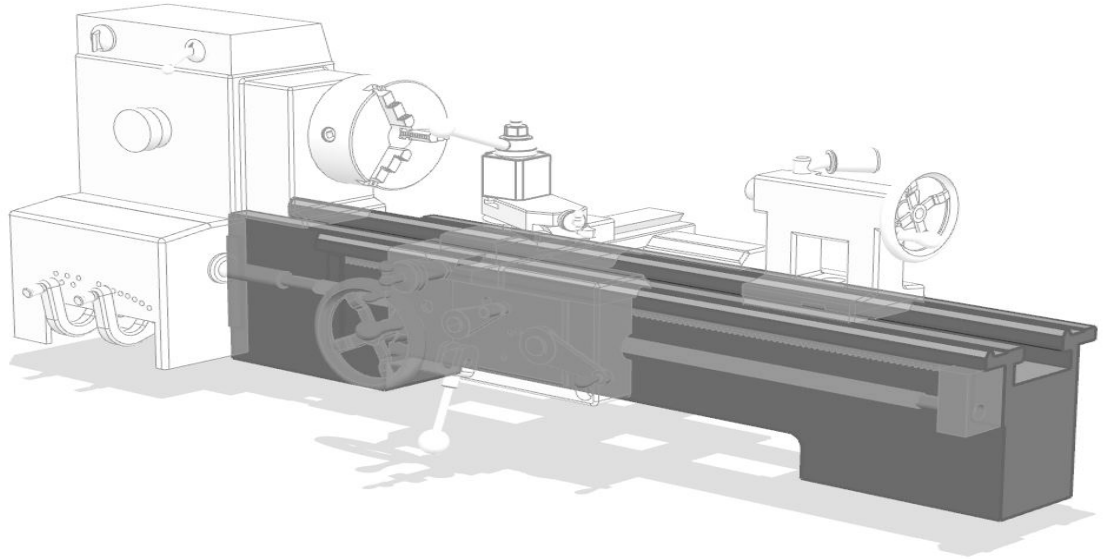
The Lathe Machine consists of following Main Parts:

- Bed
- Headstock
- Tail stock
- Carriage
- Saddle
- Cross Slide
- Compound rest
- Tool Post
- Apron
- Chuck
- Feed rod
- Lead Screw
- Spindle



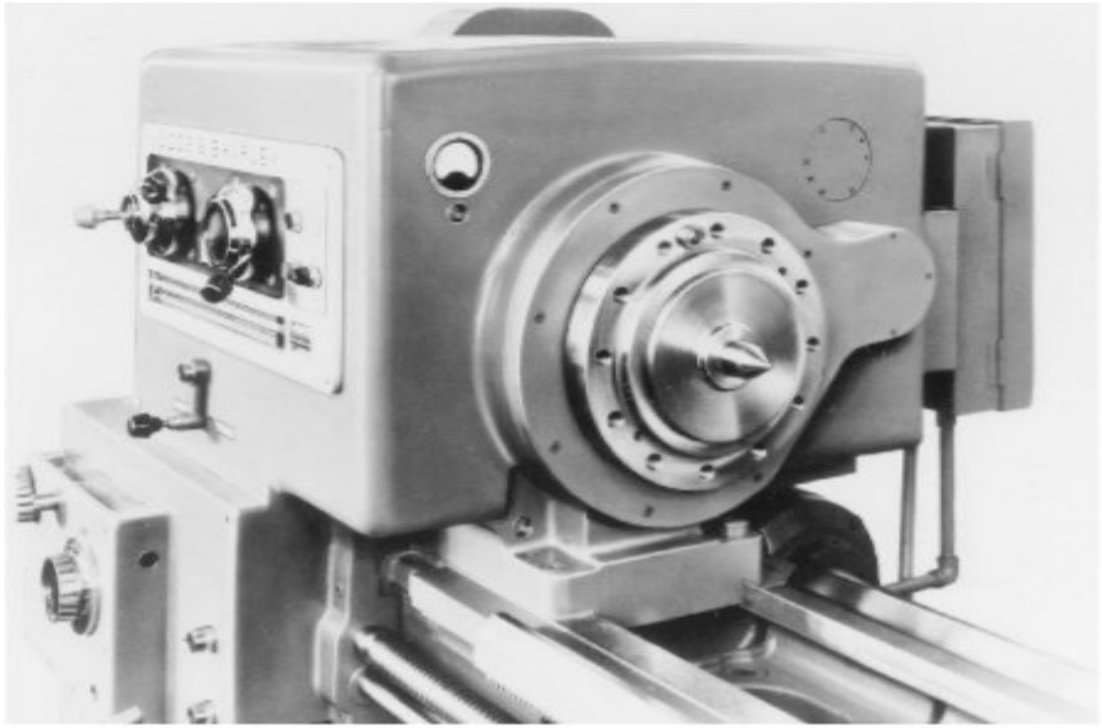
LATHE BED

- All the parts of the lathe such as headstock, tailstock, carriage etc., are mounted on the bed.
- The bed should have sufficient weight and be of proper material so that the vibrations generated during operations are damped out.



HEADSTOCK

- It is located at the left hand side of the bed.
- It supports the spindle and contains a gearbox by which the spindle and hence the workpiece may be rotated at various speeds.



Accessories mounted on the headstock spindle are:

1. Three jaw chuck.
2. Four jaw chuck.
3. Lathe center and lathe dog.
4. Collet chuck.
5. Face Plate.
6. Magnetic chuck.

TAILSTOCK

- It is situated at the right hand end of the bed. It can be moved towards or away from the operator.
- Tailstock can be locked in any position along the bed of the lathe by tightening the clamp lever or nut.

CARRIAGE

- The carriage controls and supports the cutting tool. By the help of this, cutting tool moves away or towards the head stock.
- It has five major parts:-

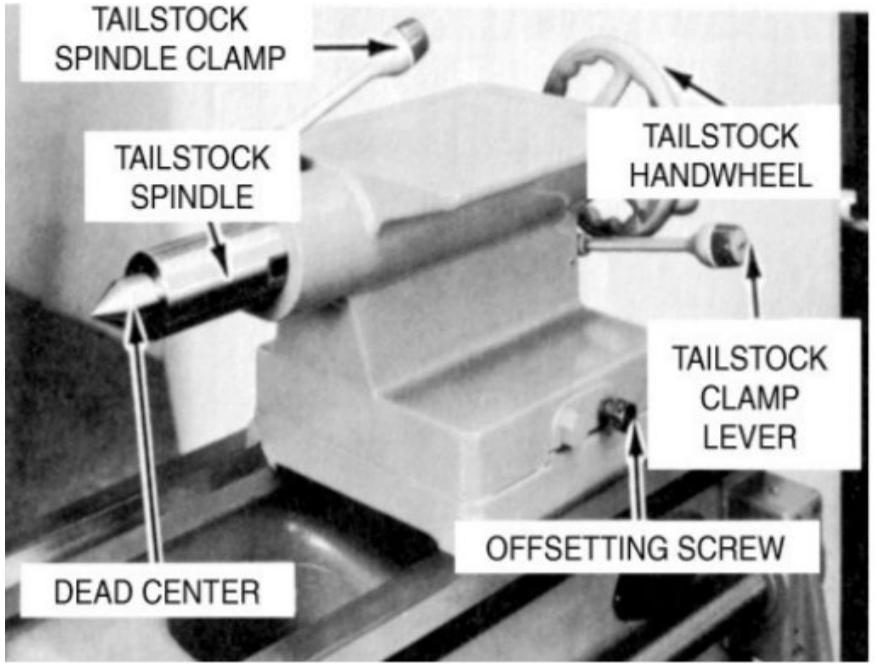
a) Saddle

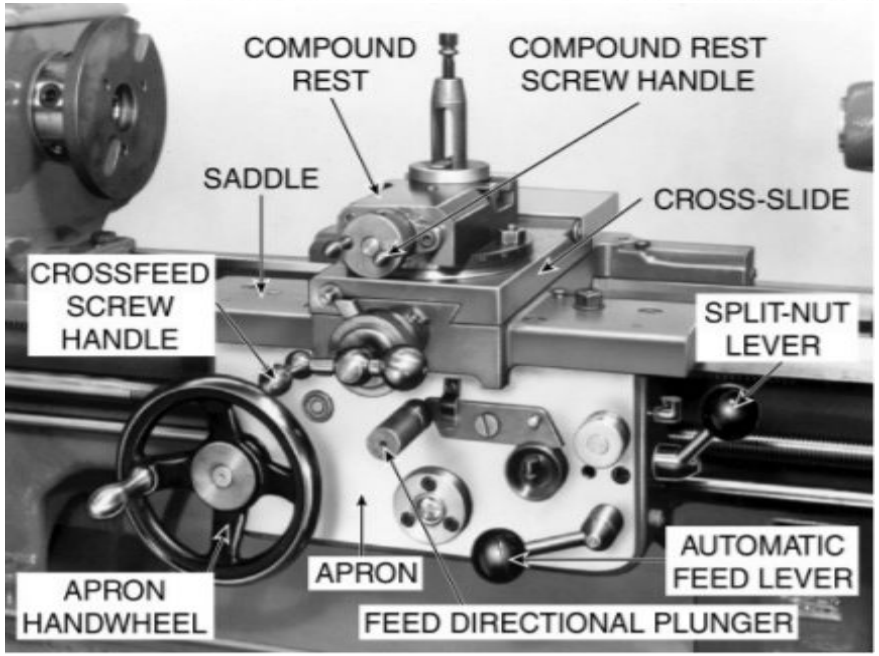
b) Cross slide

c) Compound slide

d) Tool post

e) Apron





a) 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.

b) 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.
- The top surface of the cross slide is provided with T slots to enable fixing of rear tool post or coolant attachment. Carriage basically provides a mounted or automatic cross-movement for the cutting tool.

c) 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.

d) Tool Post:

- The tool post is mounted on the compound rest. It is used to hold various cutting tool holders. The holders rest on a wedge which is shaped on the bottom to fit into a concave-shaped ring (segmental type), Which permits the height of the cutting edge to be adjusted by tilting the tool. It is fixed on the top slide. It gets its movement by the movement of the saddle, cross slide, and top slide.

- The ***three types of tool post*** which are commonly used are:

✔ **Ring and rocker tool post:** It consists of a circular tool post with a slot for accommodating the tool or tool holder**.**

✔ **Quick change tool post**

✔ **Square head tool post.**

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. It can be attached to the lathe by screwing on the spindle nose.

Four different types of chucks are most commonly used in Lathe:

- **Independent or four-jaw chuck**
- **Three jaw or universal chuck**
- **Collect chuck and**
- **Magnetic Chuck**

Independent or four-jaw chuck:

- It is used for irregular shapes, rough castings of square or octagonal in such jobs, where a hole is to be positioned off the center. It consists of four jaws and each jaw is independently actuated and adjusted by a key for holding the job.

Three jaw or universal chuck:

- It consists of three jaws that move simultaneously by turning a key and the workpiece automatically remains in the center of the chuck opening. It is used for holding a round, hexagonal bar or other symmetric work.

Collet chuck:

- It is mostly used in the places where production work is required such as in Capstan Lathe or automats. It is used for holding the bars of small sizes (below 3 inch).

Magnetic chuck:

- They are of permanent magnet type or electrically operated. In Lathe, it does not have widespread use.

FEED ROD

- Feed rod is a power transmission mechanism used for precise linear movement of the carriage along the longitudinal axis of the lathe.

LEAD SCREW

- The lead screw is used mostly in the case when the threading operation is to be performed on a lathe. As we know for threading operation requires rotational movement of the job (workpiece) and the linear movement of the tool (tool post).
- So rotation of the job is obtained by the chuck and the desired linear motion of the tool-post (as the lead screw drives the saddle when it is engaged) is provided with the help of a lead screw.

