

UNIT-II

SHAPING, SLOTTING, DRILLING, BORING, AND REAMING

SHAPER MACHINE:

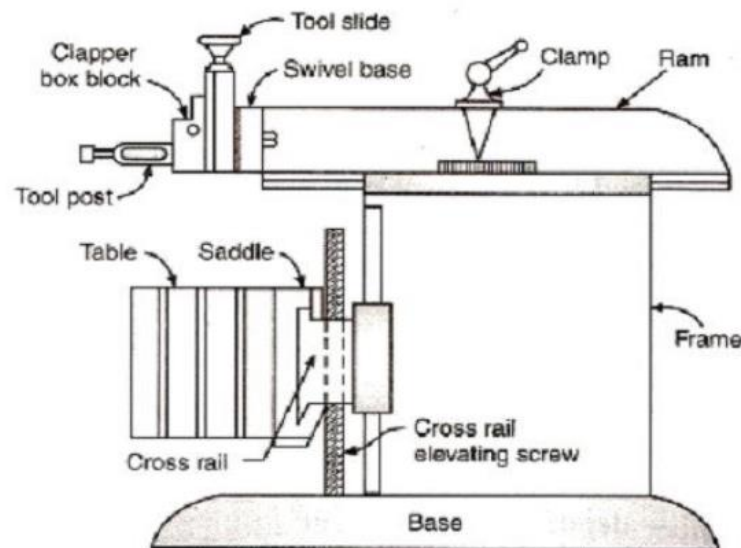
Introduction:

The shaper is a machine tool used primarily for:

1. Producing a flat or plane surface which may be in a horizontal, a vertical or an angular plane.
2. Making slots, grooves and key ways
3. Producing contour of concave/convex or a combination of these

Working Principle:

The job is rigidly fixed on the machine table. The single point cutting tool held properly in the tool post is mounted on a reciprocating ram. The reciprocating motion of the ram is obtained by a quick return motion mechanism. As the ram reciprocates, the tool cuts the material during its forward stroke. During return, there is no cutting action and this stroke is called the idle stroke. The forward and return strokes constitute one operating cycle of the shaper



Construction:

The main parts of the Shaper machine are Base, Body (Pillar, Frame, Column), Cross rail, Ram and tool head (Tool Post, Tool Slide, Clamper Box Block).

Base:

It is the main body of the machine. It consists all element of machine. It works as pillar for other parts. Base is made by cast iron which can take all compressive loads.

Ram:

It is the main part of the shaper machine. It holds the tool and provides the reciprocating motion to it. It is made by cast iron and move over ways on column. It is attached by the rocker arm which provide it motion in crank driven machine and if the machine is hydraulic driven it is attached by hydraulic housing.

Tool head:

It is situated at the front of the ram. Its main function is to hold the cutting tool. The tool can be adjusted on it by some of clamps.

Table:

It is the metal body attached over the frame. Its main function is to hold the work piece and vice over it. It has two T slots which used to clamp vice and work piece over it.

Clapper box:

It carries the tool holder. The main function of clapper box is to provide clearance for tool in return stock. It prevents the cutting edge dragging the work piece while return stock and prevent tool wear.

Column:

Column is attached to the base. It provides the housing for the crank slider mechanism. The slide ways are attached upper section of column which provide path for ram motion.

Cross ways:

It consists vertical and horizontal table sideways which allow the motion of table. It is attach with some cross movement mechanism.

Stroke adjuster:

It is attached below the table. It is used to control the stroke length which further controls the ram movement.

Table supports:

These are attached front side of the table and used to support the weight of table during working.

Types of Shaper:

Shapers can have classified into many types based on several criteria:

1) Based on the type of driving mechanism used

- a) Crank and slotted lever driving mechanism type
- b) Whitworth quick return driving mechanism type
- c) Hydraulic driving mechanism type

2) Based on the table design

- a) Plain Shaper
- b) Universal Shaper

3) Based on the position of the reciprocating ram used

- a) Horizontal shaping machine (Most common type of shaper used)
- b) Vertical shaping machine
- c) Travelling head shaping machine.

4) Based on the type of cutting stroke of the tool

- a) Push out type
- b) Draw cut type

Types of operations performed in a shaper

1. Machining horizontal surface.
2. Machining vertical surface.
3. Machining angular surface.
4. Cutting slots, grooves and keyways.
5. Machining irregular surface.
6. Machining splines or cutting gear

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 tooth head is swiveled to the required angle either towards the left or towards right from the vertical position.

Cutting Slots, Grooves, and Keyways:

A shaper can easily machine slots, grooves, and exterior and interior keyways on shafts and pulleys or gears with the right equipment (Eg. Gear shaping machine). A square nose tool is used to machine slots or keyways.

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 is swiveled towards the right or left away from the surface to be cut.

Machining Splines or Cutting Gears:

With the help of an index center, a gear or spline with identical spacing can be cut on a shaping machine. The work piece is positioned between two centres, and a spline is cut in the shape of the keyway. With the index pin and plate, the work piece is turned after the first spline is cut using a gear shaping machine and method as discussed.

Quick Return Mechanism

A quick return mechanism is a system to produce a reciprocating effect such that time taken by system in return stroke is less time taken by it in the forward stroke. In quick return mechanism, a circular motion is converted into reciprocating motion just like crank and lever mechanism but its return stroke time is different from forward stroke time. This mechanism is used in many machines. Some of them are shaper machines, slotter machines, screw press, mechanical actuator etc. With the help of quick return mechanism, the time needed to cutting is minimized.

Types of Quick Return Mechanism: -

1 Hydraulic Drive:

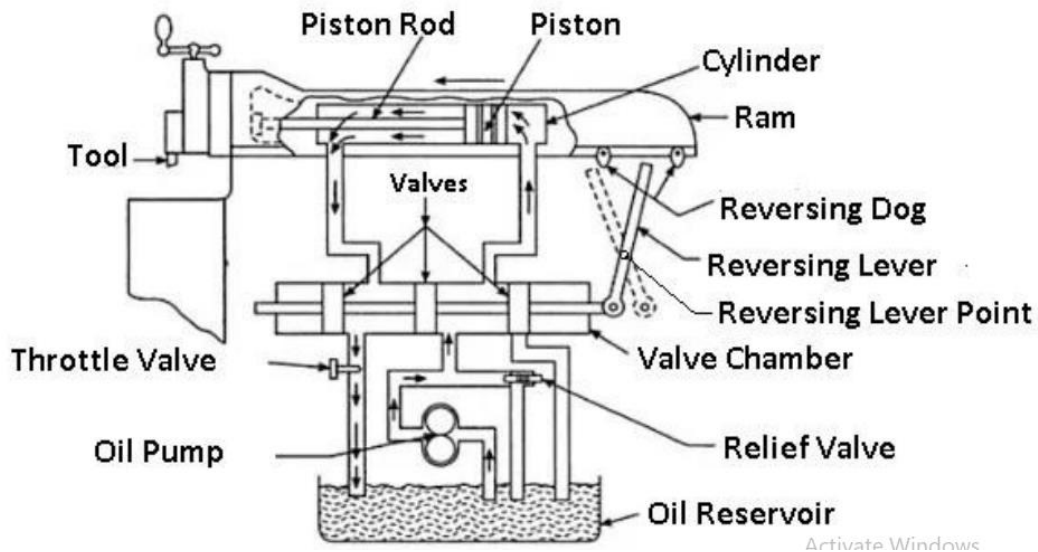
Hydraulic drive mechanism is one of the mechanisms used in shaper machine. In this mechanism, the ram is moved forward and backward by a piston moving in a cylinder placed under the ram. This machine consists of a constant discharge oil pump, a cylinder, a valve chamber and a piston. The piston rod is bolted to the ram body. Hydraulic fluid is used in hydraulic quick return mechanism for the movement of ram.

Working of Hydraulic Drive: -

In hydraulic drive, there is a tank at the bottom which contains the hydraulic fluid. This tank is also known as oil reservoir. At first the oil from the reservoir. This oil is passed through the valve chamber present in the right of the oil cylinder exerting pressure on the piston. Any oil present in the left side of the piston is discharged to the reservoir through the throttle valve. At first the fluid in the tank is pumped out and this

fluid passes through the passage present in the right side of the cylinder. This fluid exerts pressure on the piston and the ram of the machine performs forward stroke. When the ram moves forward, the lever changes its position and hits the reversing dog.

As the lever changes its position, the three valves connected to the lever also change their position and now the oil can pass through the passage present in the left side of the cylinder. After the forward stroke is completed, the valves change its position and now the pumped fluid from the reservoir moves from the passage present in the left side of the piston. Also, the passage through which the oil return to the reservoir opens and get connected to the right passage and the fluid present on the right side of the piston is discharge to the reservoir.



As the fluid moves towards the left side of the piston, the piston which is attached to the ram moves towards right and return stroke is performed by the ram. At the end of the return stroke, another dog hit against the lever and the direction of the lever as well as the stroke changes. In this way, the forward and the return stroke of the ram is repeated. The quick return takes place due to difference in the stroke volume of cylinder at both ends. The volume of passage at the left side is less than the volume of the passage on the right side.

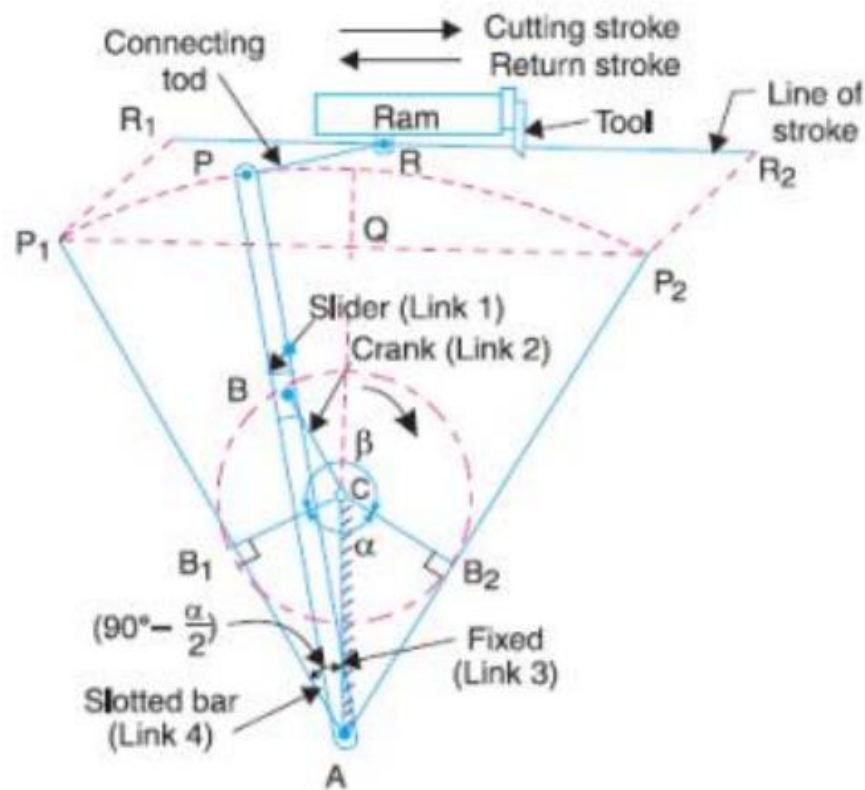
As the pump is constant discharge pump, same amount of oil will be passed on the both passage. So the pressure on the passage with less volume will be more and the return stroke will be faster than the forward stroke. The cutting speed can be controlled by controlling the flow of oil which can be controlled by using the throttle valve.

2. Whitworth Quick Return mechanism: -

This mechanism changes the rotary motion to oscillatory motion like the crank and lever mechanism. The difference between the crank and lever mechanism and Whitworth mechanism is that in whitworth mechanism the return stroke is faster than the forward stroke while in the crank and lever mechanism the forward stroke is of same speed as that of return stroke.

Parts used in Whitworth Mechanism: -

- 1) Slotted Bar.
- 2) Slider
- 3) Crank – It will rotate.



Whitworth quick return mechanism is the second inversion of slider crank mechanism in which the crank is fixed.

In this mechanism, the Slider in slotted bar is connected to the crank. When the crank rotates, the slider will slide inside the slotter bar and the slotted bar will oscillate.

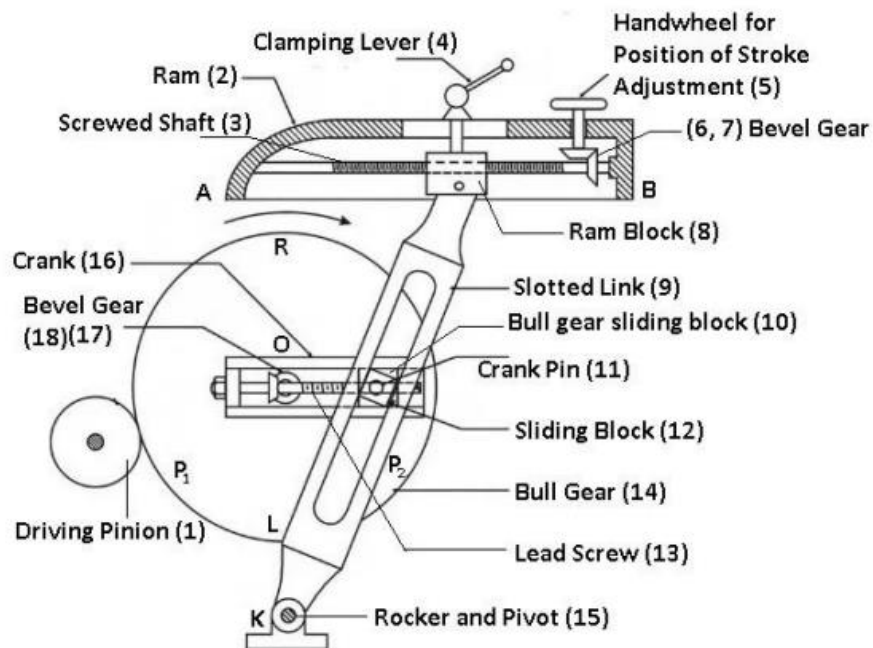
As the slotted bar oscillate, the ram will move in forward and backward direction. The return stroke or ideal is faster than the forward stroke in this mechanism.