FEED MECHANISM

- The tool movement relative to the work is known as feed. There are three types of feed:-

- Longitudinal feed :- When tool moves away or towards the head stock parallel to the axis of the work.
- Cross feed:- When the tool moves away from the or towards from the operator perpendicular to work.
- Angular feed:- By swiveling the compound rest the tool is made to move at any angle to the work

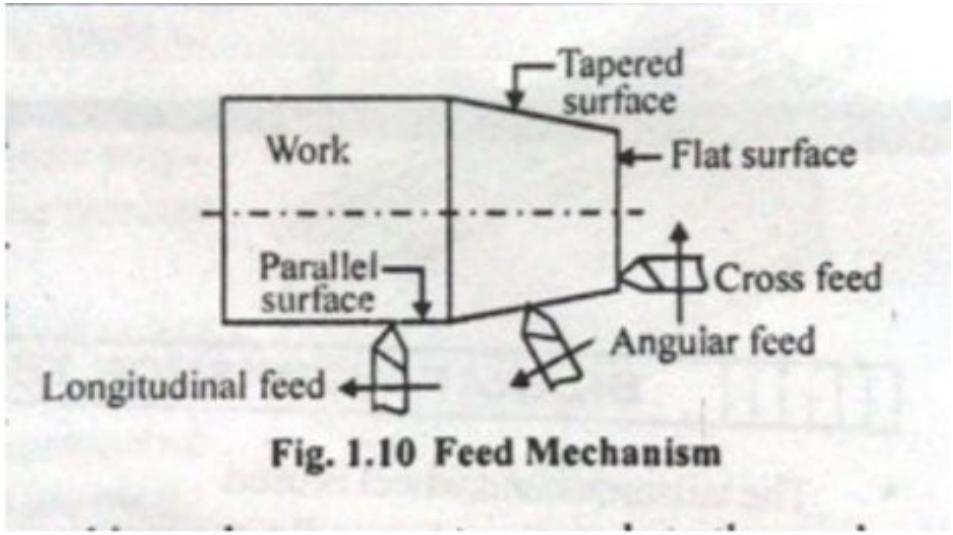
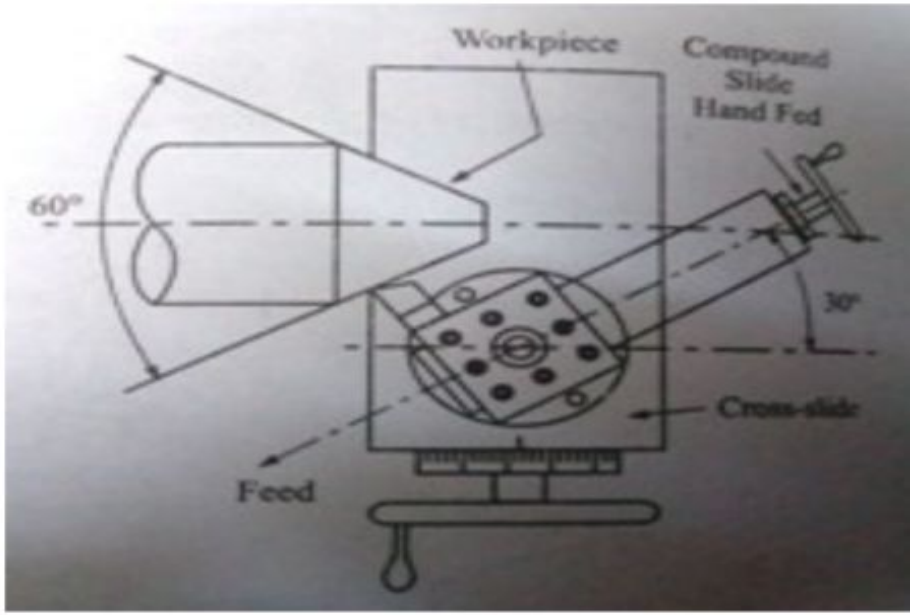
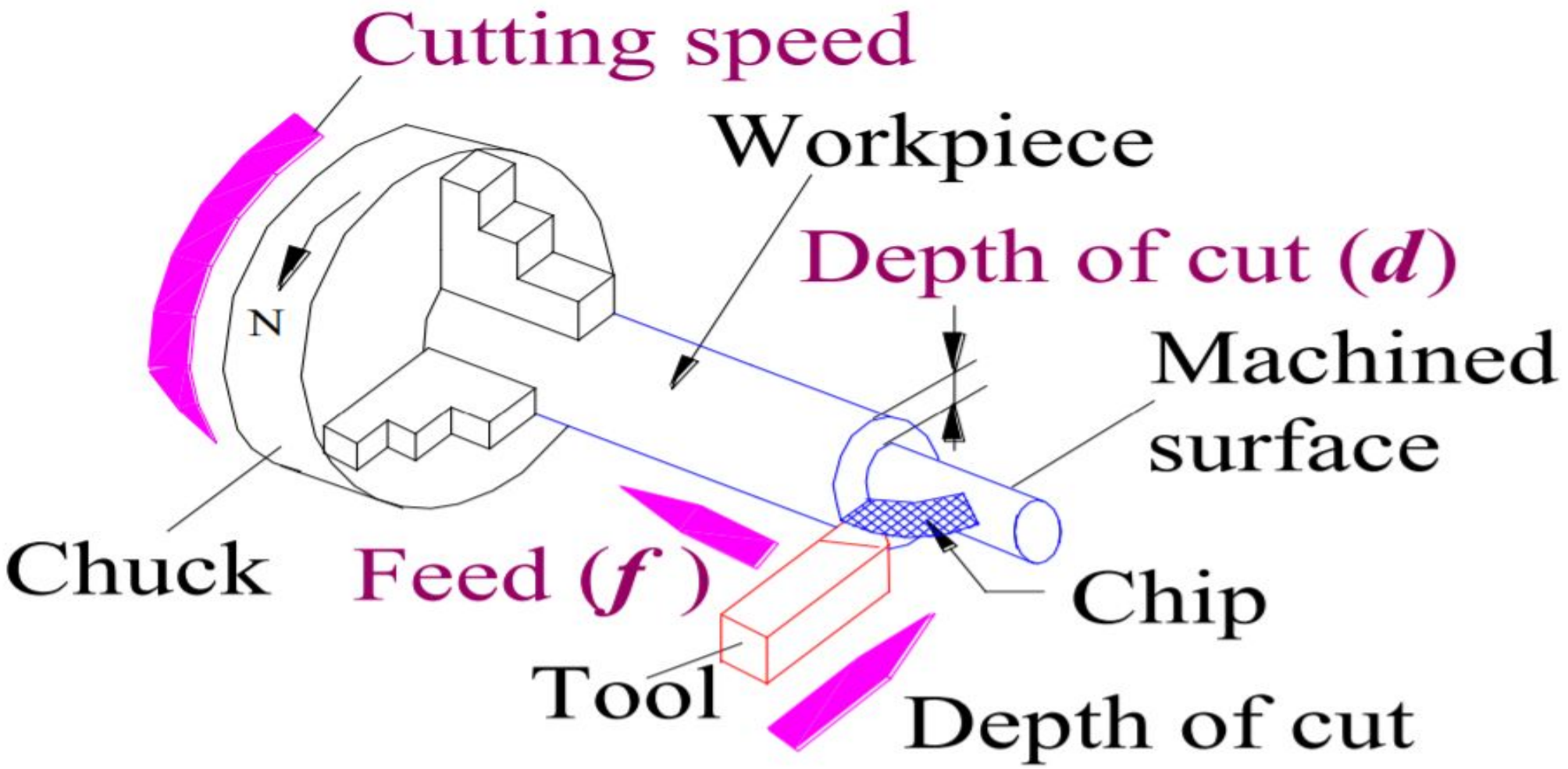


Fig. 1.10 Feed Mechanism



Operating Conditions



TYPES OF LATHE MACHINE

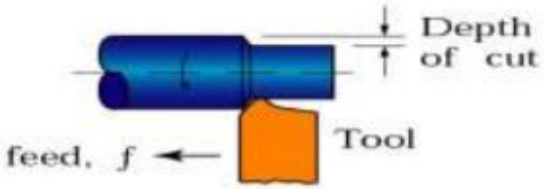
- **Lathe machines are classified according to their construction and design. Some of them are:**

1. Bench lathe machine
2. Speed lathe machine
3. Engine lathe or center lathe machine
4. Tool room lathe machine
5. Capstan and turret lathe machine
6. Special purpose lathe machine
7. Automatic lathe machine

LATHE OPERATIONS

- Turning: to remove material from the outside diameter of a workpiece to obtain a finished surface.
- Facing: to produce a flat surface at the end of the workpiece or for making face grooves.
- Boring: to enlarge a hole or cylindrical cavity made by a previous process or to produce circular internal grooves.
- Drilling: to produce a hole on the work piece.
- Reaming: to finishing the drilled hole.
- Threading: to produce external or internal threads on the work piece.
- Knurling: to produce a regularly shaped roughness on the workpiece.
- Tapping: Process in which tapping tool enters the workpiece axially and cuts the threads into an existing hole.
- Chamfering.

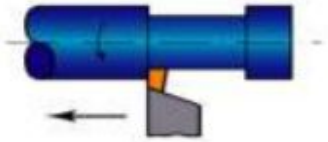
(a) Straight turning



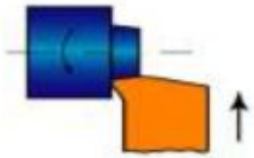
(b) Taper turning

(c) Profiling

(d) Turning and external grooving

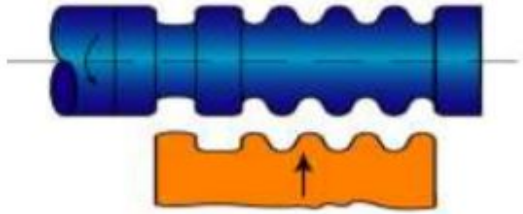


(e) Facing



(f) Face grooving

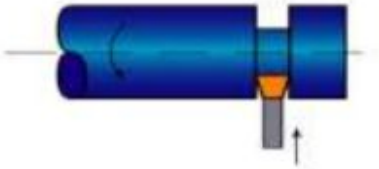
(g) Cutting with a form tool



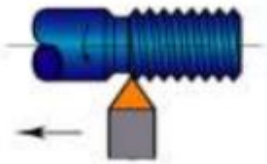
(h) Boring and internal grooving

(i) Drilling

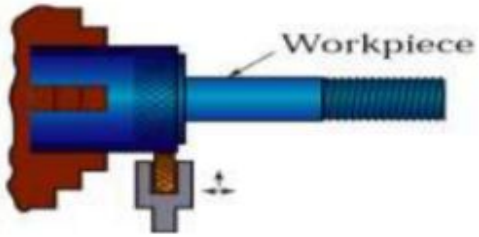
(j) Cutting off



(k) Threading



(l) Knurling



ADVANTAGES

1. High-Quality Products: Lathe machine, especially the CNC Lathe machine, produce final products with **high quality**.

2. High Speed: The machining in the lathe can be done at a very high speed especially in automatic and CNC lathe machines.

3. Saves time: Lathe machine because of its extensive high speed and high accuracy saves a lot of time, resulting in the increased production.

4. Saves Money: Lathe machine helps in reducing the cost of machining because **fewer operators** are required for machining.

DISADVANTAGES

- The Initial cost is very high.
- The high skilled worker required for the initial setup.
- CNC machines can not use for small production.

SPECIFICATIONS OF LATHE

1) The height of the centre measured from the lathe bed(H).
2) The swing diameter over bed (D).
3) The length between centres(l)
4) The swing diameter over carriage(d).
5) The maximum bar diameter.
6) The length of the bed.

DRILLING MACHINE

- A drilling machine is a type of machine in which the holes are being made on the workpiece by making use of a rotating tool called drill bit or the twist drill. Drilling is basically a technology of creating holes
- Drilling operation can also be performed on Lathe Machine. In the lathe machine, the workpiece rotates and the drilling tool is held stationary in the tailstock.
- **Drilling Machine is based upon the principle** that the rotating edge of the tool exerts a large force on the workpiece and holes are being created in the workpiece. The material is removed from the workpiece by the shearing and extrusion process.

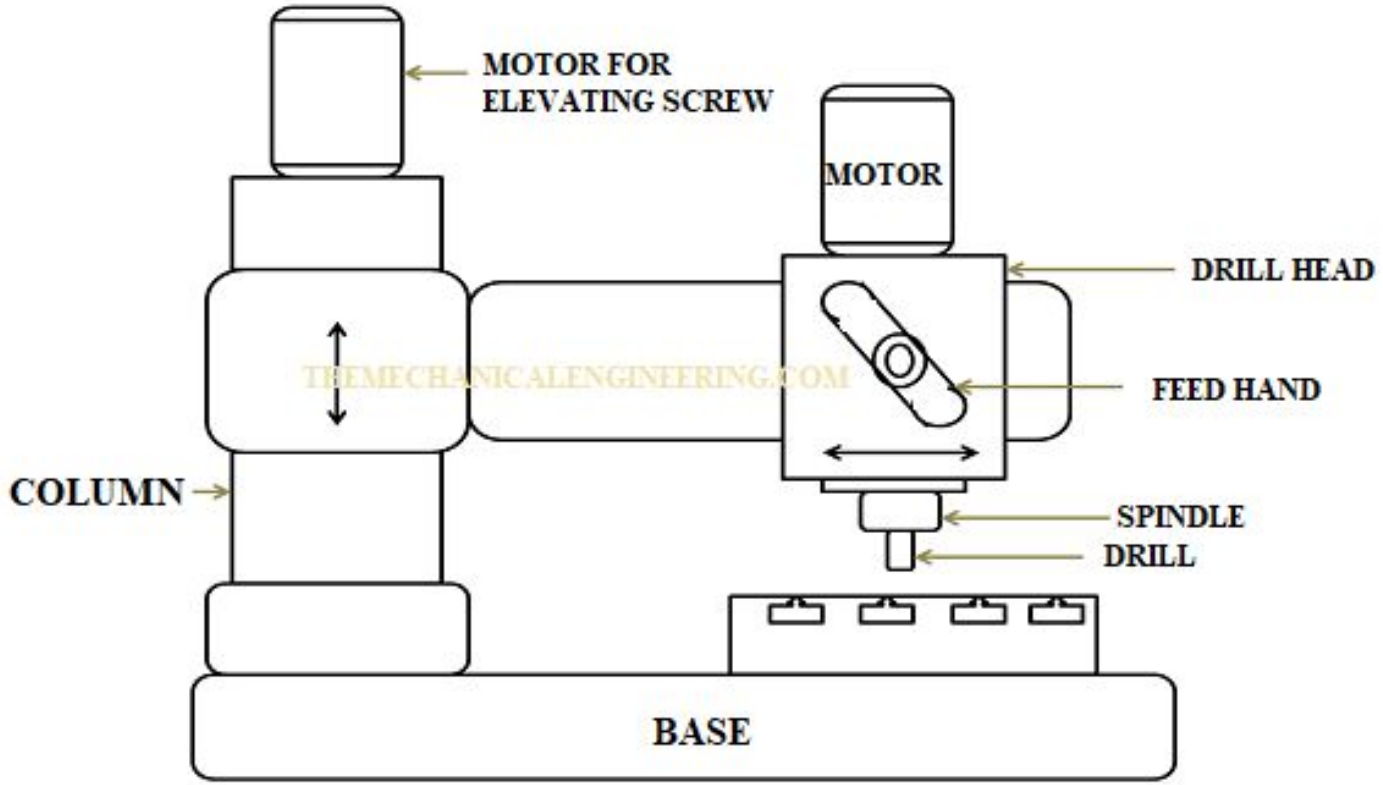
WORKING PRINCIPLE OF DRILLING MACHINE

- Drilling machine removes the unstressed grain of the metal continuously by the cutting edge of a drill.
- In drilling operation two cutting edges of the drill work continuously for removing the metal stock.
- The workpiece is placed on the adjustable table or base, and is clamped firmly both for safety and accuracy to overcome the high drilling torque.
- A loose workpiece can get damaged or break the drill or injure the operator. The cutting tool i.e the drill, is fastened at the end of the vertical spindle and is rotated at the desired speed.
- The rotating drill is fed against a stationary workpiece either by hand feed or by power feed. The vertical motion of the drill is called the feed in drilling operations.

DRILLING MACHINE PARTS

Drilling Machine consists of following Main Parts:

- Bed
- Pillar
- Swivel table
- Motor
- Steeped pulley
- Spindle
- Chuck
- Drill Bit and
- Hand-wheel.



DRILLING MACHINE PARTS

Bed:

- The bed is the main part of the machine on which the whole machine is being mounted. The bed is made up of cast iron, so it has high compressive strength and good wear resistance.

Pillar:

- The pillar is a type of vertical column that rests on the bed. Pillar is present at the center of the bed. The pillar helps the motor and the spindle head.

Swivel Table:

- The table is the place where the workpiece is being mounted. The table is attached to the column and it can be rotated around the column and can have an upward and downward moment. A table can be adjusted at any angle as per the requirement.

Motor:

- The motor is present at the top of the column. The inside motor shaft is there which is connected to a stepped pulley so that we can increase or decrease the speed of the rotation of the motor.

Stepped pulley:

- Two steeped pulleys are present on either side of the column at the top. Out of these two, one pulley will be in an upward direction while the other pulley is inverted.
- Always both the pulleys will be there in the opposite direction. The basic function of the stepped pulley is to control the speed of the rotation of the motor

Spindle:

- Spindle arrangement is present at top of the column opposite to the arrangement of the motor.
- The top of the spindle is attached to one of the stepped pulleys. The bottom of the spindle is connected to the chuck.

Chuck:

- Chuck is present at the bottom of the spindle. The basic function of the chuck is to hold the cutting tool firmly.

Drill bit:

- A drill bit is an actual cutting tool that is used to create a hole in the workpiece.

Hand Wheel:

- The basic function of the handwheel is to adjust the spindle position as per the requirement.

DRILLING MACHINE OPERATION

The various operation performed by the drilling machine are:

- Drilling Operation
- Boring Operation
- Reaming Operation
- Counter boring Operation
- Countersinking Operation
- Tapping Operation
- Spot Facing Operation
- Trepanning Operation and
- Honing Operation.

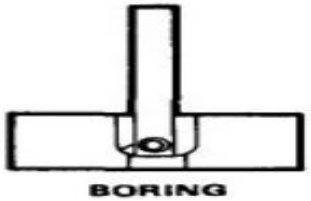
DRILLING MACHINE OPERATIONS

Drilling Operation:

- The operation of making holes on the surface of the workpiece by the use of drill bit is called Drilling Operation.

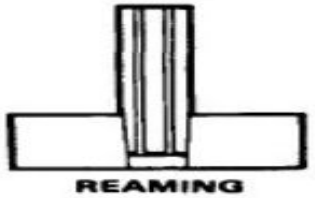
Boring Operation:

- The operation of enlarging an existing hole is called the Boring Operation. The existing hole was created by the drilling operation.



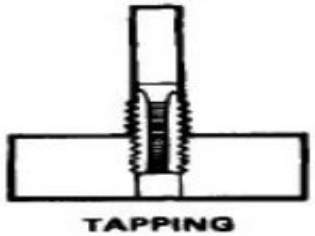
Reaming Operation:

- The operation of sizing and finishing an existing hole with the help of a reamer is called Reaming Operation.
- Reamer is a multipoint cutting tool having several cutting edges to finish the surface.



Tapping Operation:

- It is the operation of creating internal threads by means of a cutting tool called Tap and the operation is called Tapping Operation.



Spot Facing Operation:

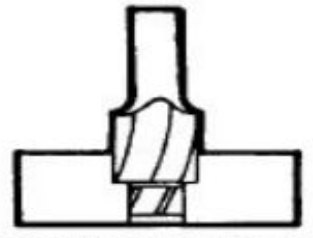
- This is an operation of removing the chips from the surface of the hole such that proper seating of bolts takes place and this removal can be done through end mill cutter using a drilling machine.

Trepanning Operation:

- Without drilling, a Trepanning operation is used for producing a large-size hole of more than 50mm in diameter. This Trepanning operation cannot be used for blind holes.

Honing Operation:

- In this operation, the tool will rotate and reciprocate about its axis for producing very smooth holes.
- This honing operation is mainly used for finishing the holes in the IC Engine cylinder.



Counterboring Operation:

- The Counter boring operation is used to enlarge a particular portion of the hole.

Countersinking Operation:

- The Countersinking operation is used to enlarge the end of the hole to give it a conical shape for a shorter distance.

DRILLING MACHINE TYPES

The different types of Drilling Machine are:

- Portable Drilling Machine
- Sensitive Drilling Machine
- Upright or Column Drill Machine
- Radial Drilling Machine
- Gang Drilling
- Multi-Spindle Drilling
- Vertical Turret Type Drilling
- Automatic Drilling Machine
- Deep hole Drilling
- Turret Drilling
- Automatics Drilling Machine.

DRILLING MACHINE ADVANTAGES

- **High speed:**
  - The main advantage of the drill machine is that the holes can be made in the workpiece with greater speed and other drilling operations can also be performed at a decent speed. High **Output:**
  - It is capable of giving high output.
  - As per the advancement of the Machine, the speed of the machine increased and especially after the introduction of automatic and radial drilling machines the output became very high.
- **Easy to operate:**
  - It is very easy to operate. Its easy moment maintains the efficiency of the operators all the time.
- **High flexibility:**
  - The modern drilling machines are highly flexible as they have multiple spindles, are automatic, and the holes can be drilled at any angle and many more features are there which makes it highly flexible.
- **Low maintenance cost and longer life:**
  - The maintenance cost of a machine is very less and they have a very long life. With very less amount of maintenance cost, they can be used for a longer period of time.

DRILLING MACHINE DISADVANTAGES

- **Limited size workpiece:** A limited size workpiece can only be machined. Workpiece which is very large cannot be operated.
- **Rough Hole:** The rough holes might be produced sometime during drilling. Rough holes are can be avoided by:

  The feed should be reduced, Point reground, Coolant used, The rigidity of the fixture ensured.
- **Chipped cutting lips:** Chipped cutting lips can be formed. This happens because of high feed and high clearance angle. To avoid chipped cutting lips proper feed speed and proper clearance should be used as per the requirement.
- **Oversize hole:** An oversized hole may be produced due to the loss of a spindle or unequal angle/ length of the cutting edges.
- **Breaking of Drill:** ***The drill may break due to the following reasons:***
  - The drill may break if it gets dull.
  - The flute is clogged by the chips.
  - Due to high feed.
  - Improper clamping of the drill and work.

MILLING MACHINE

- Milling is a process performed with a machine in which the cutters rotate to remove the material from the work piece present in the direction of the angle with the tool axis.
- The metal removal rate is higher as the cutter has a high speed and many cutting edges. It is the most important machine in the tool room as nearly all the operations can be performed on it with high accuracy.
- MRR (Material Removal Rate) can be further increased by increasing the number of teeth on the cutter.
- Milling machining is one of the very common manufacturing processes used in machinery shops and industries to manufacture high precision products and parts in different shapes and sizes.

WORKING PRINCIPLE

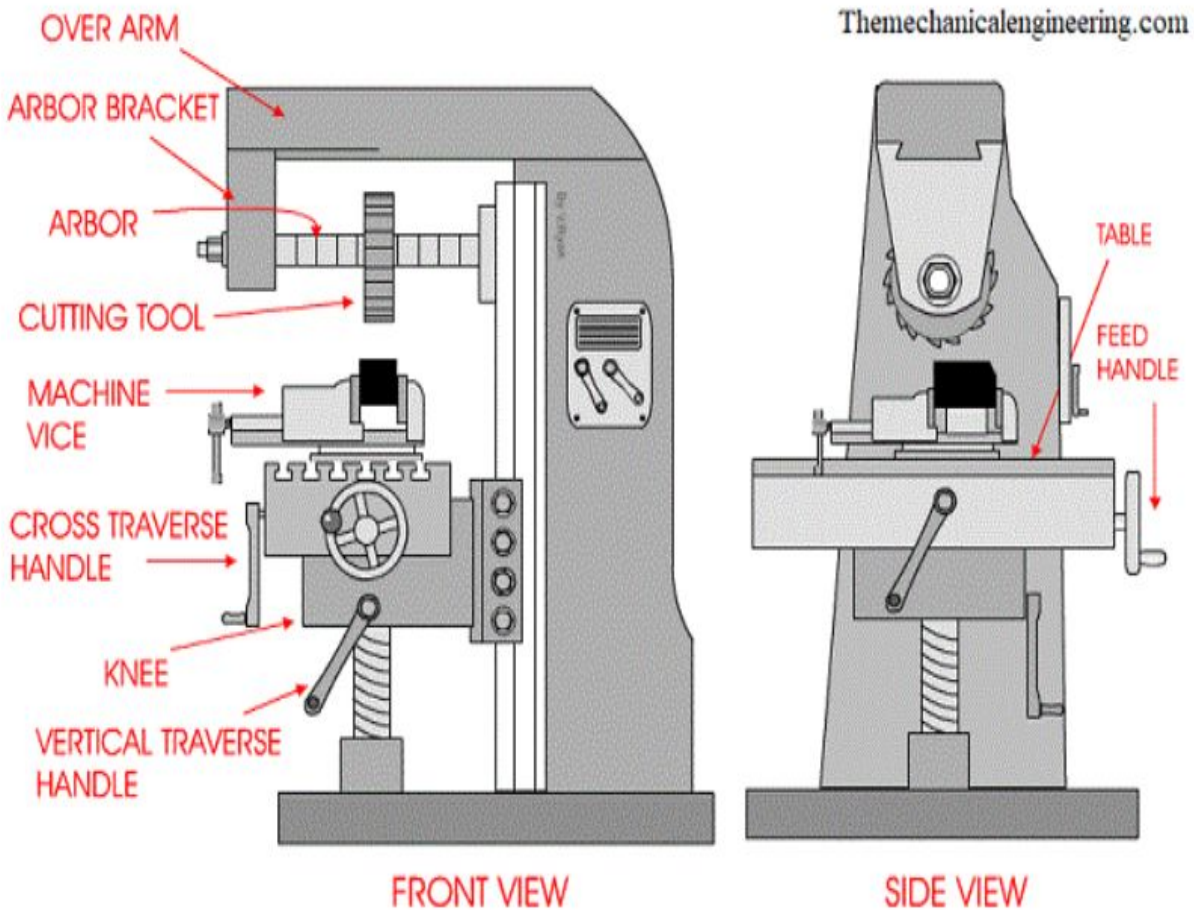
The **working principle of the Milling machine** is,

- It employed in the metal removing operation on a milling machine is that the work is rigidly clamped on the table of the machine and the revolving cutter which has multiple teeth is mounted on the arbor.
- The cutter revolves at high speed and the work is fed slowly past the cutter.
- The work can be fed in a vertical, longitudinal, or cross direction depending upon the type of milling machine being used.
- As the work proceeds, the cutter-teeth removes the metal from the surface of the job(workpiece) to produce the desired shape.

MILLING MACHINE PARTS

Milling Machine consists of following Main Parts:

- Base
- Column
- Knee
- Saddle
- Table
- Over-Arm
- Spindle or Arbor
- Arbor supports
- Ram
- Milling Head



Milling Machine Parts

- **Base:**
  - The base is the part upon which the whole machine parts are being mounted. It is a type of foundation for the machine.
  - The base is mostly made up of cast iron, so it has good strength and rigidity. It also helps in the absorption of shocks. Cutting fluid can also be stored in the base.
- **Column:**
  - The main supporting frame which consists of all the driving mechanism and the motor is called the column.
  - The driving mechanism usually consists of a cone pulley mechanism in which the v-belt is being used to connect it to the motor.
  - Further by using this driving mechanism the speed of the machine can control as per our requirement.
- **Knee:**
  - The knee shape is quite similar to that of the human body knee. The knee is an important part of this machine which supports the other parts like saddle and table**.**
  - The knee is attached to the column and has guideways by which it can move up and down with the help of the elevating screw for adjusting its height.