In the above figure AP is the slotted bar and link 1, CD is link 2, AC which is crank is link 3 and link 4 is the slider. In this mechanism the link CD i.e link 2 forming the turning pair is fixed as shown in the figure above. The crank AC revolves with uniform velocity with its centre at A.

A sliding block attached to the crank pin at B slides along the slotted bar AP and thus causes AP to oscillate about the pivoted pint A. A short link PR transmits the motion from AP to the ram which carries the tool and thus forward stroke and backward stroke is obtained. The crank needs to rotate through an angle of (β) for the forward stroke and it needs to rotate through an angle of (α) for forward stroke. As crank moves with uniform angular velocity, time taken to cover angle α will be less than the time taken to cover angle β . Hence time taken in return stroke will be less than time taken in forward stroke. In this way, the quick return mechanism works.

3) Crank and Slotted Link Mechanism: -

In crank and slotted link mechanism. The power is transmitted to the bull gear by a pinion which receives its power from an individual motor. In a two gear system, the smaller gear is called pinion and the larger gear is called bull gear.



Working of Crank and Slotted Link Mechanism: -

The radial slide is bolted to the center of the bull gear. This radial slide carries a sliding block into which the crank pin is fitted.

As the bull gear will rotate, the crank will revolve at uniform speed. The sliding block which is mounted upon the crank pin is fitted upon the crank pin is fitted with in the slotted link. This slotted link is pivoted upon at its bottom end attached to the frame of column. The upper end of the sliding link is bifurcated and attached to the ram block by a pin.

When the bull gear rotates, the crank pin revolves at a uniform speed. The sliding block fastened to the crankpin will rotate on the crank pin circle and at the same time this slider will slide up and down in the sliding link.

As the slider will move inside the sliding link, it will provide a rocking movement to the sliding link and this movement will be transferred to the ram providing it a reciprocation motion. Hence the rotary motion of the bull gear is converted into reciprocation motion of ram.

CUTTING PARAMETERS OF A SHAPER

Cutting Speed

It is defined as the average linear speed of the tool during the cutting stroke in m/min, which depends on number of ram strokes (or ram cycles) per minute and length of the stroke.

Feed

Feed f is the relative motion of the work piece in a direction perpendicular to the axis of the reciprocation of the arm. In shaper, feed is normally given to the work piece and can be automatic or manual. It is expressed in mm/double stroke or simply mm/stroke because no cutting is done in return stroke.

Depth of Cut

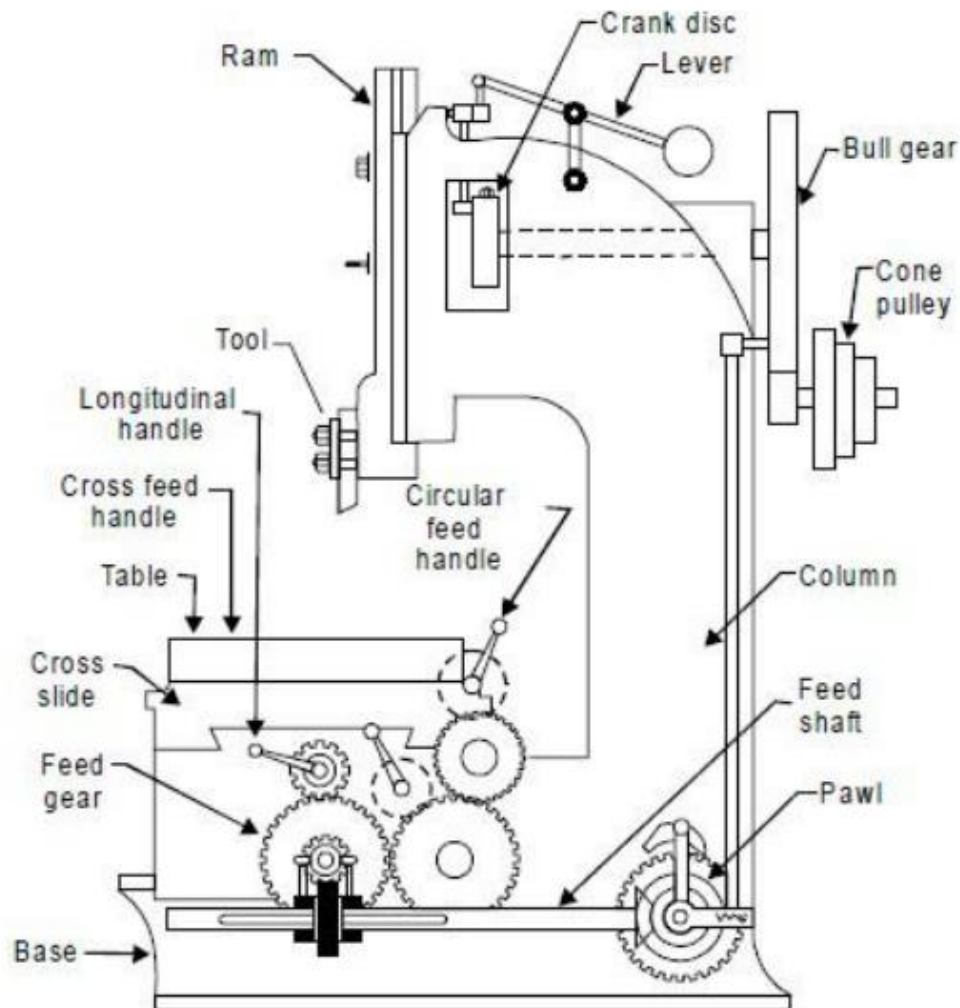
Depth of cut d is the thickness of the material removed in one cut, in mm.

SLOTTER MACHINE

Slotting machine (slotter) is a reciprocating type of machine tool similar to a shaper or a planer machine. It may be considered as a vertical shaper. The main difference between a slotter and a shaper is the direction of the cutting action. The slotting machine operates in a manner similar to the shaper. However, the cutting tool moves vertically direction rather than in a horizontal direction. The work piece is held stationary. The slotting machine has a vertical ram and a hand or power operated rotary table.

Principal Parts of a Slotting Machine:

Below figure shows a slotting machine and its various parts. The main parts of a slotting machine are discussed as under:



Bed or case:

Bed or case is made up of cast iron. It supports column, tables, ram, driving mechanism, etc. The top of the bed carries horizontal ways which the worktable can transverse.

Cross-slide:

Cross-slide can be moved parallel to the face of the column. The circular worktable is mounted on the top of the cross-slide.

Hand wheels:

Hand wheels are provided for rotating the table for the longitudinal and cross traverse.

Column is the vertical member:

They are made up of cast iron and it houses the driving mechanism. The vertical front face of the column is accurately finished for providing ways along which the ram moves up and down.

Ram:

Ram is provided to reciprocate to and fro motion. At the bottom of the ram, it carries the cutting tool. It is more massive and moves vertically, at a right angle to the worktable, instead of having the horizontal motion of a shaper.

Table:

Table holds the workpiece and is adjustable in longitudinal and crosswise direction. The table can be rotated about its center.

Operations Performed on a Slotting Machine:

A slotting machine is a very economical machine tool when used for certain classes of work given as under.

1. The slotting machine can be used to cut slots, splines keyways for both internal and external jobs such as machining internal and external gears.
2. It can be used for shaping internal and external forms or profiles.
3. It can be used for works as machining concave, circular, semi-circular and convex surfaces.

4. It can be used for machining vertical surfaces, machining angular or inclined surfaces, machining of shapes which are difficult to produce on a shaper machine and machining dies and punches.

5. It can be used for internal machining of blind holes. 6. It is used for machining dies and punches.

Cutting Parameters of Slotting machine

Cutting speed - It is the rate at which the metal is removed during downward cutting stroke and is expressed in m/min

Feed - It is the distance the work travels per double stroke at the beginning of each cutting stroke and is expressed in mm.

Depth of cut - It is the thickness of metal removed in one cut. It is measured by the perpendicular distance between machined and unmachined surfaces of the work. It is given in mm.

DRILLING MACHINE

Introduction

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 work pieces. 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 center punch. The rotating drill is pressed at the location and is fed into the work. The hole can be made upto a required depth.

Construction of a drilling machine

The basic parts of a drilling machine are a base, column, drill head and spindle. The base made of cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy duty machines are grounded on the floor. The column is

mounted vertically upon the base. It is accurately machined and the table can be moved up and down on it. The drill spindle, an electric motor and the mechanism meant for driving the spindle at different speeds are mounted on the top of the column. Power is transmitted from the electric motor to the spindle through a flat belt or a 'V' belt.

Types of drilling machines

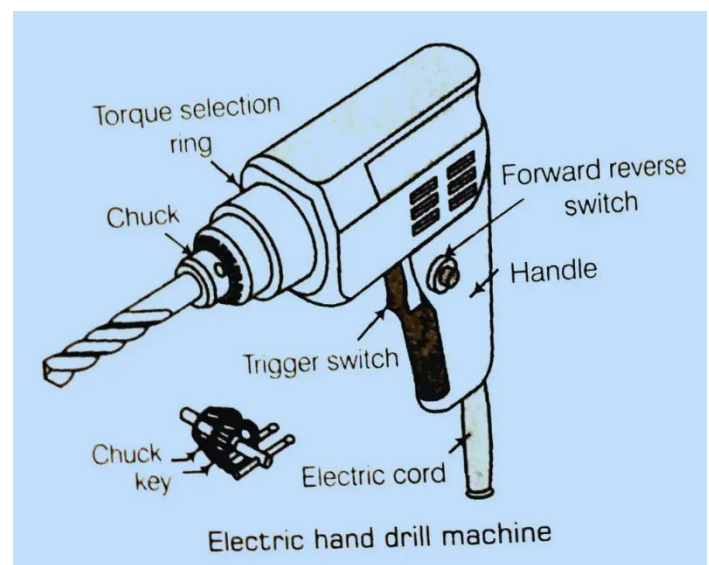
Drilling machines are manufactured in different types and sizes according to the type of operation, amount of feed, depth of cut, spindle speeds, method of spindle movement and the required accuracy.

The different types of drilling machines are:

1. Portable drilling machine (or) Hand drilling machine
2. Sensitive drilling machine (or) Bench drilling machine
3. Upright drilling machine
4. Radial drilling machine
5. Gang drilling machine
6. Multiple spindle drilling machine
7. Deep hole drilling machine

1. Portable drilling machine

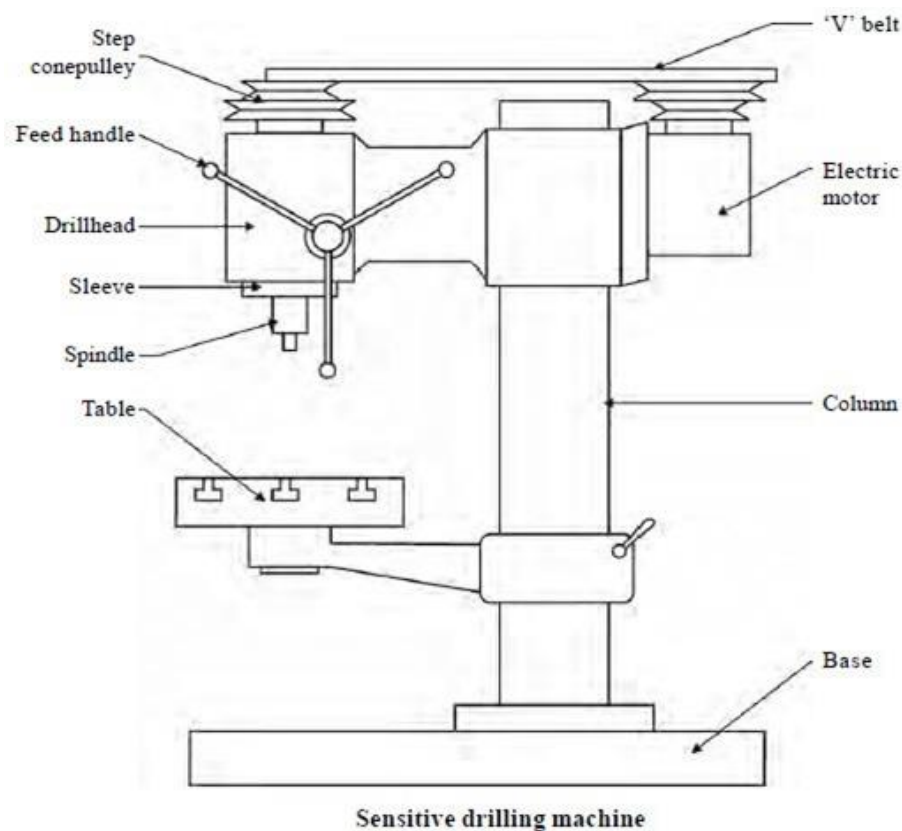
Portable drilling machine can be carried and used anywhere in the workshop. It is used for drilling holes on workpieces in any position, which is not possible in a standard drilling machine. The entire drilling mechanism is compact and small in size and so can be carried anywhere. This type of machine is widely adapted for automobile built-up work. The motor is generally universal type. These machines can accommodate drills from 12mm to 18 mm diameter. Portable drilling machines are operated at higher speeds.



2. Sensitive drilling machine

It is designed for drilling small holes at high speeds in light jobs. High speed and hand feed are necessary for drilling small holes. The base of the machine is mounted either on a bench or on the floor by means of bolts and nuts. It can handle drills upto 15.5mm of diameter. The drill is fed into the work purely by hand. The operator can sense the progress of the drill into the work because of hand feed. The machine is named so because of this reason. A sensitive drilling machine consists of a base, column, table, spindle, drill head and the driving mechanism.

A sensitive drilling machine is shown in Fig.



Base

The base is made of cast iron and so can withstand vibrations. It may be mounted on a bench or on the floor. It supports all the other parts of the machine on it.

Column

The column stands vertically on the base at one end. It supports the work table and the drill head. The drill head has drill spindle and the driving motor on either side of the column.

Table

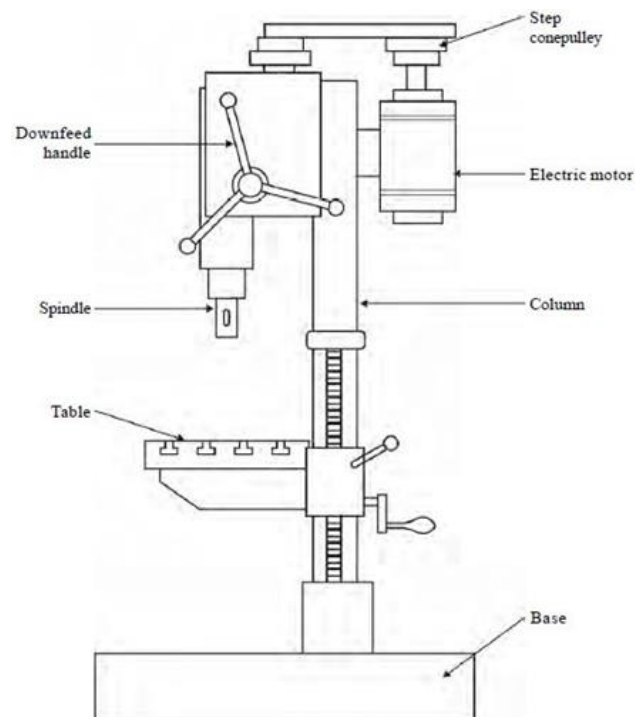
The table is mounted on the vertical column and can be adjusted up and down on it. The table has 'T'-slots on it for holding the workpieces or to hold any other work holding device. The table can be adjusted vertically to accommodate workpieces of different heights and can be clamped at the required position.

Drill head

Drill head is mounted on the top side of the column. The drill spindle and the driving motor are connected by means of a V-belt and cone pulleys. The motion is transmitted to the spindle from the motor by the belt. The pinion attached to the handle meshes with the rack on the sleeve of the spindle for providing the drill the required down feed. There is no power feed arrangement in this machine. The spindle rotates at a speed ranging from 50 to 2000 r.p.m.

3. Upright drilling machine

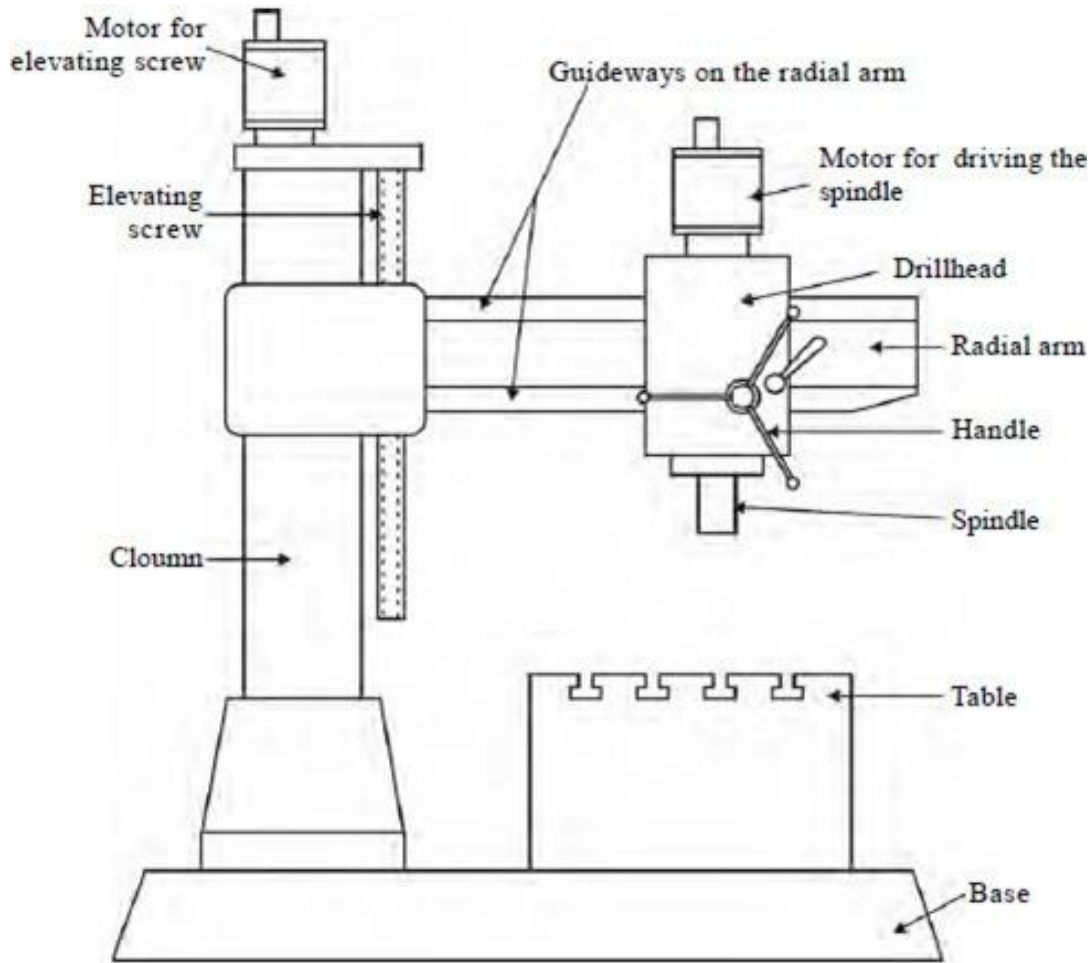
The upright drilling machine is designed for handling medium sized workpieces. Though it looks like a sensitive drilling machine, it is larger and heavier than a sensitive drilling machine. Holes of diameter upto 50mm can be made with this type of machine. Besides, it is supplied with power feed arrangement. For drilling different types of work, the machine is provided with a number of spindle speeds and feed.



: Upright drilling machine

4. Radial drilling machine

The radial drilling machine is intended for drilling on medium to large and heavy workpieces. It has a heavy round column mounted on a large base. The column supports a radial arm, which can be raised or lowered to enable the table to accommodate workpieces of different heights. The arm, which has the drill head on it, can be swung around to any position. The drill head can be made to slide on the radial arm. The machine is named so because of this reason. It consists of parts like base, column, radial arm, drill head and driving mechanism. A radial drilling machine is illustrated in Fig.



Radial drilling machine

5. Gang drilling machine

Gang drilling machine has a long common table and a base. Four to six drill heads are placed side by side. The drill heads have separate driving motors. This machine is used for production work.

A series of operations like drilling, reaming, counter boring and tapping may be performed on the work by simply shifting the work from one position to the other on the work table. Each spindle is set with different tools for different operations.

6. Multiple spindle drilling machine

This machine is used for drilling a number of holes in a workpiece simultaneously and for reproducing the same pattern of holes in a number of identical pieces. A multiple spindle drilling machine also has several spindles. A single motor using a set of gears drives all the spindles. All the spindles holding the drills are fed into the work at the same time. The distances between the spindles can be altered according to the locations where holes are to be drilled. Drill jigs are used to guide the drills.

7. Deep hole drilling machine

A special machine and drills are required to drill deeper holes in barrels of gun, spindles and connecting rods. The machine designed for this purpose is known as deep hole drilling machine. High cutting speeds and less feed are necessary to drill deep holes. A non-rotating drill is fed slowly into the rotating work at high speeds. Coolant should be used while drilling in this machine. There are two different types of deep hole drilling machines

Size of a drilling machine (Specification)

Drilling machines are specified according to their type.

To specify the machine completely the following factors are considered:

1. The maximum diameter of the drill that it can handle
2. The size of the largest workpiece that can be centred under the spindle
3. Distance between the face of the column and the axis of the spindle
4. Diameter of the table
5. Maximum travel of the spindle
6. Numbers and range of spindle speeds and feeds available
7. Morse taper number of the drill spindle

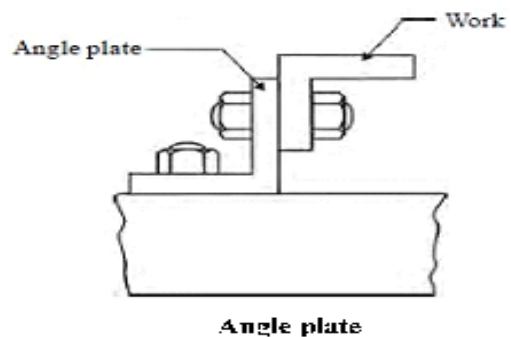
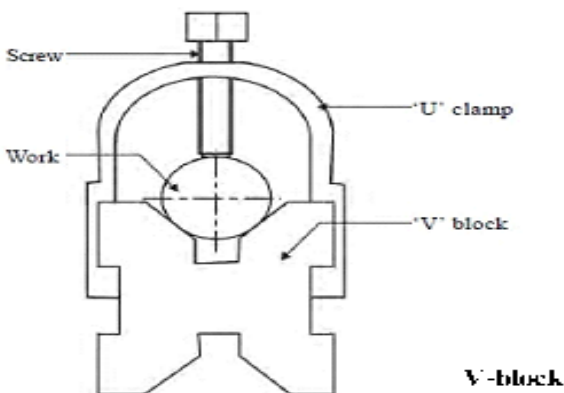
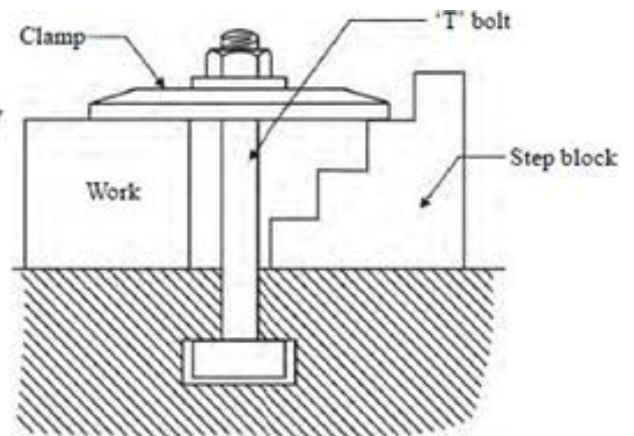
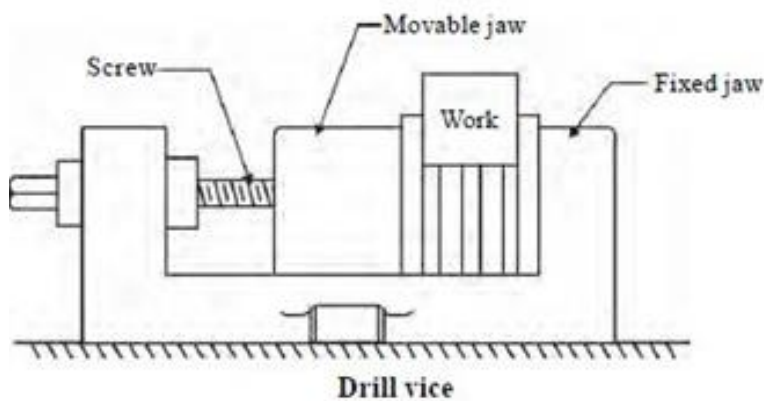
8. Floor space required
9. Weight of the machine
10. Power input is also needed to specify the machine completely.