- **Saddle:**
  - The saddle is present on the top of the knee which further carries the table. Its basic function is to support the table.
  - A saddle can slide on the guideways which are exactly at 90 degrees to the column face. Saddle moves crosswise(in or out) on guideways provided on the knee.
- **Table:**
  - The table is present on the top of the saddle. The table consists of T-slots or sometimes fixtures are used for holding up the workpiece on the table. A table can travel longitudinally in a horizontal plane.
- **Over-arm:**
  - It is also called as the over-hanging arm. Overarm is present at the top of the column. The basic function of the over-arm is to support the arbor and spindle
- **Spindle or Arbor:**
  - The top portion of the column contains the spindle. The spindle is also an important part of the machine as it the part where the multipoint cutter is attached.
  - Power required for the rotation of the spindle is obtained from the motor through belt, gear and clutch assembly.

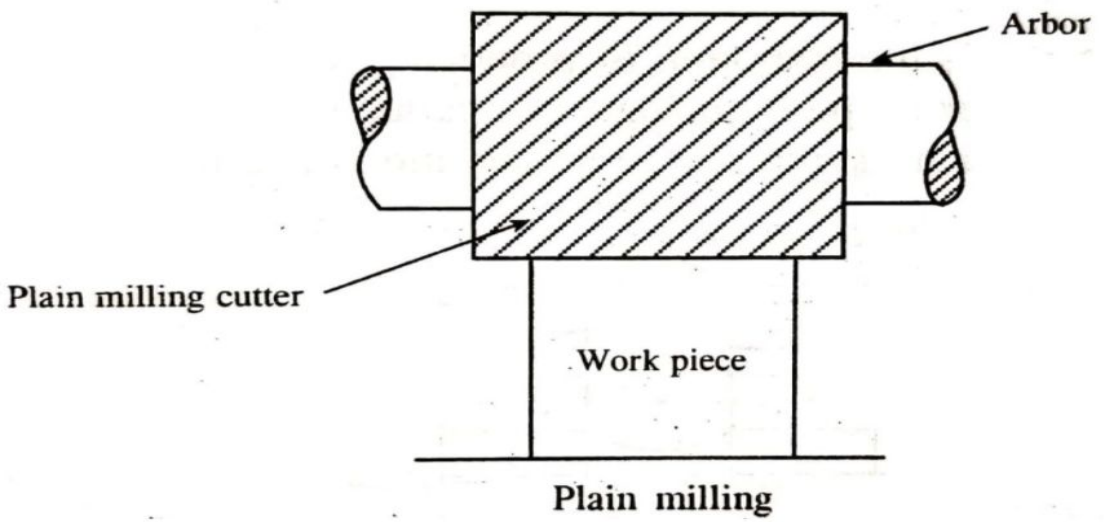
MILLING MACHINE OPERATIONS

The **following Operation is performed by the Milling Machine**:

- Plain Milling or Slab Milling Operation
- UP and DOWN Milling Operation
- Face Milling Operation
- End Milling Operation
- Gang Milling Operation
- Straddle Milling Operation
- Groove Milling Operation
- Gear Milling Operation
- Side Milling Operation and
- T-Slot Milling Operation

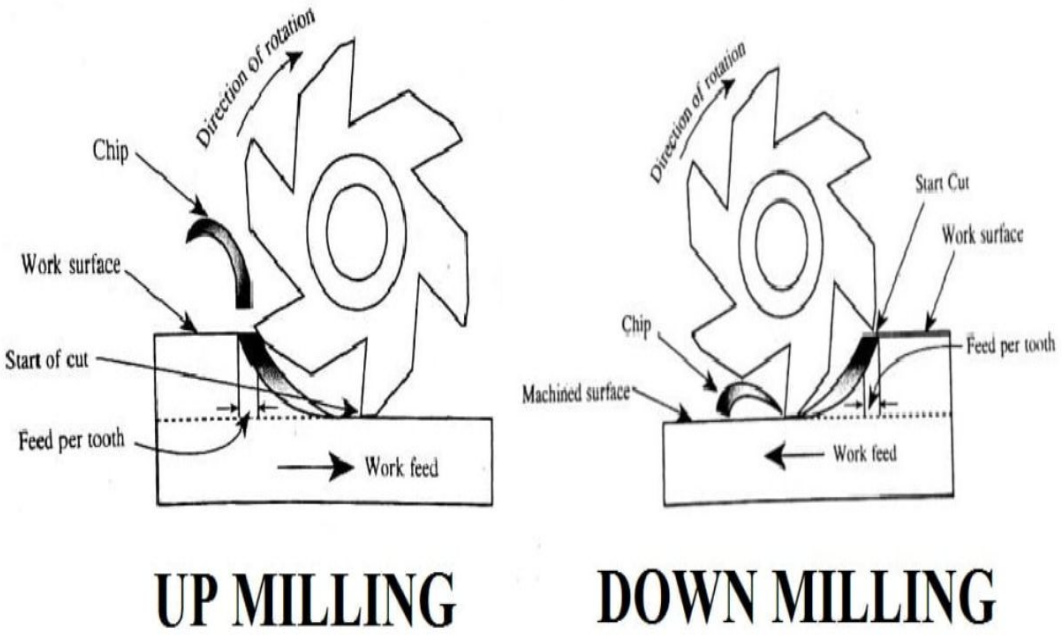
Plain Milling or Slab Milling Operation:

- Plain or slab milling is a process in which the plain, horizontal or flat surfaces are produced, which are parallel to the axis of the rotation of the cutter. A peripheral mill cuter is used for performing the slab milling operation.



Up Milling and Down Milling:

- **Up milling** is a method of milling operation in which the cutter and the workpiece both moves in the opposite direction.
- **Down Milling** is a method of milling operation in which the direction of the rotation of the cutter coincides with the direction of the work feed.

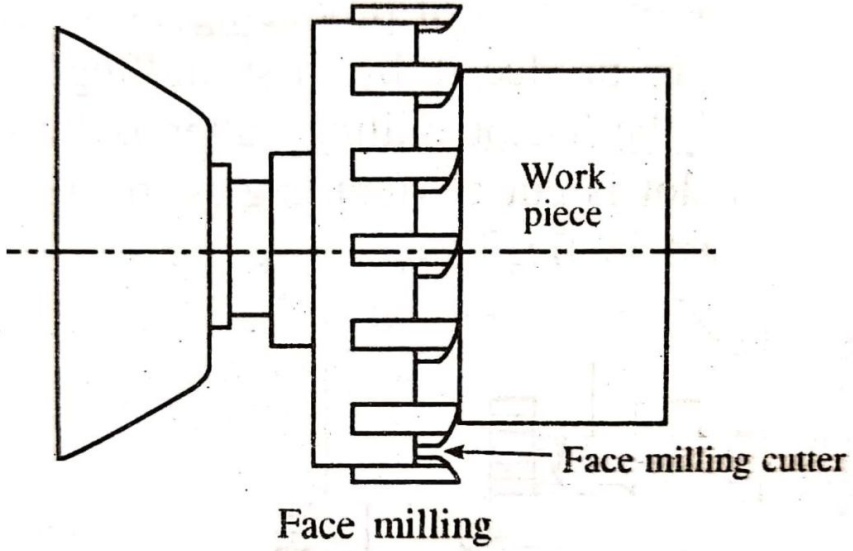


COMPARISON BETWEEN UP MILLING & DOWN MILLING

SL. NO.	UP MILLING (CONVENTIONAL MILLING)	DOWN MILLING (CLIMB MILLING)
01	Work piece fed in the opposite direction that of the cutter.	Work piece fed in the same direction that of the cutter.
02	Chips are progressively thicker.	Chips are progressively thinner.
03	Strong clamping is required since the cutting force is directed upwards & tends to lift the work piece.	Strong clamping is not required since the cutting force is directed downwards & keep the work piece pressed to the table.
04	Gives poor surface finish, since chips gets accumulated at the cutting zone.	Gives good surface finish, since the chips are thrown away during cutting.
05	Used for hard materials.	Used for soft materials and finishing operations.

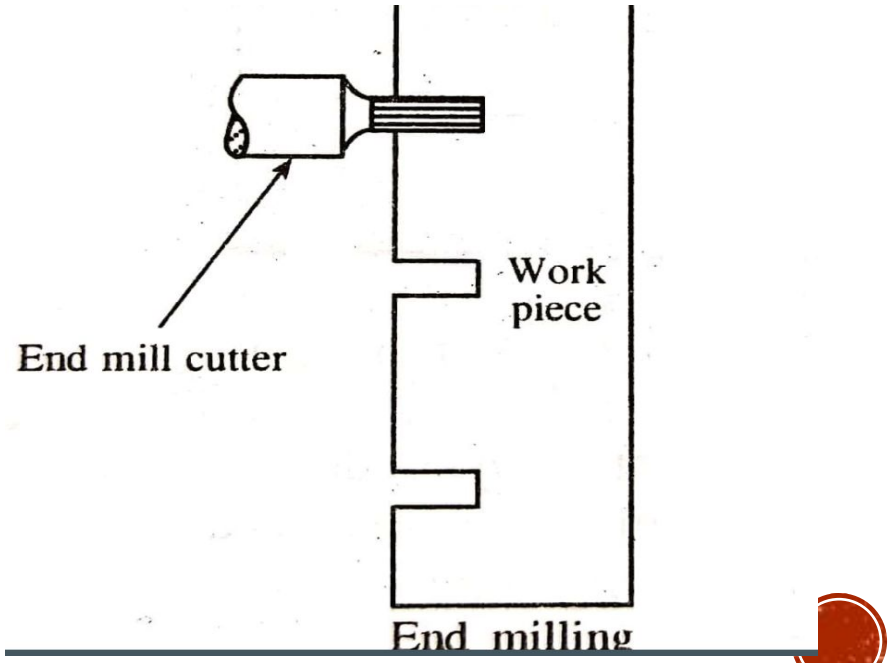
Face Milling Operation:

- It is a type of milling operation in which the layer of material is removed from the face of the material. **The end milling cutter is preferred for performing face milling operations.**
- In Face Milling operation the teeth for cutting are present on both the periphery and the face of the cutter.
- The axis of rotation of the cutter is perpendicular to the work surface. In face milling most of the cutting is done by the periphery portions of the teeth, the face portion provides finishing the action.



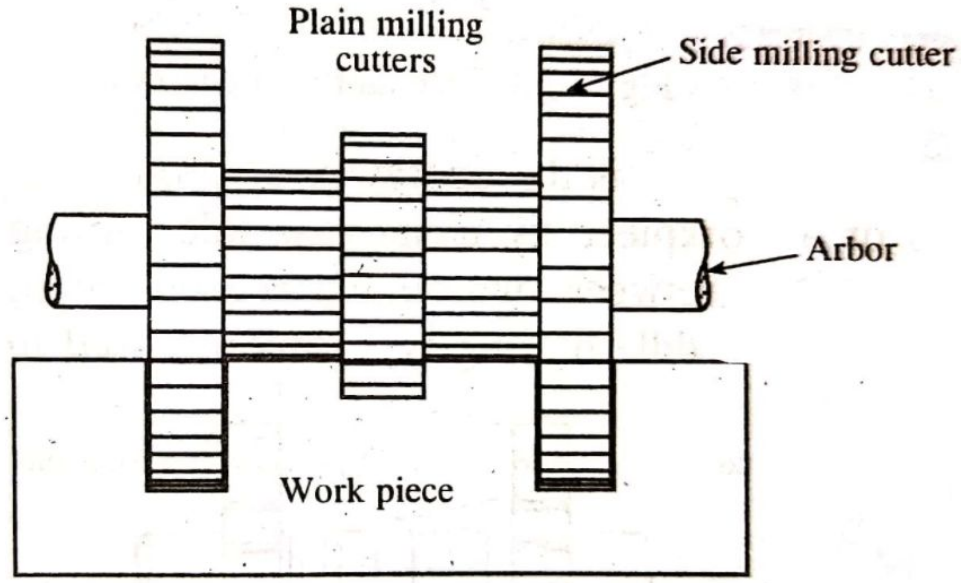
End Milling Operation:

- End milling is the combination of the slab milling and face-milling operation and used for creating slots in the workpiece and mostly used for handling the complicated profile.