Work holding devices

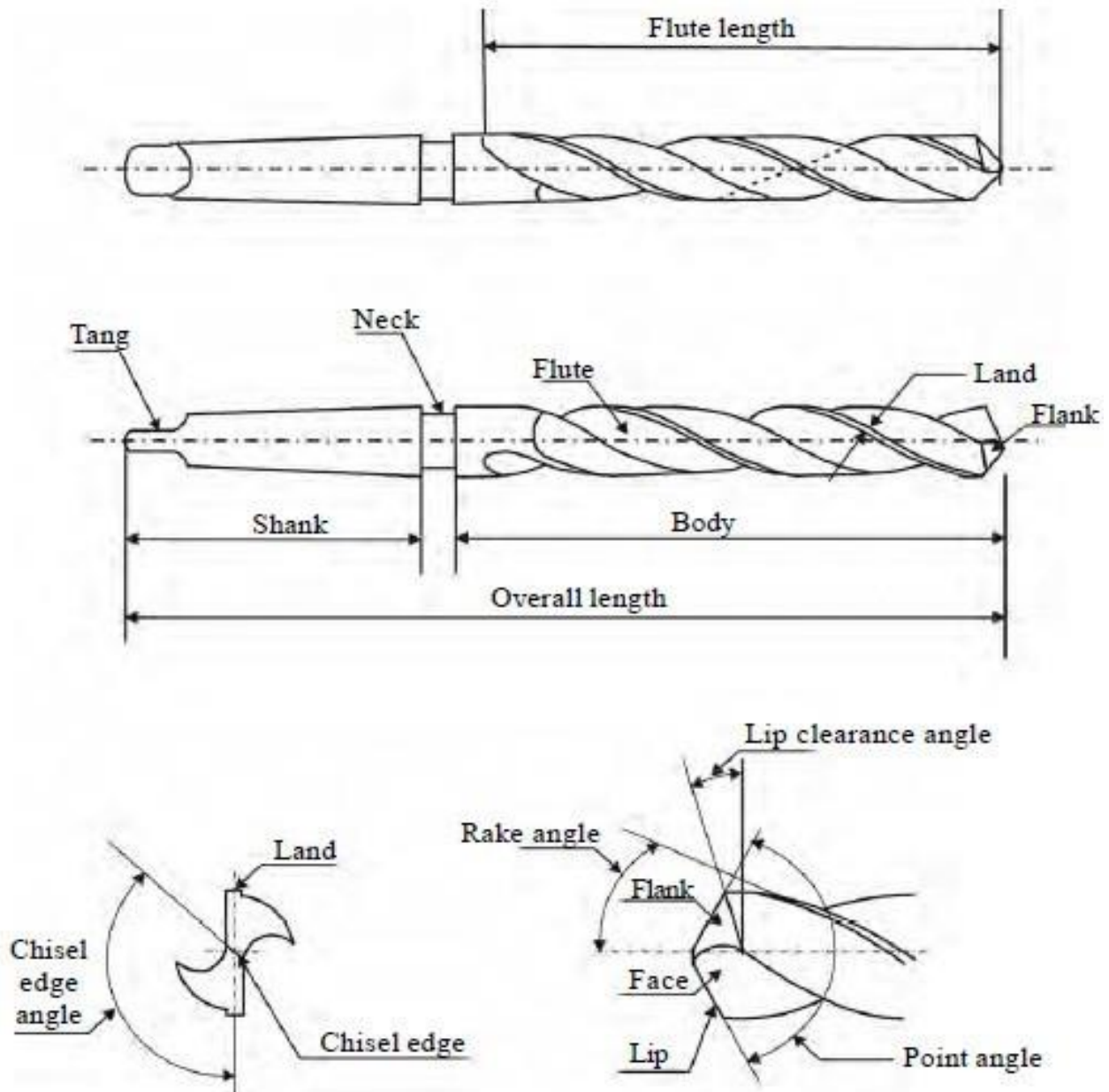
The work should be held firmly on the machine table before performing any operation on it. As the drill exerts very high quantity of torque while rotating, the work should not be held by hand. If the workpiece is not held by a proper holding device, it will start rotating along with the tool causing injuries to the operator and damage to the machine.

The devices used for holding the work in a drilling machine are

1. Drill vise
2. 'T' - bolts and clamps
3. Step block
4. V - block
5. Angle plate
6. Drill jigs



TOOL GEOMETRY (drill nomenclature)



Axis

It is the longitudinal centre line of the drill running through the centres of the tang and the chisel edge.

Body

It is the part of the drill from its extreme point to the commencement of the neck, if present. Otherwise, it is the part extending upto the commencement of the shank. Helical grooves are cut on the body of the drill.

Shank

It is the part of the drill by which it is held and driven. It is found just above the body of the drill. The shank may be straight or taper. The shank of the drill can be fitted directly into the spindle or by a tool holding device.

Tang

The flattened end of the taper shank is known as tang. It is meant to fit into a slot in the spindle or socket. It ensures a positive drive of the drill.

Neck

It is the part of the drill, which is diametrically undercut between the body and the shank of the drill. The size of the drill is marked on the neck.

Point

It is the sharpened end of the drill. It is shaped to produce lips, faces, flanks and chisel edge.

Lip

It is the edge formed by the intersection of flank and face. There are two lips and both of them should be of equal length. Both lips should be at the same angle of inclination with the axis (59°).

Land

It is the cylindrically ground surface on the leading edges of the drill flutes adjacent to the body clearance surface. The alignment of the drill is maintained by the land. The hole is maintained straight and to the right size.

Flutes

The grooves in the body of the drill are known as flutes. Flutes form the cutting edges on the point. It allows the chips to escape and make them curl. It permits the cutting fluid to reach the cutting edges.

DRILLING MACHINE OPERATIONS

Though drilling is the primary operation performed in a drilling machine, a number of similar operations are also performed on holes using different tools. The different operations that can be performed in a drilling machine are:

1. Drilling
2. Reaming
3. Boring
4. Counter boring
5. Countersinking
6. Spot facing
7. Tapping

Drilling: Producing a cylindrical hole using a rotating drill bit.

Drilling is the operation of producing a cylindrical hole of required diameter and depth by removing metal by the rotating edge of a cutting tool called drill. Drilling is one of the simplest methods of producing a hole. Drilling does not produce an accurate hole in a workpiece. The internal surface of the hole generated by drilling becomes rough and the hole is always slightly oversize due to vibration of the spindle and the drill. A hole made by a drill of size 12mm will measure approximately upto 12.125mm and by a drill of size 22mm will measure upto 22.5mm

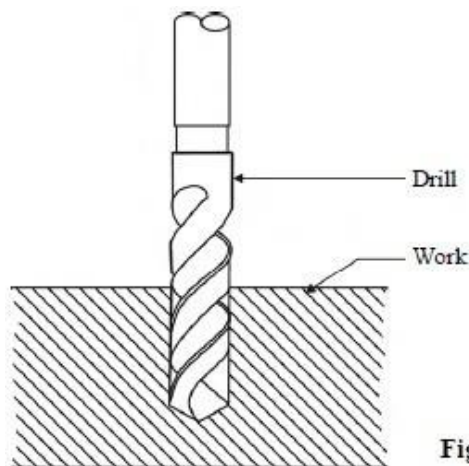
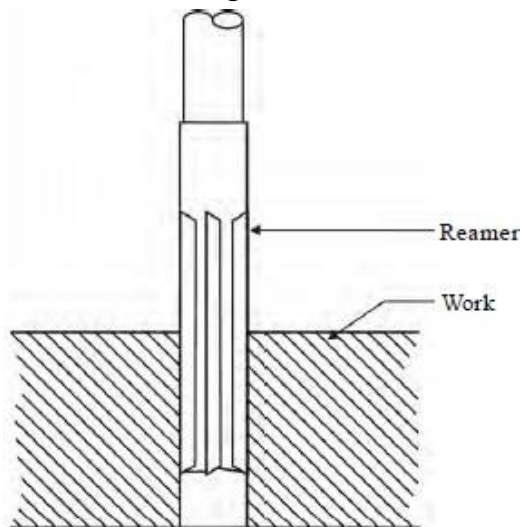


Fig 2.

Reaming: Finishing an existing hole to achieve precise size and smooth finish with a reamer tool.

The size of hole made by drilling may not be accurate and the internal surface will not be smooth. Reaming is an accurate way of sizing and finishing a hole which has been previously drilled by a multi-point cutting tool known as reamer. The surface obtained by reaming will be smoother and the size accurate. The speed of the spindle is made half that of drilling. Reaming removes very small amount of metal (approx 0.375 mm). In order to finish a hole and bring it to the accurate size, the hole is drilled slightly undersize.



Boring: Boring is the operation enlarging the diameter of the previously made hole. It is done for the following reasons.

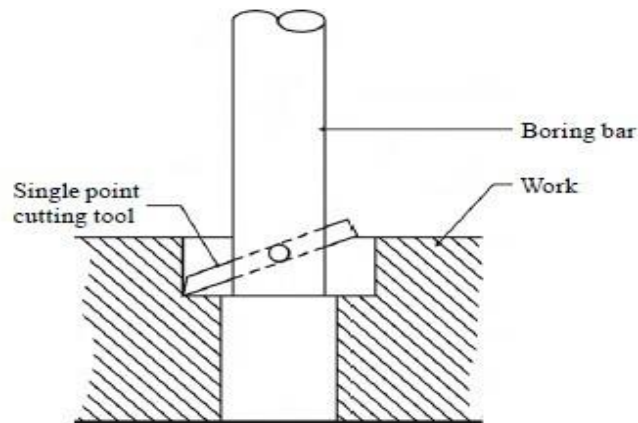
To enlarge a hole by means of an adjustable cutting tool. This is done when a suitable sized drill is not available or the hole diameter is so large that it cannot be ordinarily drilled.

To finish a hole accurately and bring it to the required size

To machine the internal surface of the hole already produced in casting

To correct out of roundness of the hole

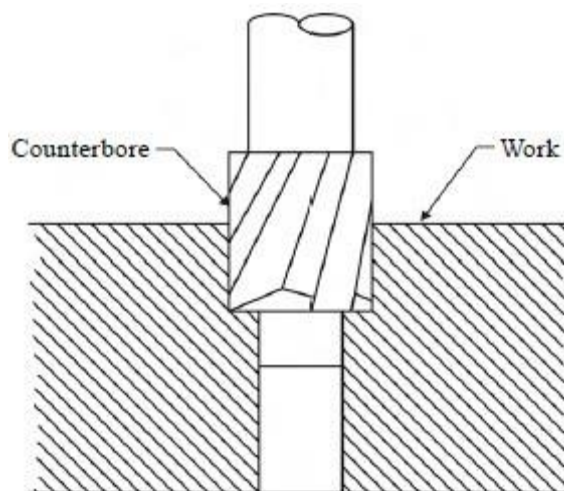
To correct the location of the hole as the boring tool follows independent path with respect to the hole



Boring tool is a tool with only one cutting edge. The tool is held in a boring bar which has a taper shank to fit into the spindle or a socket. For perfectly finishing a hole, the job is drilled undersize slightly. Boring operation in some precise drilling machine is performed to enlarge the holes to an accuracy of 0.00125mm. The spindle speed during boring should be adjusted to be lesser than that of reaming.

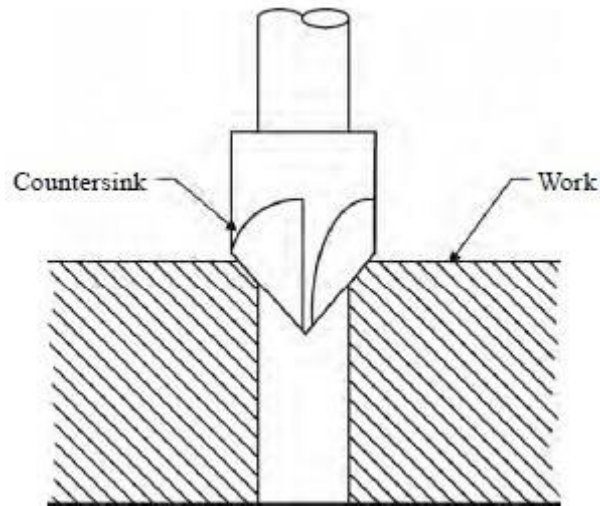
Counter-boring:

Counter-boring is the operation of enlarging the end of the hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins. The tool used for counter boring is known as counter bore. The counter-bores are made with cutting edges which may be straight or spiral. The cutting speed for counter-boring is at least 25% lesser than that of drilling.



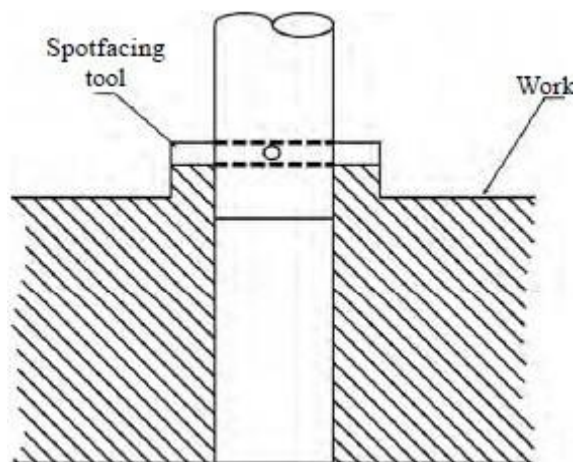
Counter-sinking: Machining a conical recess for screw heads.

Countersinking is the operation of making a cone shaped enlargement at the end of the hole. The included angle of the conical surface may be in the range of 60° to 90° . It is used to provide recess for a flat headed screw or a counter sunk rivet fitted into the hole. The tool used for counter sinking is known as a countersink. It has multiple cutting edges on its conical surface. The cutting speed for countersinking is 25% lesser than that of drilling



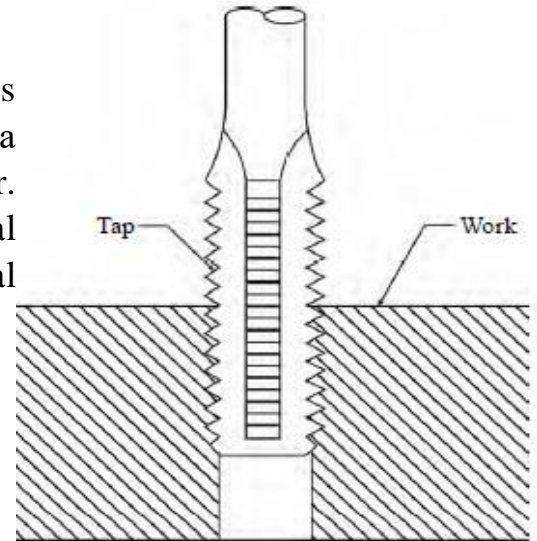
Spot Facing:

Spot facing is the operation of smoothing and squaring the surface around a hole. It is done to provide proper seating for a nut or the head of a screw. A counter-bore or a special spot facing tool may be employed for this purpose.



Tapping:

Tapping is the operation of cutting internal threads by means of a cutting tool called 'tap'. Tapping in a drilling machine may be performed by hand or by power. When the tap is screwed into the hole, it removes metal and cuts internal threads which will fit into external threads of the same size



Cutting Parameters of Drilling Machine

Cutting speed

Speed in general refers to the distance a point travels in a particular period of time. The cutting speed in a drilling operation refers to the peripheral speed of a point on the cutting edge of the drill. It is usually expressed in meters per minute. The cutting speed (v) may be calculated as

$$\text{Cutting speed (C.S)} = \pi \times d \times n \text{ meter per min } 1000 \text{ in r.p.m}$$

Where 'd' - is the diameter of the drill in mm, and

'n' - is the speed of the drill spindle in r.p.m.