Gang Milling Operation

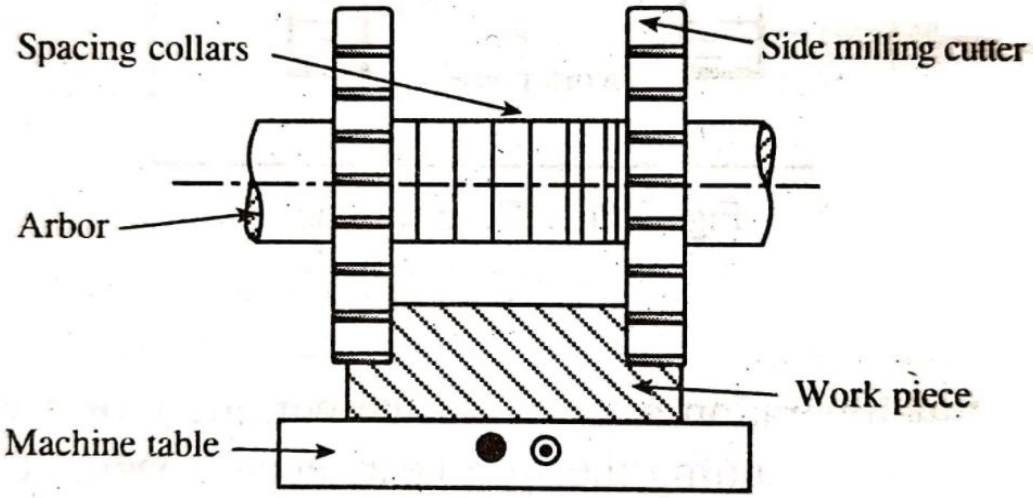
- Gang milling is a type of milling operation in which multiple cutters are being mounted on the same arbor to produce the desired shape on the workpiece.



Gang milling

Straddle Milling Operation:

- The straddle is the type of milling process in which milling is performed on two surfaces simultaneously. T-slot milling is a unique example of straddle Milling.



Straddle milling

PLAIN OR HORIZONTAL MILLING MACHINE

These are much stronger than hand millers. The table feeding is done either by hand or power. the plain milling machine having a horizontal spindle is also called as a horizontal spindle milling machine. The table may be fed in a longitudinal, cross, or vertical directions.

The feed is:

- Longitudinal – when the table is moved at right angles to the spindle.
- Cross – when the table is moved parallel to the spindle.
- Vertical – when the table is adjusted in the vertical plane.

ADVANTAGES OF MILLING MACHINE

- **High speed:**

In Milling, the rate of metal removal is very high as the cutter rotates at a high speed and has multiple cutting edges.

- **Better surface finish:**

The surface finish of the materials machined on the milling machine is better because of the multi-cutting edges.

- **Increased Productivity:**

CNC Milling Machines are the machines in which the milling operation is being controlled by software.

It has increased the overall production with better finish and accuracy.

- **High Accuracy:**

In the milling machine, the products machined are of high accuracy especially in the case of the most advanced form of milling machine which is the CNC Machine.

DISADVANTAGES OF THE MILLING MACHINE

High Flank wear:

- It has a high flank wear rate which can be prevented by reducing speed and increasing the feed rate.
- Further to avoid it one should use harder carbide with proper geometry and sharpened cutting edges.

High crater wear:

- High crater wear is found which can be tackled by reducing speed and using harder carbide.

.High Chatter:

- This happens due to poor rigidity of cutter, machine, loose arbor, and improper geometry.
- This situation can be improved by increasing feed, reducing speed and using unequal pitch cutters.

Chip clogging:

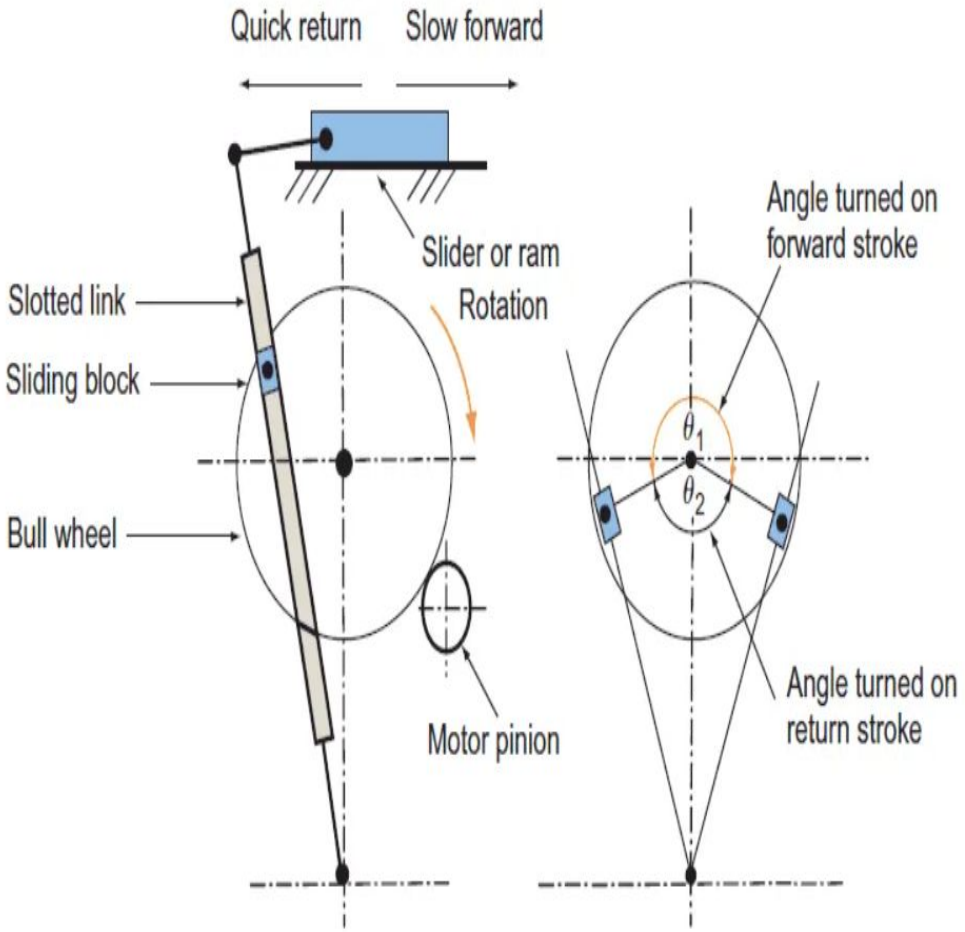
- The milling machine also suffers from the problem of chip clogging which can be reduced by using reducing the number of teeth on the cutter and increasing speed and chip pockets.

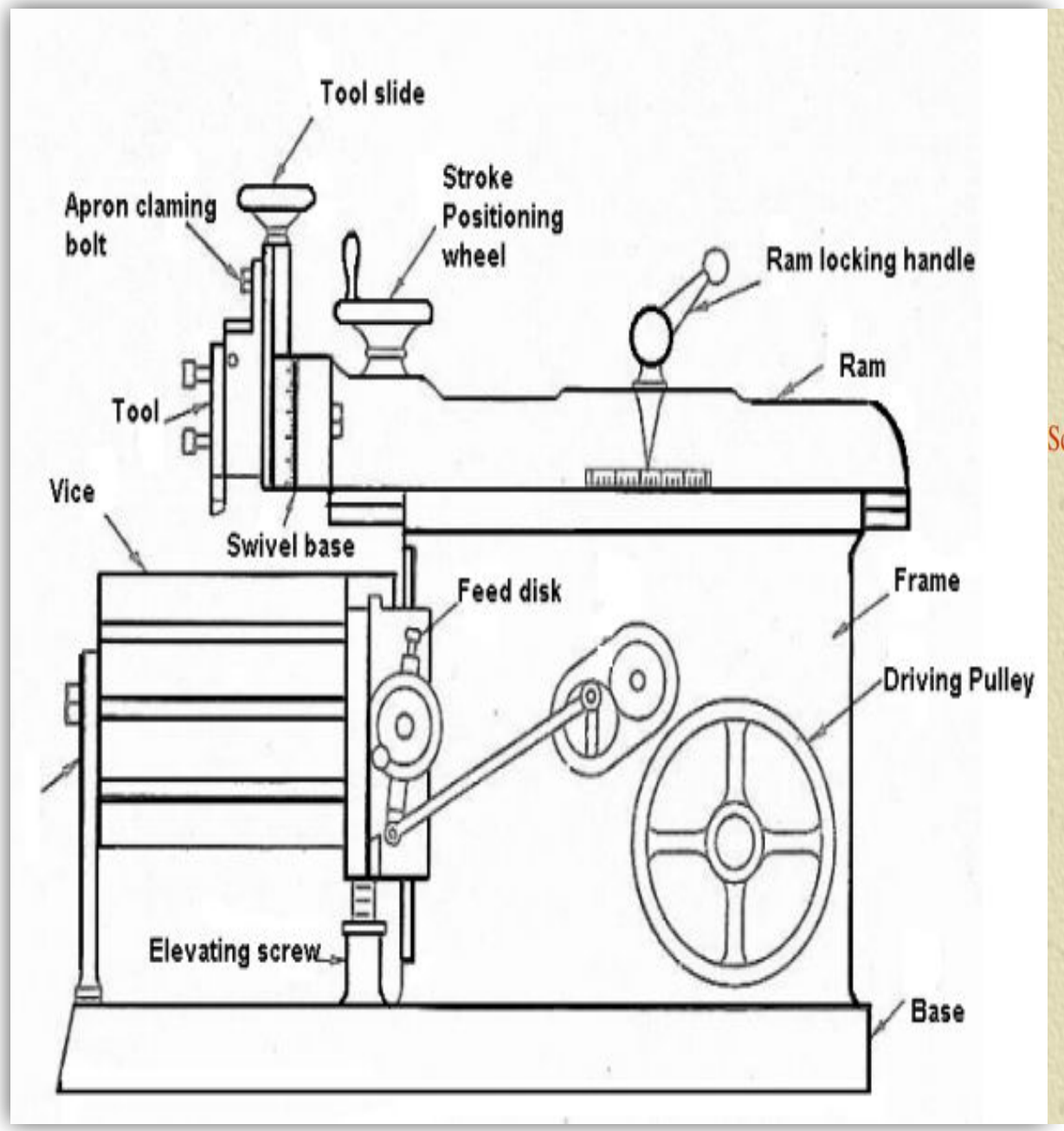
SHAPING MACHINE

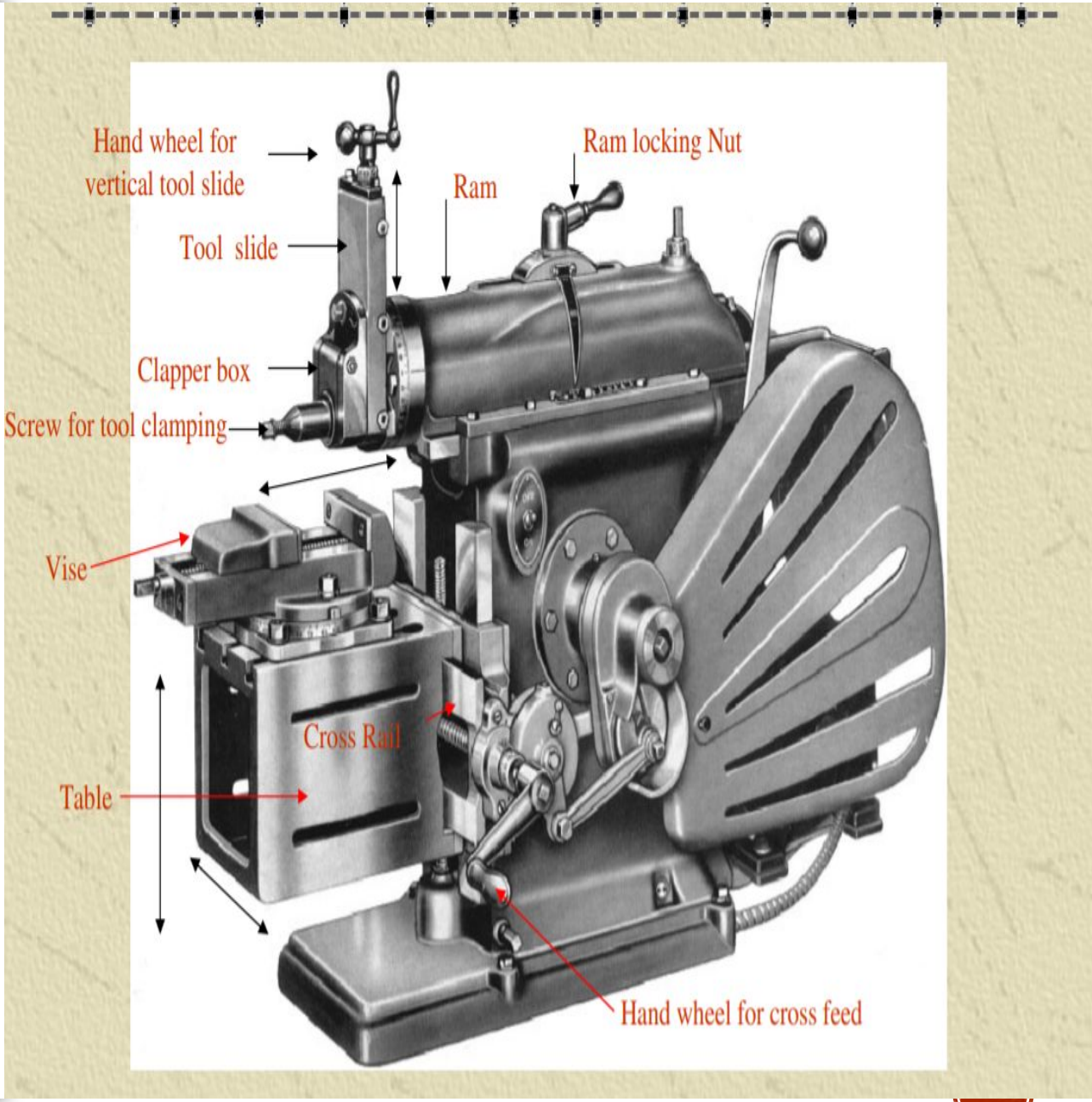
- Shaping machine is a machine designed for giving desired shapes to the surfaces that may be horizontal, vertical and flat.
- A shaping tool is used to cut in curves, different angles, and many other shapes. A disc is responsible for the tool movement which results in the forward and backward movement.
- The cutting tool is used to give the shape to the hard surface of metal or wood by removing the excess material.

WORKING MECHANISM OF SHAPING MACHINE

- The shaping machine operates in the reciprocating type of machine function. Here the work piece is fixed on the machine table and the cutting tool is placed on the work piece. Reciprocating movements over the work piece results in forward and backward strokes. Forward stroke is responsible for cutting action over the object and backward movement is responsible for restoring its position without any cutting action.
- In the shaper machine, there is another mechanism called **Quick return Motion Mechanism**.
- In the forward stroke, the Slider moves fast and removing the material from the workpiece.
- Whereas in the return stroke, the Slider moves faster than the forward stroke that means Quick return, it takes less time to return, called a return stroke.




Tool slide
Apron claming bolt
Stroke Positioning wheel
Ram locking handle
Ram
Tool
Vice
Swivel base
Feed disk
Frame
Driving Pulley
Elevating screw
Base


Hand wheel for vertical tool slide
Ram locking Nut
Ram
Tool slide
Clapper box
Screw for tool clamping
Vise
Cross Rail
Table
Hand wheel for cross feed

PARTS OF SHAPING MACHINE WITH ITS FUNCTIONS

- **Base:** The base of shaping machine is kind of bed to hold the different parts of shaping machine, it is made up of cast iron since the strength of a base is very important. The base bears the vibration shock of forward and backward movement of stroke responsible for shaping action.
- **Body:** Body of the machine consists of pats named Pillar, Frame, and Column. The body of the shaping machine is affixed on the base of the shaping machine. The column is also made up cast iron and it is box shaped part which is placed on the base. Column plays the covering role and supports the reciprocating movement in the operation of the machine.
- **Cross ways:** These are the sideways affixed vertically and horizontally across the table to allow the movement of the table.
- **Stroke adjuster**: Stroke adjuster absorbs the vibration shock of stock by controlling the length of the stroke.

PARTS OF SHAPING MACHINE WITH ITS FUNCTIONS

- **Table:** A table is kind of flat body affixed over the frame to hold the work piece on which shaping action needs to be performed,
- **Clapper box:** It is used to carry the shaping tool holder. Clapper box is responsible for the smooth and hindrance free movement of backward stroke to prevent the damage in the form of wear and tear.
- **Cross rail:** The cross rail is affixed on the front part of the body which can be moved in an upward and downward direction. It enables to perform shaping operation at different positions.
- **Ram:** The Ram is responsible for the reciprocating action of the column sideways. Forward and backward movement of ram is called a stroke.

OPERATIONS PERFORMED ON SHAPER MACHINE

There are **4-types of operations performed in a shaper machine**, and those are:

- Horizontal cutting
- Vertical cutting
- Inclined cutting
- Irregular cutting
- Keyways cutting

Horizontal cutting:

- Horizontal surfaces are machined by moving the work mounted on the machine table at a cross direction with respect to the ram movement.
- The clapper box can be set vertical or slightly inclined towards the uncut surface.
- This arrangement enables the tool to lift automatically during the return stroke. The tool will not drag on the machined surface.

- **Vertical cutting:**
  - A vertical cut is made while machining the end of a workpiece, squaring up a block or machining a shoulder.
  - The feed is given to the tool by rotating the down feed screw of the vertical slide.
  - The table is not moved vertically for this purpose.
  - The apron is swiveled away from the vertical surface being machined.
- **Inclined cutting:**
  - An angular cut is done at any angle other than a right angle to the horizontal or to the vertical plane.
  - The work is set on the table and the vertical slide of the tool head is swiveled to the required angle either towards the left or towards right from the vertical position.
- **Irregular cutting:**
  - A round nose tool is used for this operation.
  - For a shallow cut the apron may be set vertical but if the curve is quite sharp, the apron in swiveled towards the right or left away from the surface to be cut

- **Keyways cutting**: keyways cutting on a shaper is done by holding the workpiece in a vice by using a V-block. The axis of the shaft is set parallel to the movement of the stroke with the help of dial indicator. The key ways cutting operation is carried out just like cutting a groove on a shaper, but difference lies in the way the workpiece is held.
- **Machining a thin job on a shaper-** while machining a thin job on a shaper, it should be prevented from springing.

ADVANTAGES

- The tool (Single Point cutting tool) cost is low.
- The workpiece can be held easily in this machine.
- It produces flat or angular surfaces.
- Setup of Shaper is very easy and tool changing is also easy.

DISADVANTAGES

- By nature, it is a slow machine because of its straight-line forward and returns strokes the single point cutting tool requires Several strokes to complete a work. (They are slow)

- The cutting speed is not usually very high speeds of reciprocating motion due to high inertia force developed in the motion of the units and components of the machine.

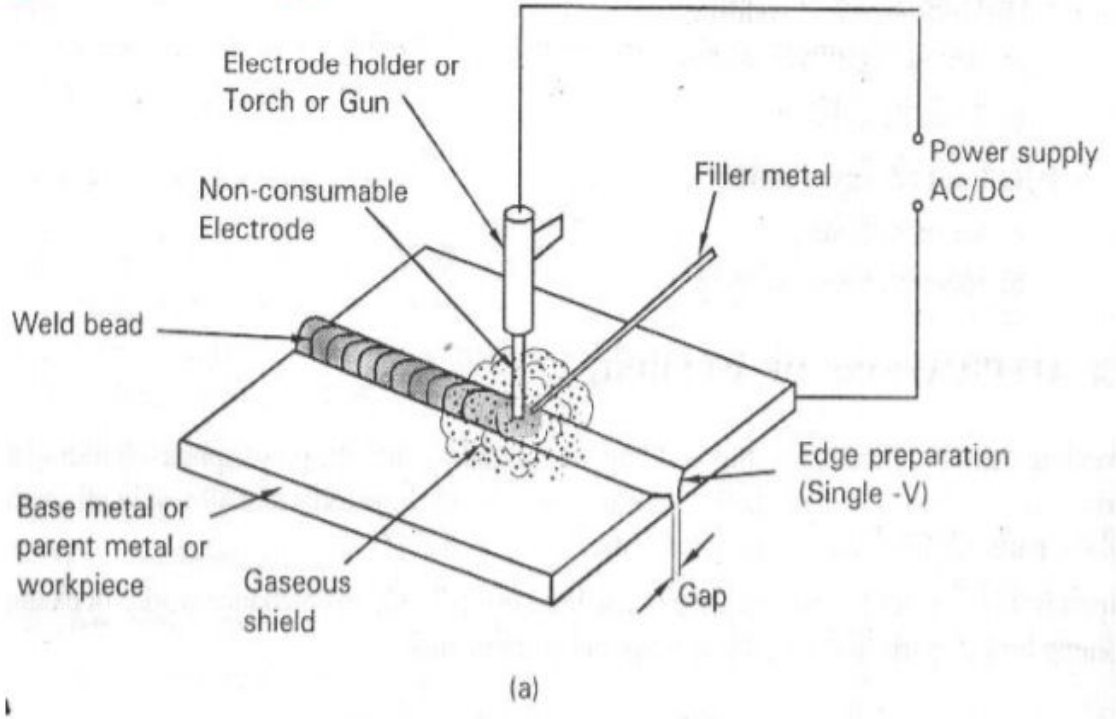
APPLICATION OF SHAPER MACHINE

- A shaper Machine is used to make Internal splines.
- It generates straight and flat surfaces either horizontal, vertical or angular planes.
- It also makes gear teeth.
- Make keyways in pulleys or gears.
- It also Producing contour of concave/convex or a combination of these.

WIELDING

- 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. Welding is usually used on metals and thermoplastics but can also be used on wood. The completed welded joint may be referred to as a weldment.
- Some materials require the use of specific processes and techniques. A number are considered 'unweldable,' a term not usually found in dictionaries but useful and descriptive in engineering.
- The parts that are joined are known as a parent material. The material added to help form the join is called filler or consumable. The form of these materials may see them referred to as parent plate or pipe, filler wire, consumable electrode (for arc welding), etc.
- Consumables are usually chosen to be similar in composition to the parent material, thus forming a homogenous weld, but there are occasions, such as when welding brittle cast irons, when a filler with a very different composition and, therefore, properties is used. These welds are called heterogeneous.
- The completed welded joint may be referred to as a weldment.

Welding terminology



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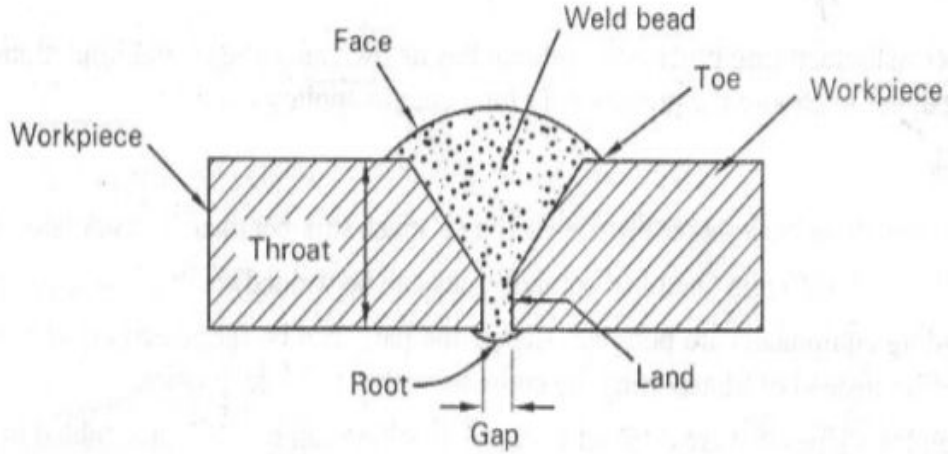
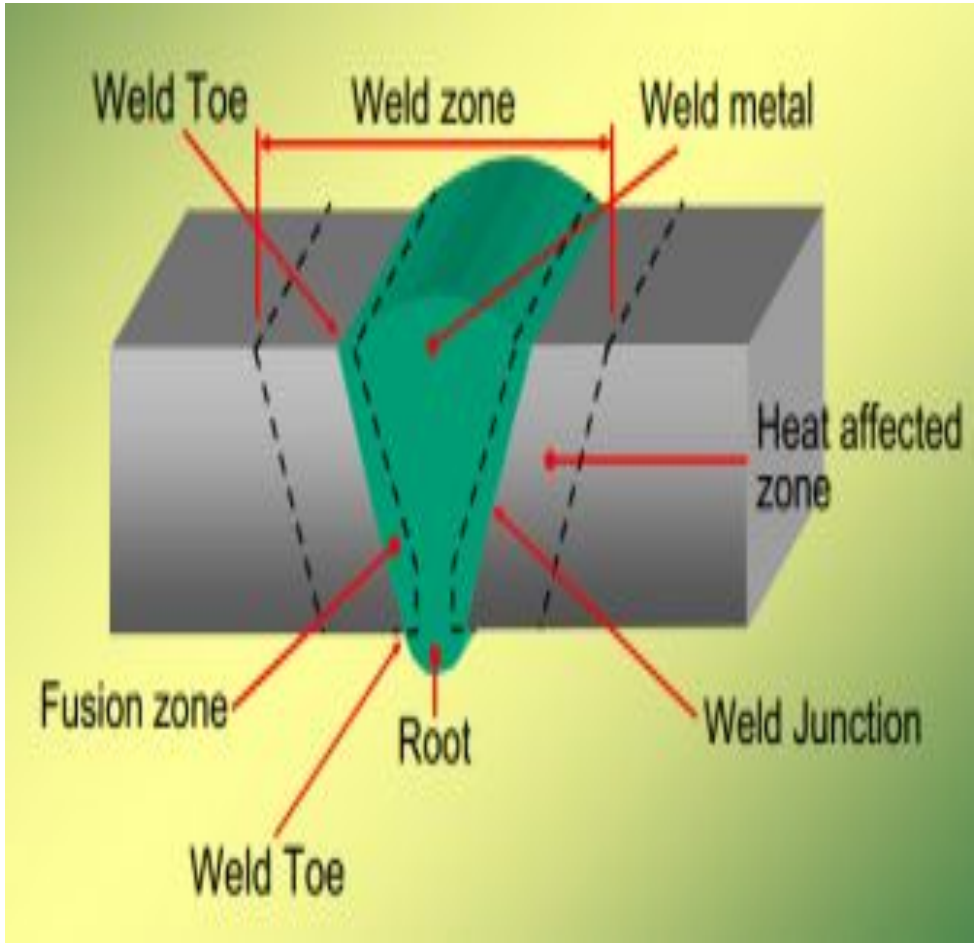




PRINCIPLE OF WELDING

• An ideal joint between two pieces of metal or plastic can be made by heating the workpieces to a suitable temperature. In other words, on heating, the materials soften sufficiently so that the surfaces fuse together.