The cutting speed of a drill depends, as in other machining processes, upon several factors like the cutting tool material, the kind of material being drilled, the quality of surface finish desired, the method of holding the work, the size, type and rigidity of the machine.

Feed

The feed of a drill is the distance the drill moves into the work at each revolution of the spindle. It is expressed in millimeters. The feed may also be expressed as feed per minute. The feed per minute may be defined as the axial distance moved by the drill into the work per minute. Feed depends upon factors like the material to be drilled, the rigidity of the machine, power, depth of the hole and the type of finish required.

Depth of cut

The depth of cut in drilling is equal to one half of the drill diameter. If 'd' is the diameter of the drill, the depth of cut (t) $t = d/2$ mm.

BORING

Boring is a process of producing circular internal profiles on a hole made by drilling or another process. It uses single point cutting tool called a boring bar. In boring, the boring bar can be rotated, or the work part can be rotated. Machine tools which rotate the boring bar against a stationary workpiece are called boring machines (also boring mills). Boring can be accomplished on a turning machine with a stationary boring bar positioned in the tool post and rotating workpiece held in the lathe chuck as illustrated in the figure. In this section, we will consider only boring on boring machines.



Boring machines

Boring machines can be horizontal or vertical according to the orientation of the axis of rotation of the machine spindle. In horizontal boring operation, boring bar is mounted in a tool slide, which position is adjusted relative to the spindle face plate to machine different diameters. The boring bar must be supported on the other end when boring long and small- diameter holes. A vertical boring mill is used for large, heavy work parts with diameters up to 12 m. The typical boring mill can position and feed several cutting tools simultaneously. The work part is mounted on a rotating worktable.

PRINCIPLE OF BORING

In horizontal boring machine, the work piece is held on the machine table and kept stationary, while boring tool revolves. At the same time, the tool may be moved forward or backward in a direction parallel to its axis of rotation and can also be offset in a direction perpendicular to its axis of rotation.

HORIZONTAL BORING MACHINE

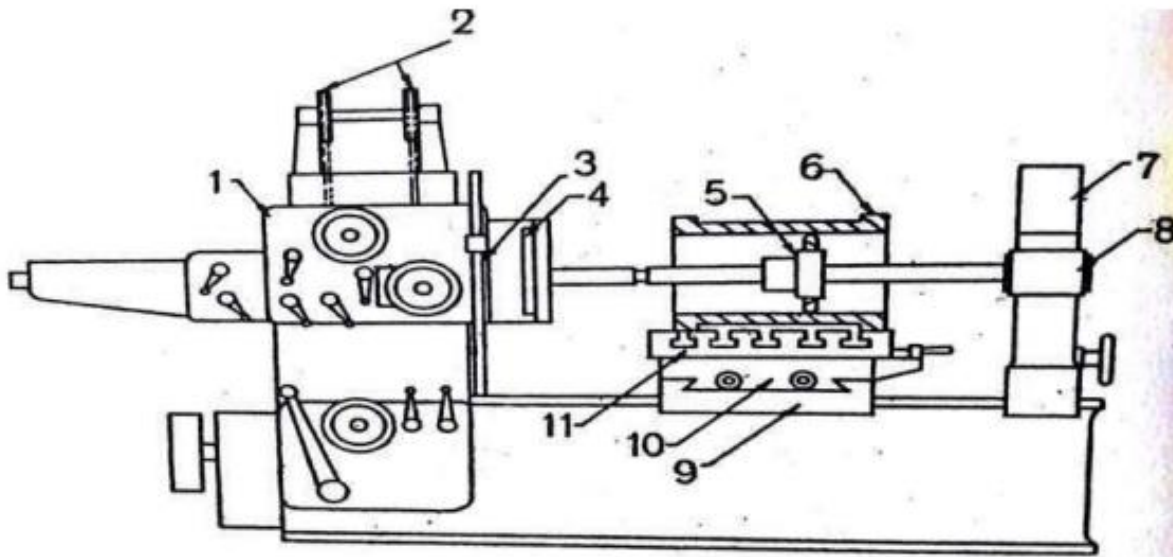
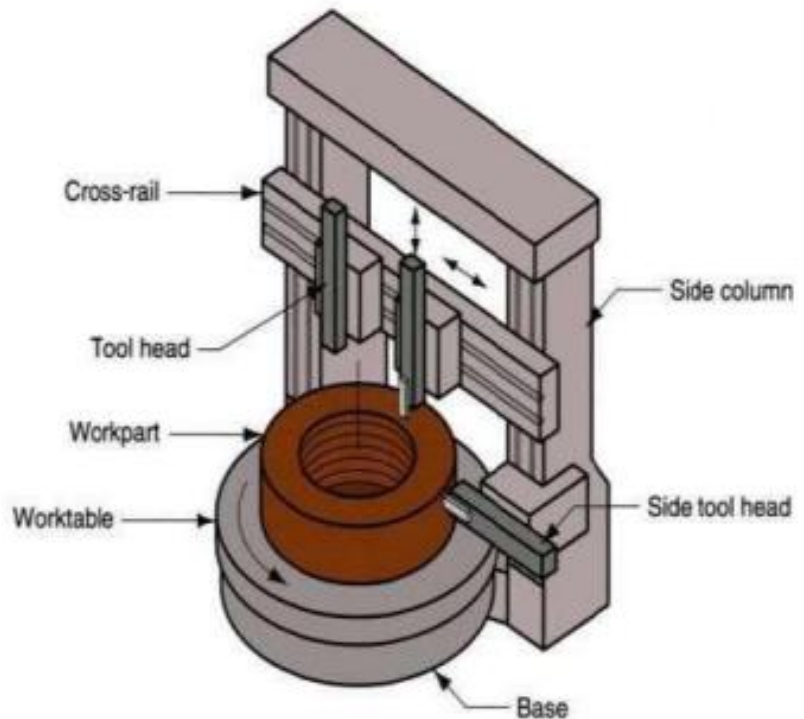


Figure 6.1 Horizontal boring machine

1. Headstock, 2. Pulley for counter balancing weight of headstock, 3. Headstock elevating screw, 4. Boring head, 5. Boring cutter on boring bar, 6. Work, 7. End supporting column, 8. Bearing block, 9. Saddle, 10. Cross-slide, 11. Table.

VERTICAL BORINGMACHINE

A vertical boring mill is used for large, heavy work parts with diameters up to 12 m. The typical boring mill can position and feed several cutting tools simultaneously. The work part may be mounted on a rotating worktable.



Cutting tool for boring

The typical boring bar is shown in the figure. When boring with a rotating tool, size is controlled by changing the radial position of the tool slide, which holds the boring bar, with respect to the spindle axis of rotation. For finishing machining, the boring bar is additionally mounted in an adjustable boring head for more precise control of the bar radial position.

1. Forged tool
2. Inserted teeth boring tool
3. Boring tool bit in boring bar



BORING OPERATIONS

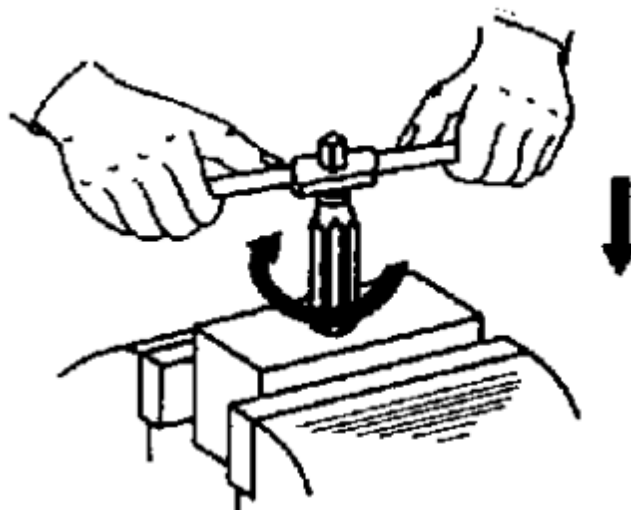
- Internal taper boring
- External taper boring
- Necking or cutting off
- Boring a large diameter
- Boring a small diameter
- Spot facing
- Reaming
- Counter boring
- Threading
- Facing

REAMER

Reaming is a precision finishing process used to refine the size, roundness, and surface finish of pre-drilled holes. It's essential when tight tolerances and smooth finishes are critical—such as in aerospace, automotive.

Reaming is applied after drilling in order to

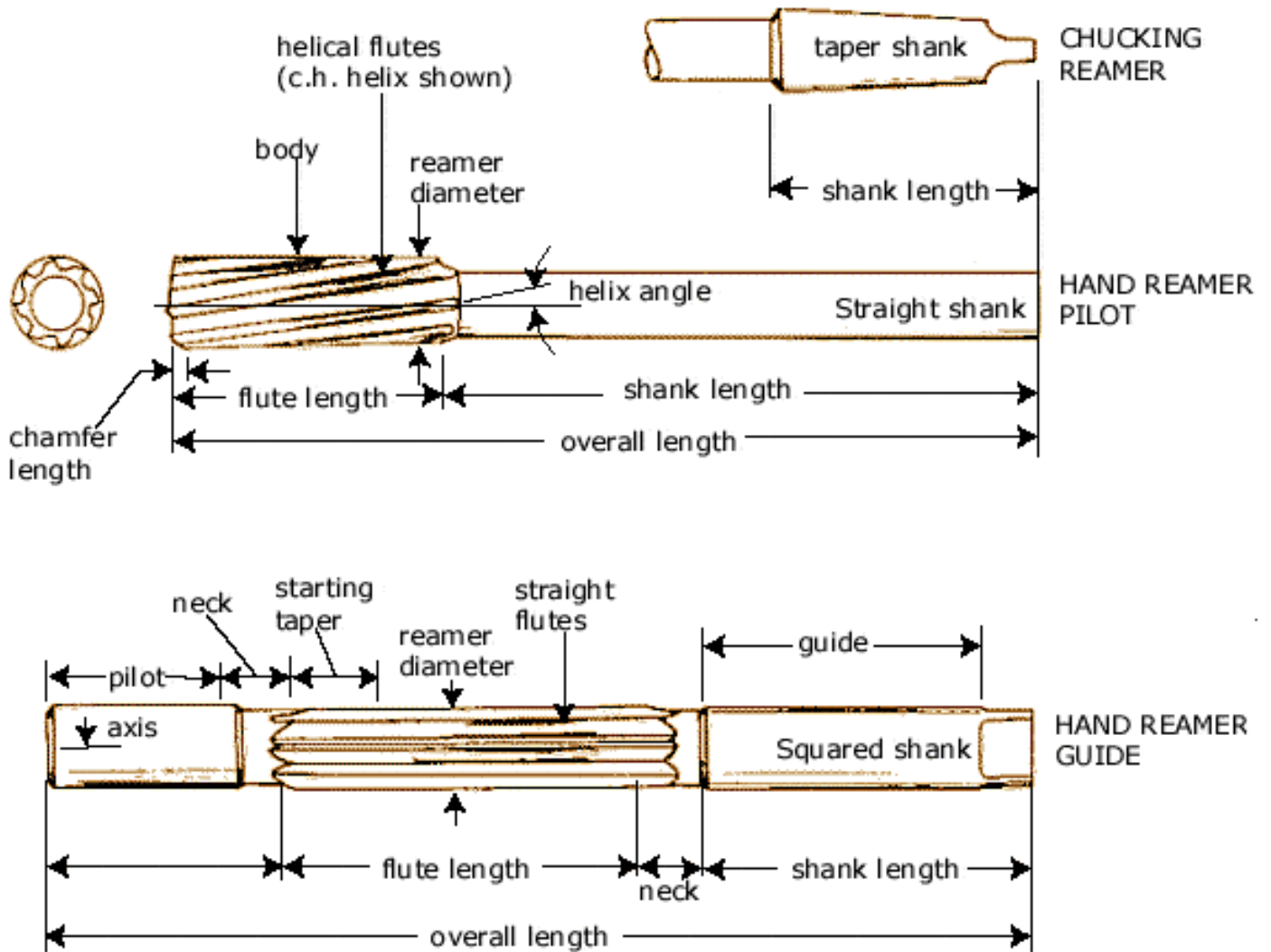
- make bore holes true to size, e.g. for plain pin connections (in ranges from hundredth to thousandth millimeters).
- fine-finish the inside surfaces of bore holes.
- align offset bores with riveted joints.
- make conical bore holes for machine taper or taper pin joint.



The drill does not always produce the correct hole some time with good finish. Thus a correct hole is produced with good finish of a predrilled hole using a reamer. A common hand reamer is shown in Fig. It is commonly employed to remove minimum amount of metal (100 to 150 micron for rough reaming and 5 to 20 micron for fine reaming) from the hole. During reaming operations, the job should be properly supported and rigidly held.

A stock wrench of appropriate size for holding the reamer is used. The reamer must be kept in its correct position relative to the job. It must be run slowly and excessive feed must be avoided. It should be always be turned in the cutting direction. Sufficient amount of cutting fluid should also be employed. When removing the

reamer, it must be turned in the cutting direction. Reamers with blunt or chipped edges must not be used.



reamer Nomenclature

No special machines are used for reaming. Reaming can be performed on drilling machines, lathes, milling machines and machining centers, or by hand. Basic reamer types include: hand (straight and tapered), machine (rose and fluted), shell, expansion, adjustable and indexable insert reamers. Titanium nitride coatings are sometimes used to increase tool life. Combination drills and reamers are also available.

Types of reamers

The reamers are classified as under.

- (i) Hand reamer
- (ii) Machine reamers
- (iii) Parallel reamer
- (iv) Taper reamer
- (v) Reamers with straight flutes
- (vi) Reamers with spiral flutes

Function of Reaming

Improves Dimensional Accuracy

Reaming is used to refine an existing hole to a high-precision diameter, commonly achieving tolerances of ± 0.005 mm or tighter. It is ideal for achieving H7 fits or tighter in precision assemblies.