• The bonding force holds the atoms, ions or molecules together in a solid. This 'bonding on contact' is achieved only when:

– the contaminated surface layers on the workpiece are removed,

– recontamination is avoided, and

– the two surfaces are made smooth, flat and fit each other exactly.

• In highly deformable materials, the above aims can be achieved by rapidly forcing the two surfaces of the workpiece to come closer together so that plastic deformation makes their shape conform to each another; at the same time, the surface layers are broken up, allowing the intimate contact needed to fuse the materials.

• This was the principle of the first way known to weld metals; by hammering the pieces together while they are in hot condition.

CLASSIFICATION OF WELDING PROCESSES

• There are about 35 different welding and brazing processes and several soldering methods in use by industry today.

• There are various ways of classifying the welding and allied processes. For example, they may be classified on the basis of:

– Source of heat, i.e., flame, arc, etc.

– Type of interaction i.e. liquid/liquid (fusion welding) or solid/solid (solid state welding).

• In general, various welding and allied processes are classified as follows:

CLASSIFICATION OF WELDING PROCESSES

Gas Welding:-
- Air Acetylene Welding
- Oxyacetylene Welding
- Oxy hydrogen Welding
- Pressure gas Welding

Arc Welding:-
- Carbon Arc Welding
- Shielded Metal Arc Welding
- Flux Cored Arc Welding
- Submerged Arc Welding
- TIG (or GTAW) Welding
- MIG (or GMAW) Welding
- Plasma Arc Welding
- Electro slag Welding
- Electro gas Welding
- Stud Arc Welding.

Resistance Welding:-
- Spot Welding
- Seam Welding
- Projection Welding
- Resistance Butt Welding
- Flash Butt Welding
- Percussion Welding
- High Frequency Resistance Welding

Solid State Welding:-
- Cold Welding
- Diffusion Welding
- Explosive Welding
- Forge Welding
- Friction Welding
- Hot Pressure Welding
- Roll Welding
- Ultrasonic Welding.

Thermo-Chemical Welding Processes:-
- Thermit Welding
- Atomic Hydrogen Welding.

Radiant Energy Welding Processes:-
- Electron Beam Welding
- Laser Beam Welding.

ADVANTAGES OF WELDING

- A good weld is as strong as the base metal.
- General welding equipment is not very costly.
- Portable welding equipment's are available.
- Welding permits considerable freedom in design.
- A large number of metals/alloys both similar and dissimilar can be joined by welding.
- Welding can join workpieces through spots, as continuous pressure tight seams, end-to-end and in a number of other configurations.
- Welding can be mechanized.

DISADVANTAGES 0F WELDING

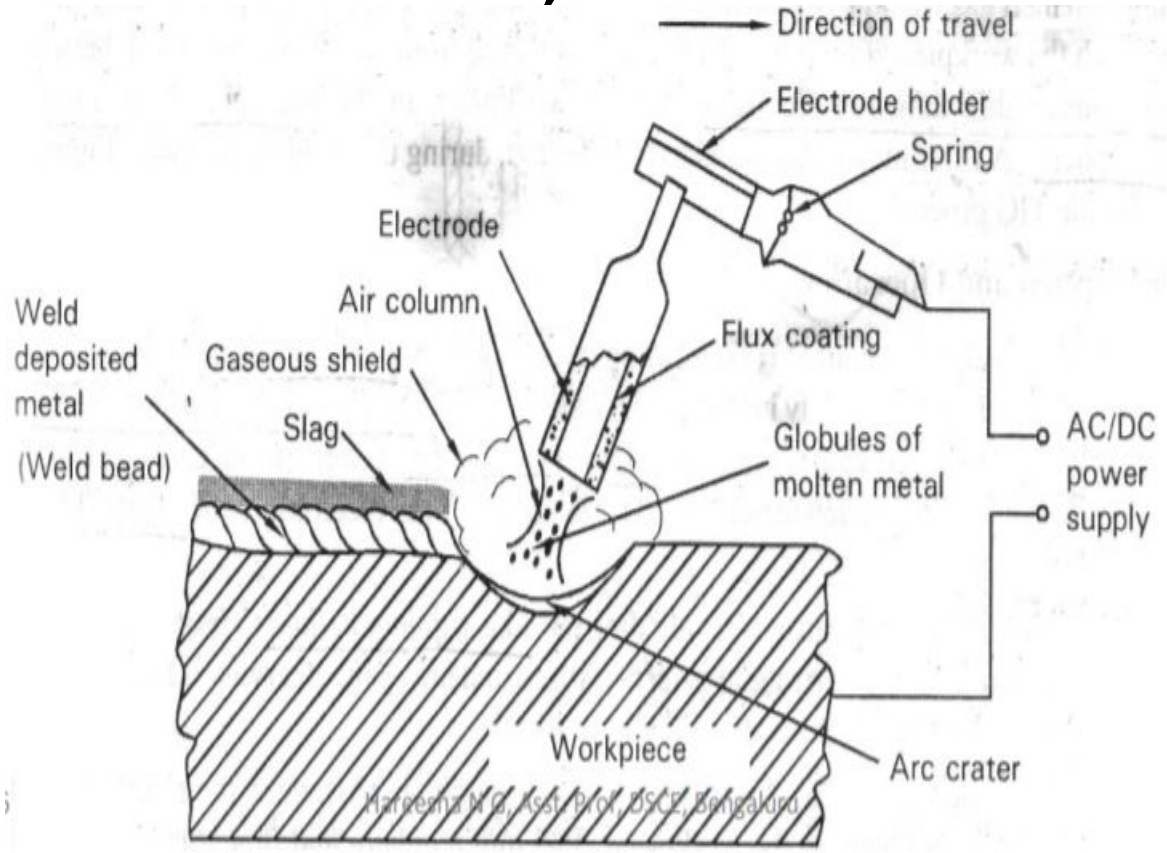
- Welding gives out harmful radiations (light), fumes and spatter.
- Welding results in residual stresses and distortion of the work-pieces.
- Edge preparation of the workpieces is generally required before welding them.
- A skilled welder is a must to produce a good welding job.
- Welding heat produces metallurgical changes. The structure of the welded joint is not same as that of the parent metal.
- A welded joint, for many reasons, needs stress-relief heat-treatment.

FLUX SHIELDED METAL ARC WELDING (MMAW OR SMAW)

It is an arc welding process wherein coalescence is produced by heating the workpiece with an electric arc set up between a flux coated electrode and the workpiece.

The flux covering decomposes due to arc heat and performs many functions, like arc stability, weld metal protection, etc.,

The electrode itself melts and supplies the necessary filler metal.



PRINCIPLE OF THE PROCESS

- Heat required for welding is obtained from the arc struck between a coated electrode and the workpiece.

• The arc temperature and thus the arc heat can be increased or decreased by employing higher or lower arc currents.

• A high current arc with a smaller arc length produces very intense heat.

• The arc melts the electrode end and the job.

• Material droplets are transferred from the electrode to the job, through the arc, and are deposited along the joint to be welded.

• The flux coating melts, produces a gaseous shield and slag to prevent atmospheric contamination of the molten weld metal.

ADVANTAGES OF SHIELDED METAL ARC WELDING

- SMAW is the simplest of all the arc welding processes.
- The equipment can be portable and the cost is fairly low.
- This process finds innumerable applications, because of the availability of a wide variety of electrodes.
- A big range of metals and their alloys can be welded.
- Welding can be carried out in any position with highest weld quality.

LIMITATIONS

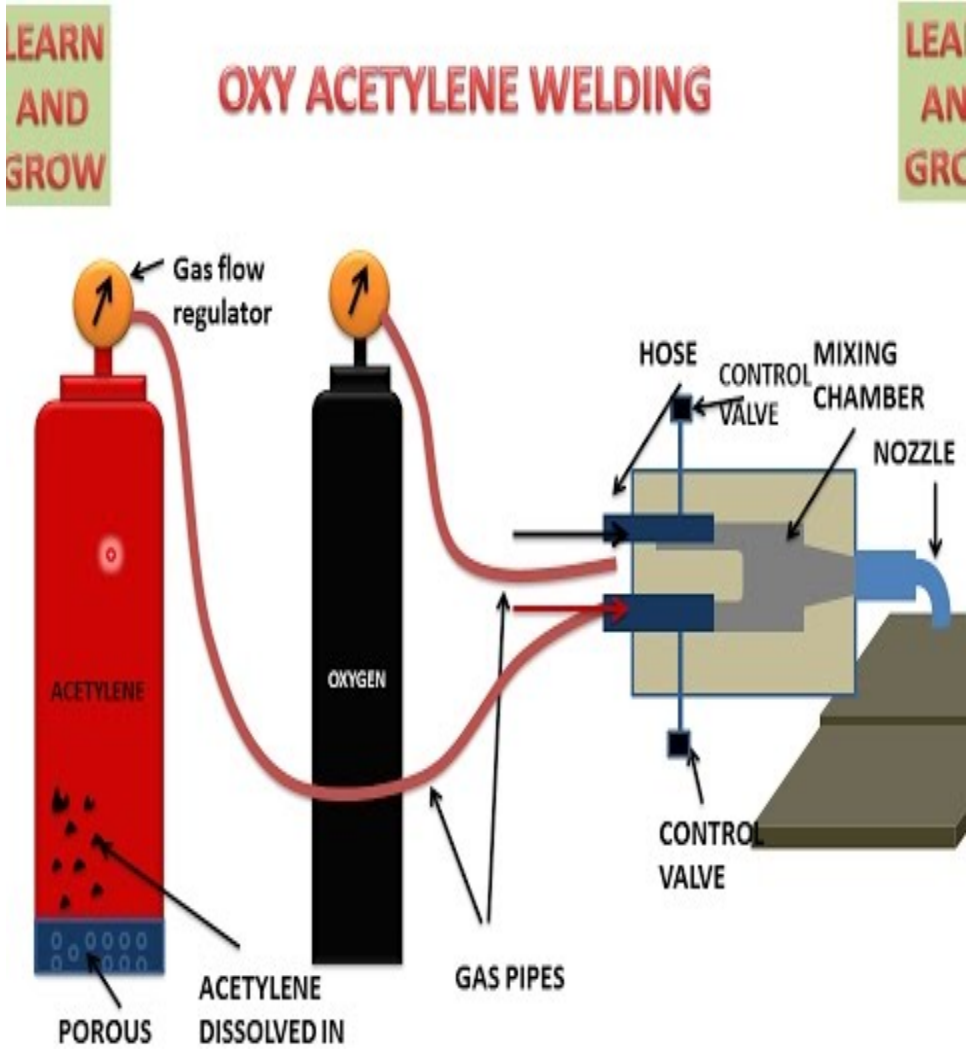
- Because of the limited length of each electrode and brittle flux coating on it, mechanization is difficult.
- In welding long joints (e.g., in pressure vessels), as one electrode finishes, the weld is to be progressed with the next electrode. Unless properly cared, a defect (like slag inclusion or insufficient penetration) may occur at the place where welding is restarted with new electrode.
- The process uses stick electrodes and thus it is slower as compared to MIG welding.
- Because of flux coated electrodes, the chances of slag entrapment and other related-defects are more as compared to MIG or TIG welding.

OXY ACETYLENE WELDING

- Principle of Operation
- When acetylene is mixed with oxygen in correct proportions in the welding torch and ignited, the flame resulting at the tip of the torch is sufficiently hot to melt and join the parent metal.
- • The oxy-acetylene flame reaches a temperature of about 3200°C and thus can melt all commercial metals which, during welding, actually flow together to form a complete bond.
- • A filler metal rod is generally added to the molten metal pool to build up the seam slightly for greater strength.

The types of Flames in Oxy-Acetylene Gas Welding are as follows.

1. Neutral Flam =**O2/C2H2 = 1, T** max = **3260**°C
2. Oxidizing Flame =**O2/C2H2 = 1.15 to 1.5, T** max = 3380°C
3. Carburizing Flame =**O2/C2H2=0.85 to 0.95, T**max = **3040**°C



DESCRIPTION AND OPERATION

- The equipment consists of two large cylinders: one containing oxygen at high pressure and the other containing acetylene gas.
- Two pressure regulators fitted on the respective cylinders regulates or controls the pressure of the gas flowing from the cylinders to the welding torch as per the requirements.
- The welding torch is used to mix both oxygen and acetylene gas in proper proportions and burn the mixture at its tip.
- A match stick or a spark lighter may be used to ignite the mixture at the torch tip.
- The resulting flame at the tip has a temperature ranging from 3200°C - 3500°C and this heat is sufficient enough to melt the workpiece metal.
- Since a slight gap usually exists between the two workpieces, a filler metal is used to supply the additional material to fill the gap.
- The filler metal must be of the same material or nearly the same chemical composition as that of the workpiece material.
- The molten metal of the filler metal combines with the molten metal of the workpiece and upon solidification form a single piece of metal.
- Flux, if required, may be used during the process. It can be directly applied to the surface of the workpiece or, the heated end of the filler metal may be dipped in

ADVANTAGES OF OXY-ACETYLENE WELDING

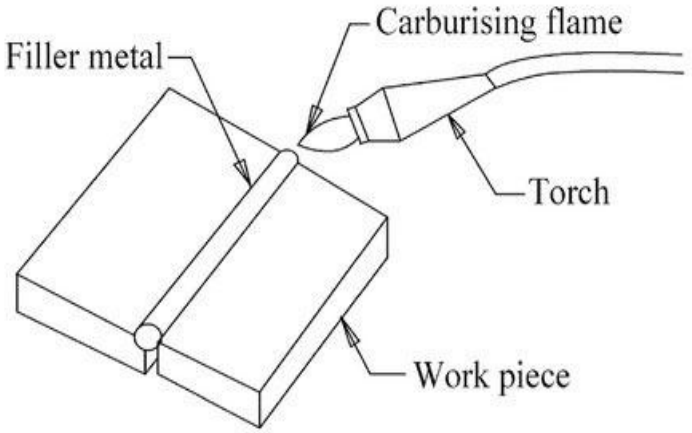
- It's easy to learn.
- The equipment is cheaper than most other types of welding rigs (MIG/TIG welding)
- The equipment is more portable than most other types of welding rigs (MIG/TIG welding)
- Oxy/Acetylene equipment can also be used to "flame-cut" large pieces of material.

DISADVANTAGES OF OXY-ACETYLENE WELDING

- Oxy/Acetylene weld lines are much rougher in appearance than other kinds of welds, and require more finishing if neatness is required.
- Oxy/Acetylene welds have large heat affected zones (areas around the weld line that have had their mechanical properties adversely affected by the welding process).

BRAZING

- Brazing is a joining process wherein metals are bonded together using a filler metal with a melting (liquidus) temperature greater than 450 °C (840 °F), but lower than the melting temperature of the base metal. Filler metals are generally alloys of silver (Ag), aluminum (Al), gold (Au), copper (Cu), cobalt (Co) or nickel (Ni).
- Here, the capillary attraction is driving the filler metal into the joint (clearance is very small)
- This filler metal fills the gap during the operation. The brazing process also needs a suitable flux to prevent the oxidation of the base metal, and commonly used fluxes are borax, fluorides, chlorides, and boric acid.
- The brazing finds its applications in automobile radiators used for cooling, containers and other tanks, pipe fittings, heat exchangers, etc.

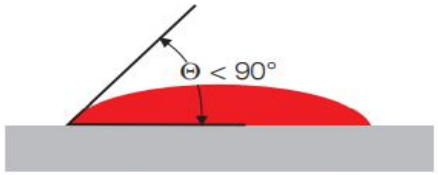
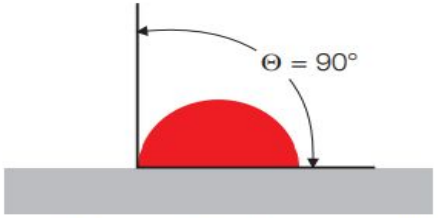
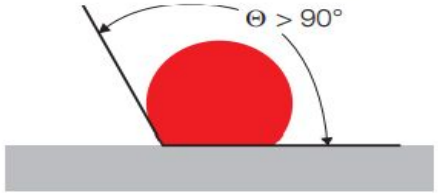


Brazing process

CAPILLARY BRAZE ACTION

- Capillary attraction: The force by which a liquid, in this case the braze filler metal, in contact with a solid is distributed between closely fitting adjacent surfaces. The ability of the filler metal, in a liquid state, to pull its mass along the solid contact surfaces between two components permits brazing of blind joints.

Wetting in braze joints

Braze alloy deposit	**Good wetting condition**
 Braze alloy deposit on a prepared metal surface (prior to brazing)	 The conditions are present to allow the braze alloy to spread out onto the base metal
Poor, non-wetting condition	**De-wetting condition**
 Poor conditions during brazing prohibit the alloy from wetting	 Braze conditions were so poor that the alloy pulled up and away from the base metal

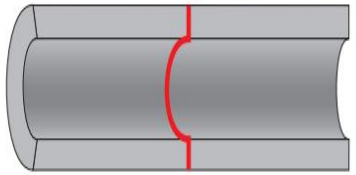
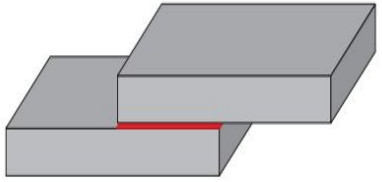
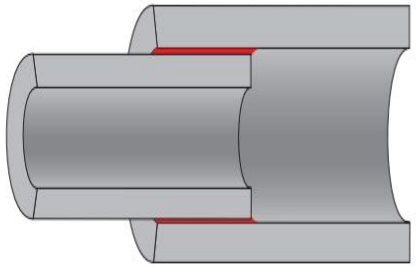
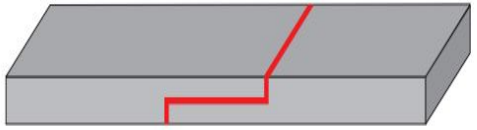
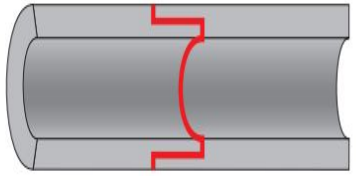
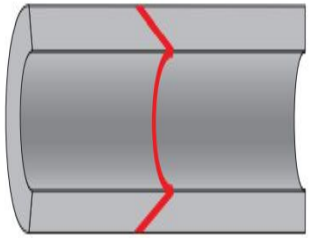
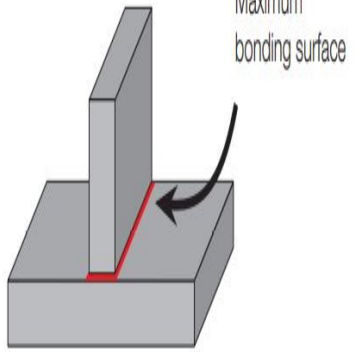
PRINCIPLE

- The joint is produced by diffusion of elements of filler metal into the base metal or vice versa. Diffusion of the elements creates bonds, which contributes to joint. Since the filler metal is in liquid state the diffusion rate is faster than in solids. The capillary action plays an important role in holding the liquid filler metal which would otherwise flow out. After soaking the samples for a long time at brazing temperature the samples are quenched to room temperature.

STEPS IN BRAZING

- The assembly or the region of the parts to be joined is heated to a temperature of at least 450ºC.
- The assembled parts and brazing filler metal reach a temperature high enough to melt the filler metal but not the parts.
- The molten filler metal, held in the joint by surface tension, spreads into the joints and wets the base metal surfaces.
- The parts are cooled or solidify, the filler metal, which is held in the joint by capillary attraction and anchors the parts together by metallurgical reaction and atomic bonding.

BRAZE JOINT DESIGN

Joint type	Flat parts	Tubular parts (cutaway)
Butt joint		
Lap joint		
Butt-lapp joint		
Scarf joint		
Tee joint		

- **How is soldering different from brazing?**

Soldering is a joining process wherein metals are bonded together using a non-ferrous filler metal with a melting (liquidus) temperature lower than 450 °C (840 °F). Whenever the filler metal liquidus is greater than 450 °C (840 °F), the joining process is considered to be a brazing process rather than a soldering process.

- **How is brazing different from welding?**

Welding is a joining process wherein metallic components are joined through fusion (melting) or recrystallization of the base metal by applying heat, pressure or both. This process differs from brazing, where only the filler metal melts during processing.

ADVANTAGES

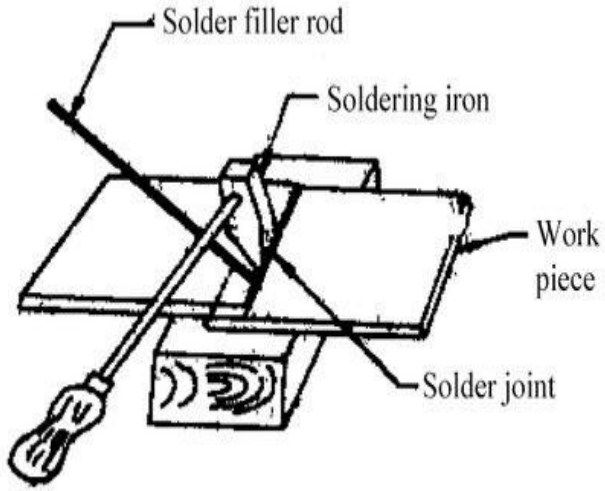
1. Economical fabrication of complex and multi component assemblies
2. Simple method to obtain extensive joint area or joint length
3. Joint temperature capability approaching that of base metal
4. Excellent stress distribution and heat transfer properties
5. Ability to preserve protecting metal coating or cladding
6. Ability to join cast materials to wrought metals
7. Ability to join nonmetals to metals

DISADVANTAGES

1. The joints are not effective at higher temperatures. Because the low melting point of filler material.
2. The color of the joint is often different from that of the base metal that create an aesthetic disadvantage.
3. Weak joint as compared to welding.
4. Metal to join must very close to ensure capillary action of molten filler metal.
5. Need a flux during brazing and flux residue must be removed.
6. The job size is limited - large plates of metal can't braze.

SOLDERING

- Soldering is the process of joining two metal pieces with the help of suitable filler material and at a temperature below 450°C.
- It is a process of metal joining at a low temperature of about below 450° C.
- The main advantages of soldering are that two dissimilar metals can also be joined. The filler metal used for soldering is called solder, and it is an alloy of lead and tin.
- The solders available in the market are in the form of soft solder and hard solder. Soft solder is made up of lead and tin, and hard solder is made up of copper, tin, and silver.
- These metals are mixed in different proportions to get a variety of solders.
- A suitable flux is used in the soldering process to clean and remove the impurities produced due to oxidation. Usually, zinc chloride is used as a flux for the soldering process.
- Soldering finds its applications in automotive and fabrication industries and is used in automotive radiators or tin cans.
- It is also used in Electrical Connections in television and radio, joining thermally sensitive components, and sometimes used to join dissimilar metals.



Soldering process

SOLDERING PROCESS / PROCEDURE.

1. The soldering equipment is soldering iron, solder, or filler for power supply. The procedure of soldering is explained as below.

- The workpieces must be cleaned before the soldering process. The presence of oil, grease, dist., wetness, rust, etc., is removed.
- Sometimes suitable cleaning agents are used for cleaning the soldering surfaces. Presence of foreign materials on the surfaces to be soldered leads to weak joints lowers the strength of joint produced.
- The commonly used cleaning agent is flux, such as borax or resin. This flux helps to remove all unwanted material from the surfaces of the workpiece and get strong bonding.

2. First, the soldering iron tip (made up of copper) is cleaned and heated. It is then applied with solder using resin. This will create a thin film of solder on the soldering iron tip and is called tinning.

3. Once the solder is taken in the soldering iron tip, the soldering iron tip is heated, and the solder will be melted. This melted solder then it flows over the joining area and fills the gap. Finally, the joint formed is allowed to cool slowly.

- After complete soldering, the soldered surfaces must be cleaned. To clean the leftover flux, a suitable chemical is used, or it is cleaned by using cotton waste.

ADVANTAGES

1. Dissimilar metals can be joined.
2. It is simple, low cost, flexible, economical, and user-friendly.
3. The life of the solder will be more.
4. Low amount of power is required to heat the soldering iron.
5. The soldering can be done at low temperature, and controlling is very easy.
6. Soldered joints can be dismantled.

DISADVANTAGES

1. The soldering process can not join heavy sections. It is suitable for small parts only.
2. Solders are costlier, and soldering requires proper solder to get strong bonding.
3. Skilled labor is required for soldering.

Brazing.

1. Filler metal boiling point is above 450°C.

2. The filler metals may be of copper, aluminum, nickel, silver.

3. The flux used may be borax or boric acid.

4. The brazing produces stronger joints than soldering.

5. The brazing gives better accuracy, and joints may have a good aesthetic appearance.

6. Brazing is used in radiators, containers and other tanks, pipe fittings, heat exchangers.

Soldering.

1. Filler metal boiling point is below 450°C.

2. The filler metals are made up from of tin and lead.

3. The flux used is usually rosin, zinc chloride, aluminum chloride.

4. The soldering process produces less stronger joints compared to brazing.

5. The soldering does not give accuracy in the workpiece.

6. Soldering is used in electronic circuit board connections.

COMPARISION

S.No	Welding	Soldering	Brazing
1	Welding joints are strongest joints used to bear the load. Strength of the welded portion of joint is usually more than the strength of base metal.	Soldering joints are weakest joints out of three. Not meant to bear the load. Use to make electrical contacts generally.	Brazing are weaker than welding joints but stronger than soldering joints. This can be used to bear the load up to some extent.
2	Temperature required is 3800 degree Centigrade in Welding joints.	Temperature requirement is up to 450 degree Centigrade in Soldering joints.	Temperature may go to 600 degree Centigrade in Brazing joints.
3	Work piece to be joined need to be heated till their melting point.	Heating of the work pieces is not required	Work pieces are heated but below their melting point.
4	Mechanical properties of base metal may change at the joint due to heating and cooling.	No change in mechanical properties after joining.	May change in mechanical properties of joint but it is almost negligible.
5	Heat cost is involved and high skill level is required.	Cost involved and skill requirements are very low.	Cost involved and sill required are in between others two.
6	Heat treatment is generally required to eliminate undesirable effects of welding.	No heat treatment is required.	No heat treatment is required after brazing.
7	No preheating of workpiece is required before welding as it is carried out at high temperature.	Preheating of workpieces before soldering is good for making good quality joint.	Preheating is desirable to make strong joint as brazing is carried out at relatively low temperature.