Enhances Roundness and Concentricity

Compared to drilling or boring, reaming provides superior control over hole roundness and alignment, making it suitable for components requiring rotational accuracy or tight alignment.

Optimizes Surface Finish

Reamed holes can reach a surface roughness of R_a 0.2–0.4 μm , suitable for applications involving seals, sliding bearings, or high-speed rotating shafts.

Ensures Consistency in Mass Production

Thanks to the stable geometry of reamers, the process delivers consistent hole sizes across batches, which enhances product quality and assembly reliability.

Balances Efficiency and Precision

Reaming offers a faster and more economical alternative to processes like honing, while still delivering high precision—making it the preferred solution for most industrial fine-hole finishing tasks.

Work Principle of Reaming

Minimal Material Removal (Chip Thickness: 0.1–0.5 mm)

Reaming removes only a thin layer from the hole wall—typically 0.1 to 0.5 mm in diameter. This small chip load minimizes heat generation and reduces tool wear.

Guided Cutting Action

Reamers do not lead the cutting path; they follow the pre-drilled hole. The front of the reamer includes a pilot or guide section that stabilizes tool alignment and prevents deflection.

Multi-Flute Engagement

Multiple cutting edges (usually 4 to 8 flutes) engage the material simultaneously. This distributes cutting forces evenly, reducing vibration and improving hole geometry.

Shearing with Burnishing Effect

In addition to cutting, reamers often have chamfered or relief lands that smooth the hole surface after cutting. This produces fine finishes down to Ra 0.2–0.4 μm , ideal for precision fits.

Axial Cutting Force Dominance

Reaming generates primarily axial forces, typically 30–50% lower than drilling. This makes it suitable for thin-walled or delicate components that are sensitive to radial stress.

Controlled Cutting Parameters

Reaming is performed at low cutting speeds (typically 30–80 m/min) and moderate feed rates (0.05–0.2 mm/rev). These parameters ensure high surface quality while maintaining tool life and dimensional consistency. By combining low-stress cutting with high geometric guidance, reaming achieves accurate, round, and smooth holes efficiently—especially critical for press-fit assemblies and precision alignment features.

Reaming Process

Workpiece Clamping

Proper clamping is essential for precision reaming. Even slight vibrations—over $5\ \mu\text{m}$ —can cause chatter, tapered holes, or poor surface finish. Fixtures must be rigid, with total indicated runout (TIR) kept under $0.01\ \text{mm}$ for tight-tolerance jobs. Use soft jaws, hydraulic clamps, or tailored fixtures to ensure stability. For long parts, apply tailstocks or steady rests to prevent flexing. Reliable clamping directly affects hole accuracy, especially when aiming for tolerances of $\pm 0.005\ \text{mm}$ and $R_a \leq 0.4\ \mu\text{m}$.

Pre-drilling or Boring

Before reaming, the hole must be drilled or bored to 2–3% smaller than the final diameter. For instance, a $\text{Ø}12.00\ \text{mm}$ target hole should be pre-machined to $\text{Ø}11.64\text{--}11.76\ \text{mm}$. Undersizing ensures sufficient material (typically $0.15\text{--}0.30\ \text{mm}$) is left for the reamer to cut evenly. Excess material increases torque and tool wear, while too little may cause poor finish or chatter. Optimal pre-hole concentricity and straightness are also critical—TIR should be within $0.02\ \text{mm}$.

Tool Selection

Choosing the correct reamer depends on required tolerances (e.g., $\pm 0.005\ \text{mm}$), workpiece material (e.g., steel, aluminum, titanium), and production volume. For hard metals or high-volume runs, carbide or PCD reamers offer longer life and consistent surface finish ($R_a \leq 0.4\ \mu\text{m}$). For prototypes or soft materials, HSS reamers may be sufficient. Tool geometry, flute type, and coating must also align with cutting speed and chip evacuation needs.

Reamer Setup and Alignment

Proper alignment is critical—reamers naturally follow the existing hole path. Even a $0.01\ \text{mm}$ misalignment from drilling can result in taper or oversize. Using floating holders compensates for minor axis errors, while precision collets ensure concentricity below $0.005\ \text{mm}$. Runout should be checked with a dial indicator, total indicated runout (TIR) must be $\leq 0.01\ \text{mm}$ for high-precision applications like H7 fits.

Reaming Operation

Reaming is typically performed at $40\text{--}80\ \text{m/min}$ cutting speed for carbide tools in steel, about 50% of drilling speed. The feed rate is often $0.2\text{--}0.5\ \text{mm/rev}$, nearly twice that of drilling. Excessive speed increases wear and reduces accuracy, while too

low feed causes chatter. Maintaining a steady feed and adequate coolant ensures dimensional accuracy within ± 0.005 mm and surface finish of Ra 0.4 μm or better.

Chip Removal and Lubrication

Effective chip evacuation is essential, especially in deep-hole reaming. Without proper removal, chips can cause tool deflection or surface damage. For holes deeper than $3 \times D$, high-pressure coolant (≥ 20 bar) or cutting oil is recommended. Emulsion-based coolants improve flushing and reduce friction. Consistent lubrication minimizes heat buildup and maintains dimensional accuracy within ± 0.005 mm while extending tool life by up to 30%.

Inspection

Post-reaming inspection ensures the hole meets strict quality standards. Dimensional accuracy is verified using calibrated plug gauges, typically in 0.01 mm steps. Surface roughness is measured with a profile meter, aiming for Ra 0.2–0.4 μm . For aerospace components, tolerances are often within ± 0.005 mm.

PRECISION FINISHING

Precision finishing refers to the process of achieving extremely accurate and refined surface qualities on a workpiece. It involves using various techniques, tools, and equipment to enhance the appearance, functionality, and performance of a product by refining its surface texture, geometry, and other properties.

Precision finishing is crucial in industries where even the smallest imperfections can have a significant impact on the final product's quality and functionality. This can include industries such as aerospace, automotive, electronics, medical devices, jewellery, and more.

Precision finishing focuses on refining the surface of a workpiece to achieve specific desired qualities, such as smoothness, shine, texture, and uniformity. It aims to eliminate or minimize defects such as burrs, scratches, and roughness.

Achieving tight tolerances in terms of dimensions and geometries is essential in precision finishing. This ensures that the final product meets its design specifications precisely.

Types of Precision finishing

Abrasive Flow Finishing (AFF)

Chemo Mechanical Polishing

Magnetic Abrasive Finishing (MAF)

Magneto Rheological Finishing

Magneto Rheological Abrasive Flow Finishing (MRAFF)

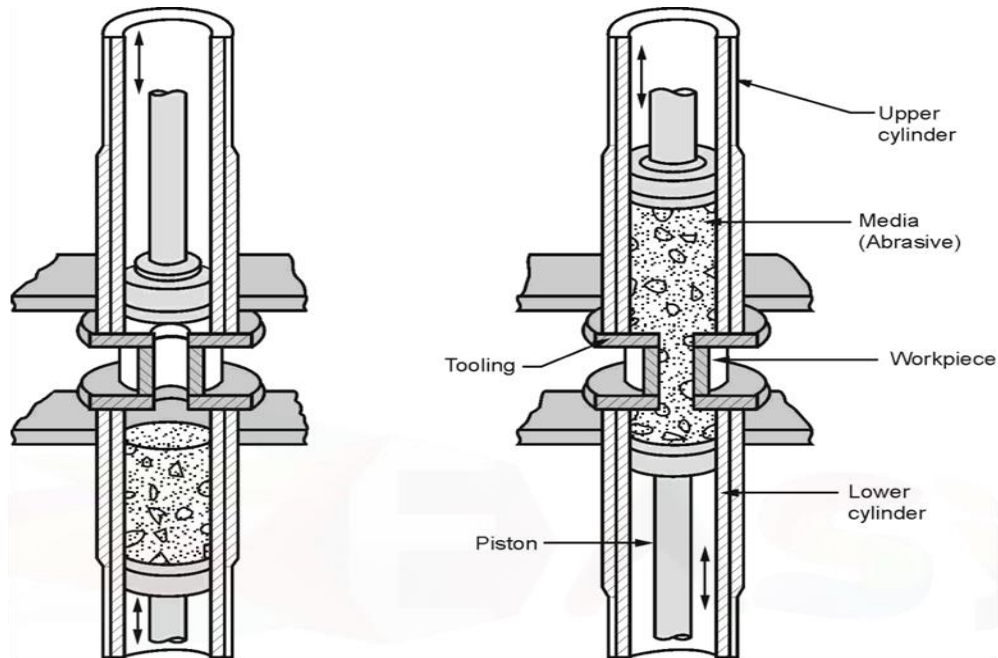
1. Abrasive Flow Finishing (AFF)

- Now - a - days developments in the field of material science are taking place but at the same time the demand for better quality and low cost products is also increases.
- There is a consistent demand for a decreased lead time from design to production.
- In a production cycle, finishing operations usually cost almost 15 % of the total cost. Also, a need of automated finishing operations instead of manual is felt.
- Therefore, a non - traditional finishing process called as Abrasive Flow Machining (AFM) or Abrasive Flow Finishing (AFF) has been developed.
- This method provides better accuracy and high efficiency, economically and consistently.

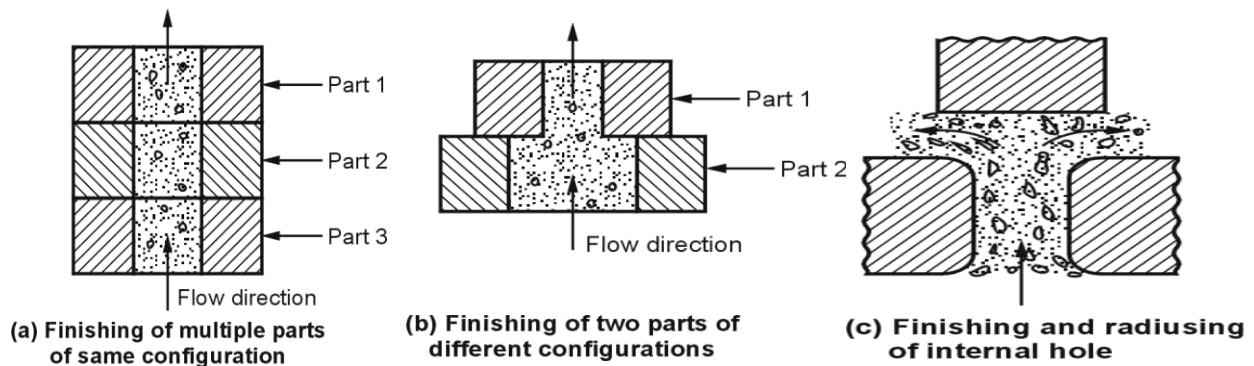
Working principle:

- AFF is a kind of finishing process in which small quantity of material is removed by flowing a semisolid abrasive slurry (putty) over the surface to be machined.
- The abrasive media has high viscosity. The common types of abrasives are aluminium oxides (Al_2O_3), silicon carbide (SiC), cubic boron nitride and diamond dust.
- The process consists of two vertically opposed cylinders which extrude abrasive media back and forth through the passage formed either by workpiece and tooling (fixture) or by workpiece alone.
- This process is suitable for operations like deburring, radiusing, polishing, removing recast layer, etc.
- The process can be used to machine multiple parts at the same time to increase the productivity.
- Also, the machine has high flexibility i.e. the same machine can be used for different workpieces by altering the toolings, machining parameters, media and abrasives.

- The semisolid abrasive media is forced through the workpiece (restricted passage) formed by workpiece and tooling together.



- The force may be applied either hydraulically or mechanically. Also, the flow velocity of media is governed by the cross-section area of passage.
- To maintain a constant viscosity of media, in some cases, coolers are also used to lower the temperature of the media. Manual or computer control machines are also available.
- The basic purpose of tooling is to hold the parts in position and to contain the media and direct its flow.
- As the process has low MRR (Material Removal Rate), the maximum machining takes place wherever there is a maximum restriction to the flow of abrasive.
- Fig. (a), (b) and (c) shows the finishing of internal surfaces.



Process variables

The important factors that affect the performance of the process and the quality of product are as follows :

- Workpiece material (Hardness and composition)
- Machine and tooling (fixture design, cylinder size, clamping pressure, etc.)
- Geometry of component (passage shape, length, diameter, etc.)
- Media (Viscosity and its change during the process, flow rate, type and size of abrasive, etc.)
- Adjustable parameters (Pressure and number of strokes)

Applications:

It is very useful for finishing of the following parts :

- Extrusion dies (improves die performance and life)
- Nozzle of flame cutting torch
- Airfoil surfaces of impellers of turbine
- Deburring of aircraft valve bodies and spools.
- Removing recast layer after EDM or LBM.

It is used for finishing operations mainly in the industries related to the manufacturing of aerospace, automotive, semiconductor, medical parts, etc.

It also improves the mechanical fatigue strength of blades, disks, hubs, shafts, etc

Advantages:

- By using AFF deburring, polishing and radiusing are conducted in one operation.
- This process can finish in accessible area.
- AFF is suitable for batch production.
- It is a very fast method.
- This method provides better accuracy and high efficiency.
- Media temperature control generally not required.
- Excellent process control and quick change tooling.

Disadvantages:

- Tooling or fixtures required are expensive.
- Initial cost of the machine is high.
- This process is not suitable for blind holes.

2. Chemo Mechanical Polishing

Demands for high quality surface finish, dimensional and form accuracy are required for optical surfaces and it is very difficult to achieve this using conventional grinding methods. ELPD is new and efficient method that uses a metal bonded diamond grinding wheel to achieve a mirror surface finish especially on hard and brittle materials.

Working principle:

The basic elements of ELID grinding are shown in Fig. ELID cell comprises of a metal bonded grinding wheel, cathode electrode, DC power supply and electrolyte.

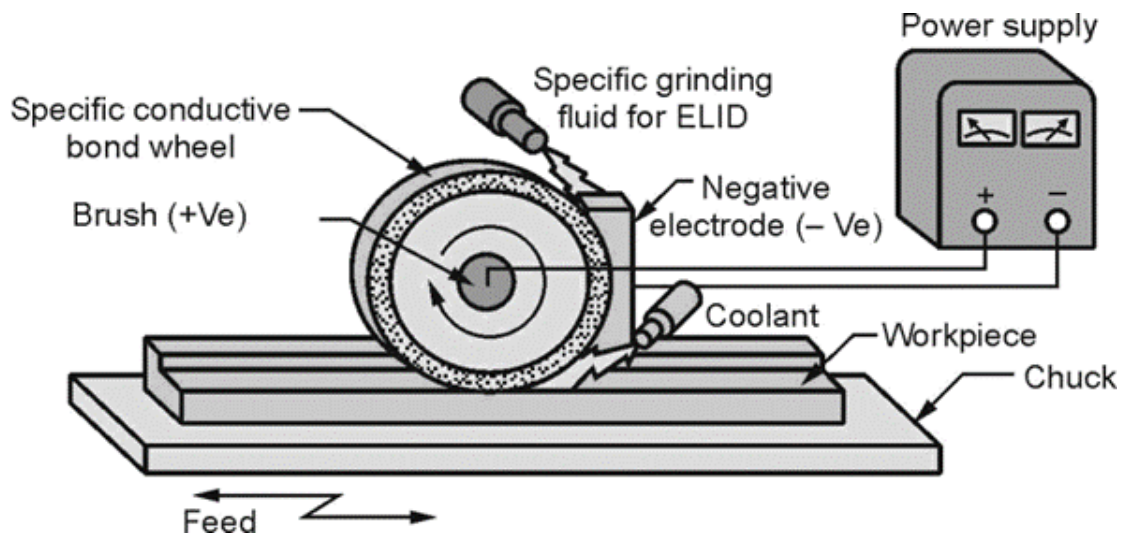


Fig. Basic elements of ELID grinding

- The grinding wheel is connected to the positive terminal of DC supply by a carbon brush, whereas electrode is connected to the negative terminal of DC supply. Generally, alkaline liquids are used as electrolyte as well as coolant for grinding.
- An electrolyte is injected into the gap between the wheel and electrode by using a nozzle. Usually, this gap is 0.1 to 0.3 mm.
- Due to electrochemical reaction an anodic oxide layer is formed on the circumference of the grinding wheel.
- It is soft and brittle in nature as compared to original metal bond and easily gets worn off because of the excessing grinding force.
- Fig. shows the basic mechanism of ELID grinding.

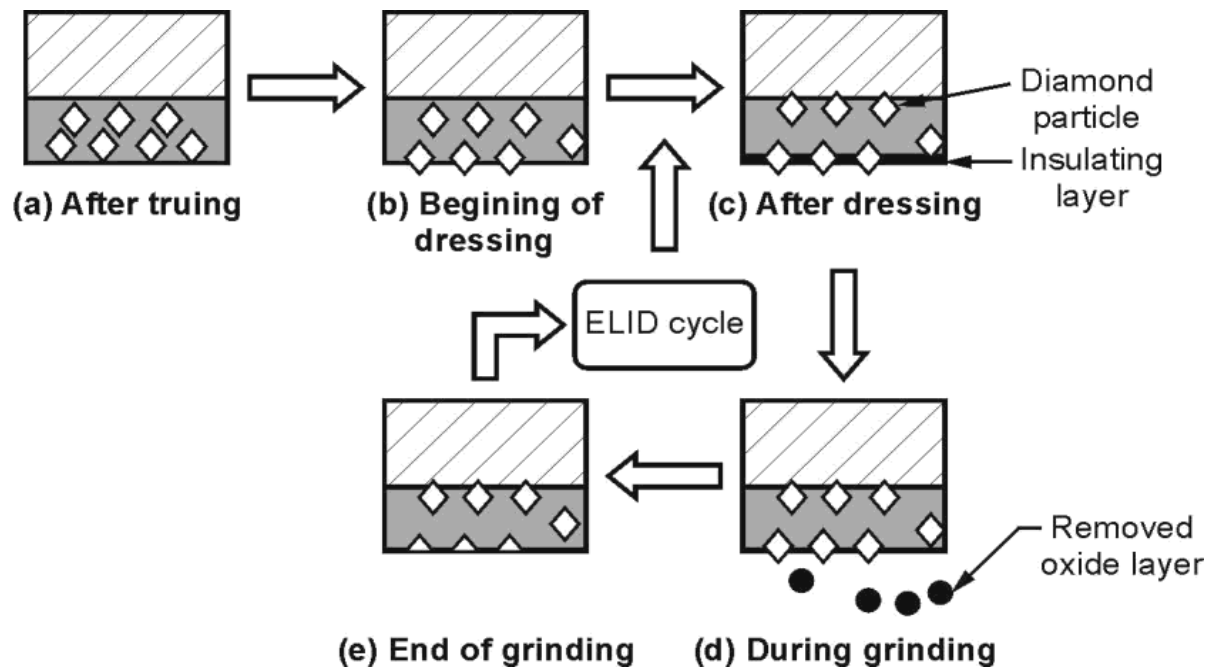


Fig. Basic mechanism of ELID grinding

- After truing, the grains and bonding material (metal) of the wheel surface are flattened. Refer Fig. (a).
- For the trued wheel it is necessary to be electrically predressed to protrude the grains on the wheel surface and the dressing continues during the grinding operation.
- When predressing starts as shown in Fig. (b), the bonding material flows out from the grinding wheel and an insulating layer composed of the oxidized bonding material is formed on the wheel surface. Refer Fig. (c).
- This insulating layer reduces the conductivity of the wheel surface and prevents excessive flow out of the bonding material from the wheel. At the same time, the grits are held by the bonding material and oxide layer.
- The oxide layer is soft and brittle in nature and easily wears off when it comes in contact with the workpiece during the grinding. Refer Fig. (d).
- As grinding continues, diamond grains wear out and cutting force increases. This force will cause falling off the blunt grits which is held by the brittle insulating material. Refer Fig. (e).
- Due to breakage of insulating layer, electrical conductivity of wheel surface increases and electrolytic dressing restarts with the flow out of bonding material from grinding wheel.

- Thus, the protrusions of new diamond grains from the grinding wheel remains constant.

Advantages:

- Good surface finish
- High surface accuracy
- Low subsurface damage

Applications:

- This process is used for grinding of silicon surfaces in semiconductor industry.
- This process produces nano surface finish on glass and ceramics.
- It also helps in production of aspherical surfaces for lenses and moulding dies in optical industry.
- It is used for precision grinding of bearing steel.
- Finishing of internal cylindrical holes in a hard and brittle material is performed by ELID.

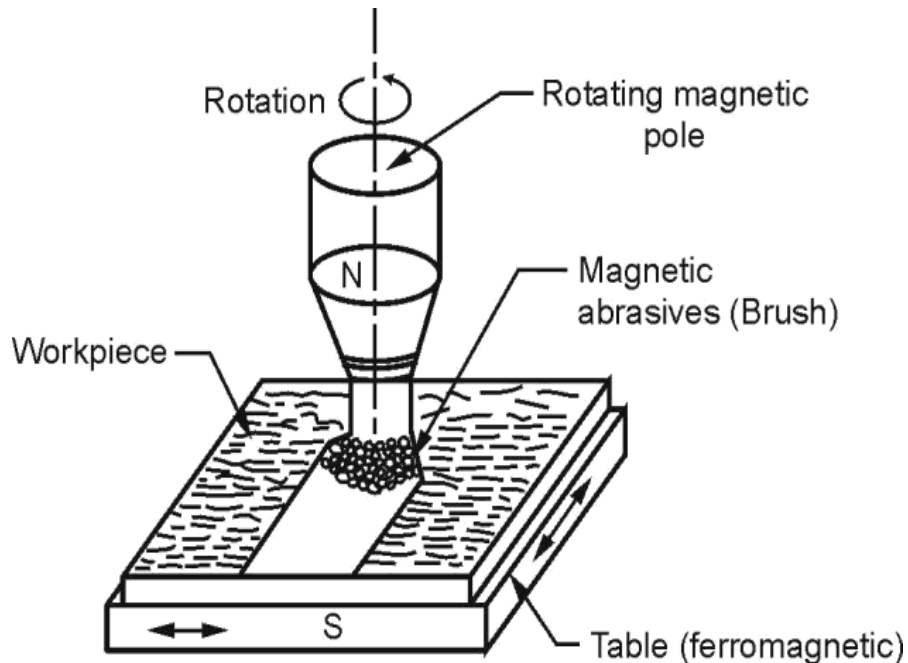
3. Magnetic Abrasive Finishing (MAF)

- We know that, every magnet has two poles [north pole (N) and south pole (S)] and magnetic lines of force (magnetic field) travels from north pole to south pole.
- This magnetic principle is used in the Magnetic Abrasive Finishing (MAF) process.
- This process is suitable for finishing of cylindrical workpieces (external and internal surfaces) and for flat workpieces also.
- It is used for internal finishing of tubes, external finishing of rods, finishing of flat surfaces, etc.
- The workpiece may be made of ferromagnetic or non - ferromagnetic materials.

Working Principle:

- In MAF process, granular magnetic abrasive composed of ferromagnetic material (as iron particles) and abrasive grains like AlO₃, SiC or diamond dust are used as cutting
- tools and the finishing pressure is applied by electro - magnetically generated field
Refer Fig.

- The magnetic particles are joined to each other magnetically between magnetic poles along the lines of magnetic force forming **Flexible Magnetic Abrasive Brush (FMAB)**.



Working principle of MAF

- When a cylindrical workpiece with rotary, vibratory and axial movement is inserted in such a magnetic field, the finishing of surface and edges is performed by the magnetic abrasive brush.
- If the workpiece is of non - magnetic material, the lines of magnetic field go around it (through magnetic abrasives) and if it is of magnetic material then they pass through the workpiece.
- The magnitude of magnetic force between the two poles is also affected by the material, shape and size of workpiece as well as magnetic poles.
- The pressure exerted by the magnetic abrasives is decreased as the gap between the magnetic pole and workpiece is increased.
- The magnetic abrasives have been used in the form of either a mixture (unbounded) of abrasive and ferromagnetic particles or abrasive held in a ferromagnetic matrix (bonded) form by sintering.
- The unbounded magnetic abrasives yield higher metal removal rates whereas bonded magnetic abrasive give better surface finish.

Process Variables

The process variables of MAF process are as follows:

- Type and size of magnetic abrasives
- Mixing ratio of abrasive grains with ferromagnetic particles
- Working clearance
- Rotational speed and vibration (both amplitude and frequency)
- Material properties of workpiece
- Flux density and relative speed of magnetic abrasive to the workpiece surface.

Advantages:

- MAF process can finish ferromagnetic as well as non - ferromagnetic materials.
- The finishing tool requires neither compensation nor dressing.
- This process has capability to access hard to reach areas.
- The process is capable of modifying roughness without changing the form.
- MAF is able to attain wide range of surface characteristics by careful selection of magnetic particles.
- The set - up of process is independent of workpiece material. It can easily finish ceramics, stainless steel, brass, coated carbide and silicon.
- Due to flexible magnetic abrasive brush, it can finish any symmetric workpiece shape.

Disadvantages

- This process is not suitable for mass production.
- It is a time consuming process.
- The cost of process is very high.
- The process is not applicable for some ordinary finishing task where conventional finishing technique can be easily applied.

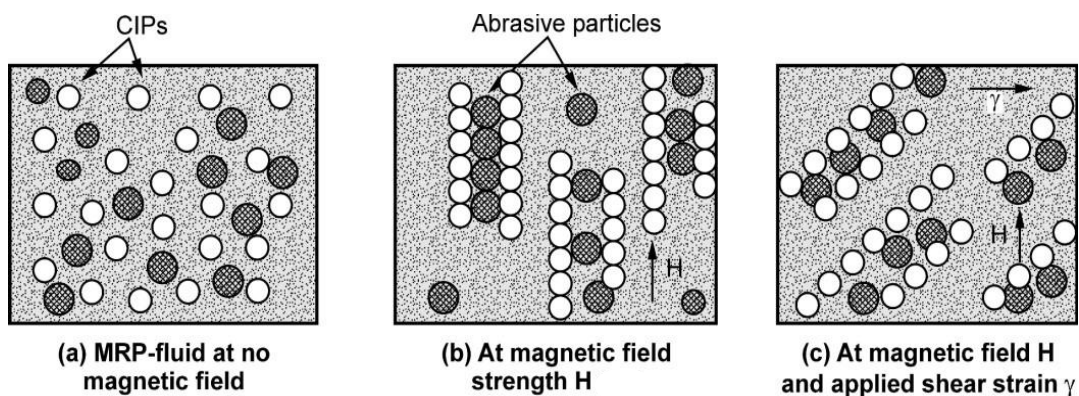
Applications

- MAF is used for finishing of internal surfaces of capillary tubes and other small gauge needles.
- It is suitable for finishing of cutting tools, airfoils, optics, turbine blades, prosthetics, etc.
- Also suitable for internal finishing of sanitary pipes, food industry, curved pipe, medical field (stents, catheter shafts, needles, etc.).

4. Magneto Rheological Finishing

- Traditional methods of finishing high precision lenses, ceramics and semiconductor wafers are very expensive and labor intensive.
- Lenses are usually made of brittle materials such as glass, which tends to crack while it is machined, and every device that uses either lasers or fiber optics requires at least one high precision lens, increasing its demand higher than ever.
- The lens manufacturer generally uses its in-house opticians for the finishing process, which makes it an arduous, labor- intensive process. Lens manufacturing can be classified into two main processes: **grinding and finishing**. Grinding gets the lens close to the desired size, while finishing removes the cracks and tiny surfaces imperfections that the grinding process either over looked or created.
- To overcome these difficulties, Center for Optics Manufacturing (COM) in Rochester,
- N.Y. has developed a technology to automate the lens finishing process known as Magneto Rheological Finishing (MRF).
- The MRF process relies on a unique "smart fluid", known as Magnetorheological (MR) fluid.
- MR-Fluids are suspensions of micron sized magnetizable particles such as carbonyl iron, dispersed in a non- magnetic carrier medium like silicone oil, mineral oil or water.
- In the absence of a magnetic field, an ideal MR-fluid exhibits Newtonian behaviour.
- On the application of an external magnetic field to a MR- suspension, a phenomenon known as Magneto Rheological Effect, shown in Fig. is observed.

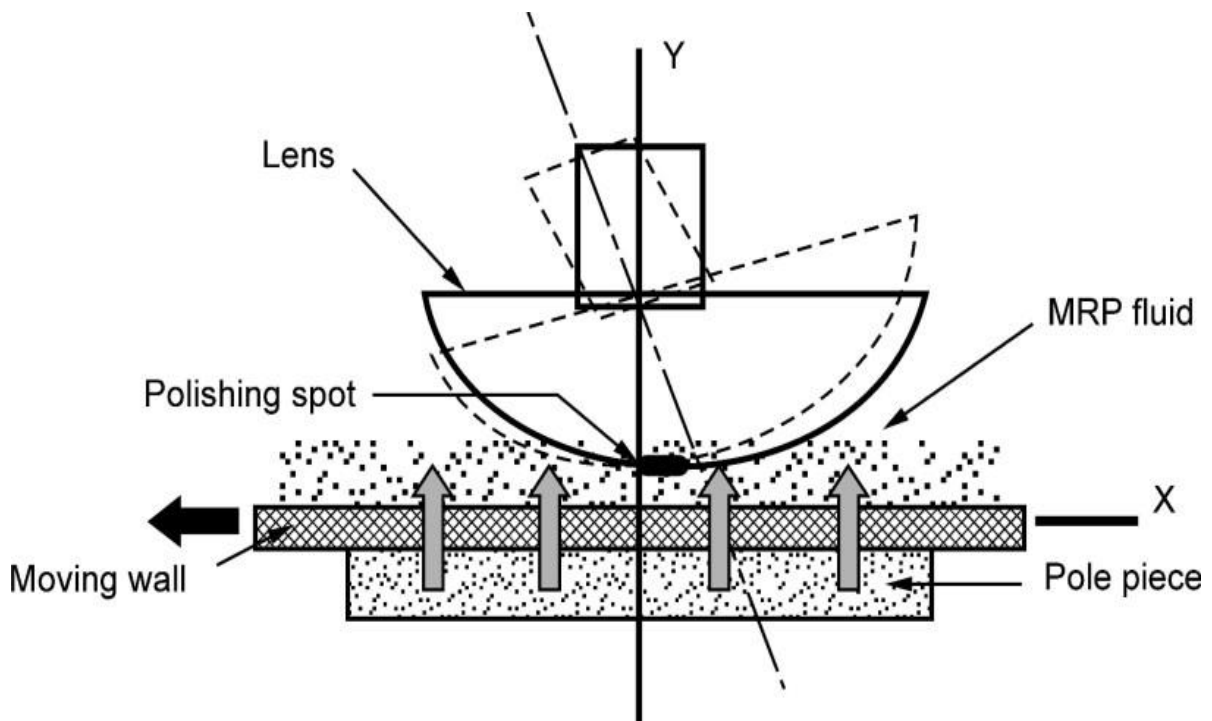
Magneto Rheological Effect



- In Fig. (a) shows the random distribution of the particles in the absence of external magnetic field.
- In Fig. (c) shows an increasing resistance to an applied shear strain, γ due to this yield stress.
- When the field is removed, the particles return to their random state and the fluid again exhibits its original Newtonian behavior.
- In Fig. (b) particles magnetize and form columns when external magnetic field is applied.
- The particles acquire dipole moments proportional to magnetic field strength and when the dipolar interaction between particles exceeds their thermal energy, the particles aggregate into chains of dipoles aligned in the field direction.
- Because energy is required to deform and rupture the chains, this micro-structural transition is responsible for the onset of a large "controllable" finite yield stress.

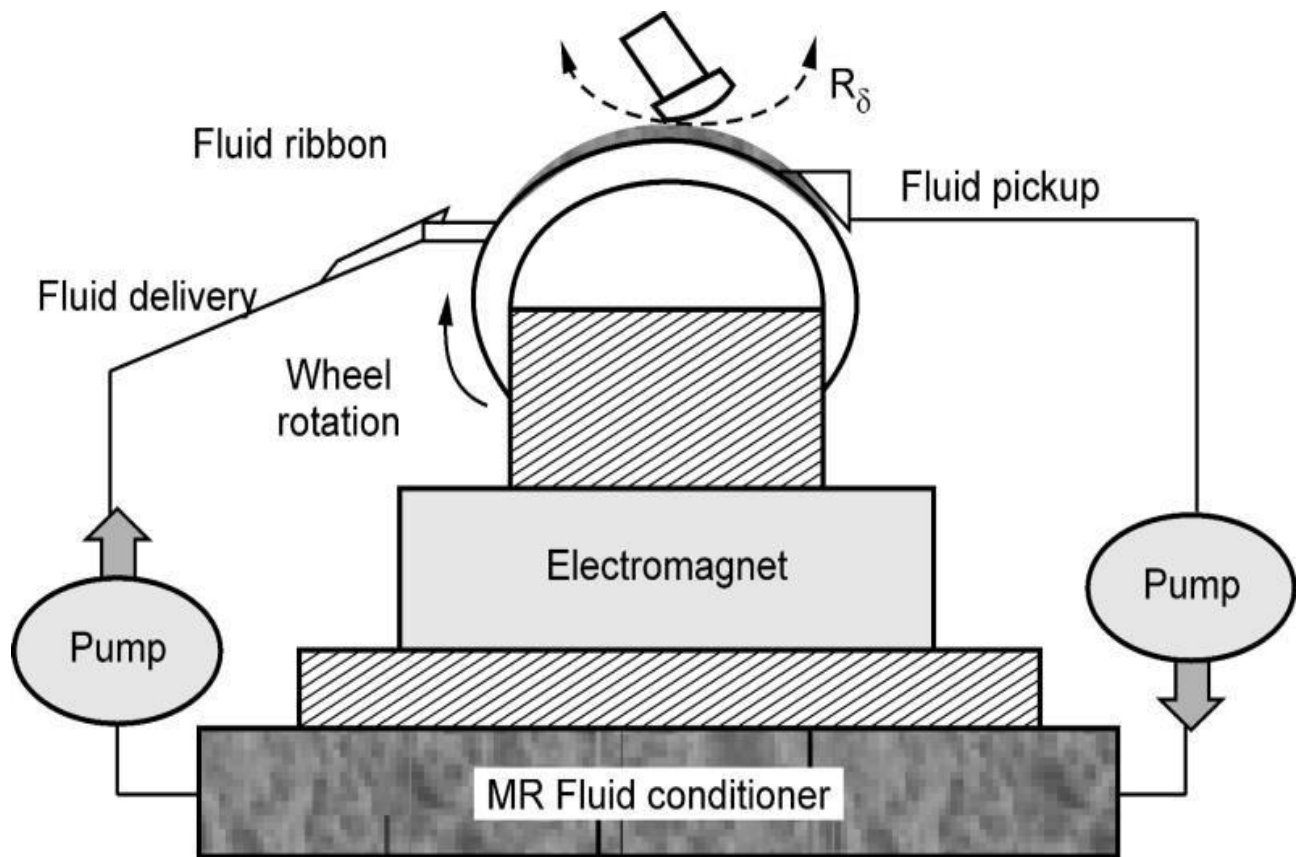
Magneto Rheological Finishing Process

In the Magneto rheological finishing process, a convex, flat, or concave work piece is positioned above a reference surface. A MR fluid ribbon is deposited on the rotating wheel rim. By applying magnetic field in the gap, the stiffened region forms a transient work zone or finishing spot.



Surface smoothing, removal of sub-surface damage, and figure correction are accomplished by rotating the lens on a spindle at a constant speed while sweeping the lens about its radius of curvature through the stiffened finishing zone.

Material removal takes place through the shear stress created as the Magneto Rheological polishing ribbon is dragged into the converging gap between the part and carrier surface. Deterministic finishing of flats or spheres can be done by mounting the part on rotating spindle and sweeping it through the spot under computer control, such that dwell time determines the amount of material removal. The zone of contact is restricted to a spot which conforms perfectly to the local topography of the part.



MRP Fluid

Magneto rheological polishing fluid comprises of MR-fluid with fine abrasive particles dispersed in it. On the application of magnetic field, the carbonyl iron particles (CIP) form a chain like columnar structure with abrasives embedded in between. The magnetic force between iron particles encompassing abrasive grain provides bonding strength to it and its magnitude is a function of iron concentration, applied magnetic field intensity, magnetic permeability of particles and particle size.

The MR-polishing fluid has following merits: -

1. Its compliance is adjustable through the magnetic field.
2. It carries heat and debris away from the polishing zone.
3. It does not load up as in grinding wheel.
4. It is flexible and adapts the shape of the part of the work piece which is in its contact.

Applications

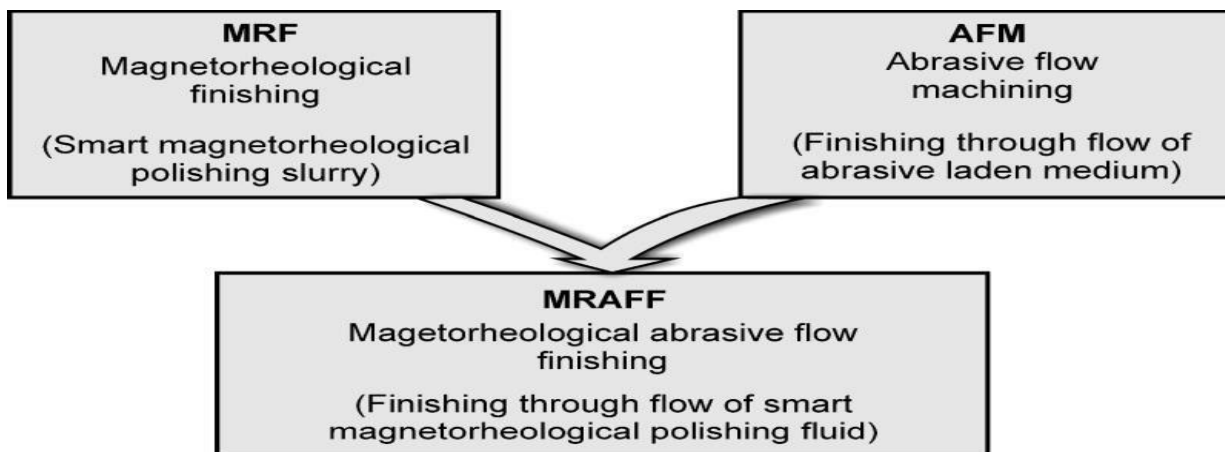
- High precision lenses include medical equipment such as endoscopes
- Military's night vision equipment like infrared binoculars.

5. Magneto Rheological Abrasive Flow Finishing (MRAFF)

In AFM, the polishing medium acts as compliant lap and overcomes shape limitation inherent in almost all traditional finishing processes. As abrading forces in AFM process mainly depend on rheological behavior of polymeric medium, which is least controllable by external means, hence lacks determinism.

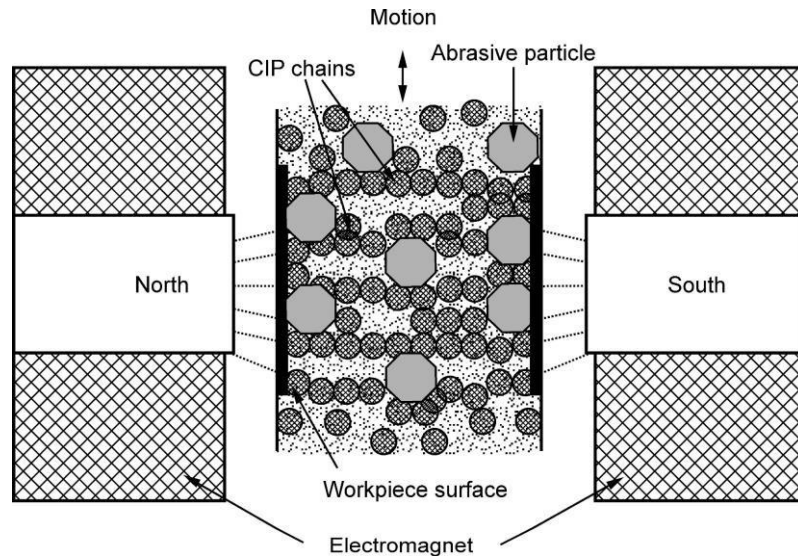
The process magneto rheological finishing, uses magnetically stiffened ribbon to deterministically finish optical flats, spheres and aspheres. In order to maintain the versatility of Abrasive Flow Machining process and at the same time introducing determinism and controllability of rheological properties of abrasive laden medium, a new hybrid process termed as Magnetorheological Abrasive Flow Finishing (MRAFF) is used.

This process relies on smart behavior of magneto rheological Fluids whose Rheological properties are controllable by means of external magnetic field.



Mechanism of MRAFF Process

In MRAFF process, a magnetically stiffened slug of magneto rheological polishing fluid is extruded back and forth through or across the passage formed by work piece and fixture.



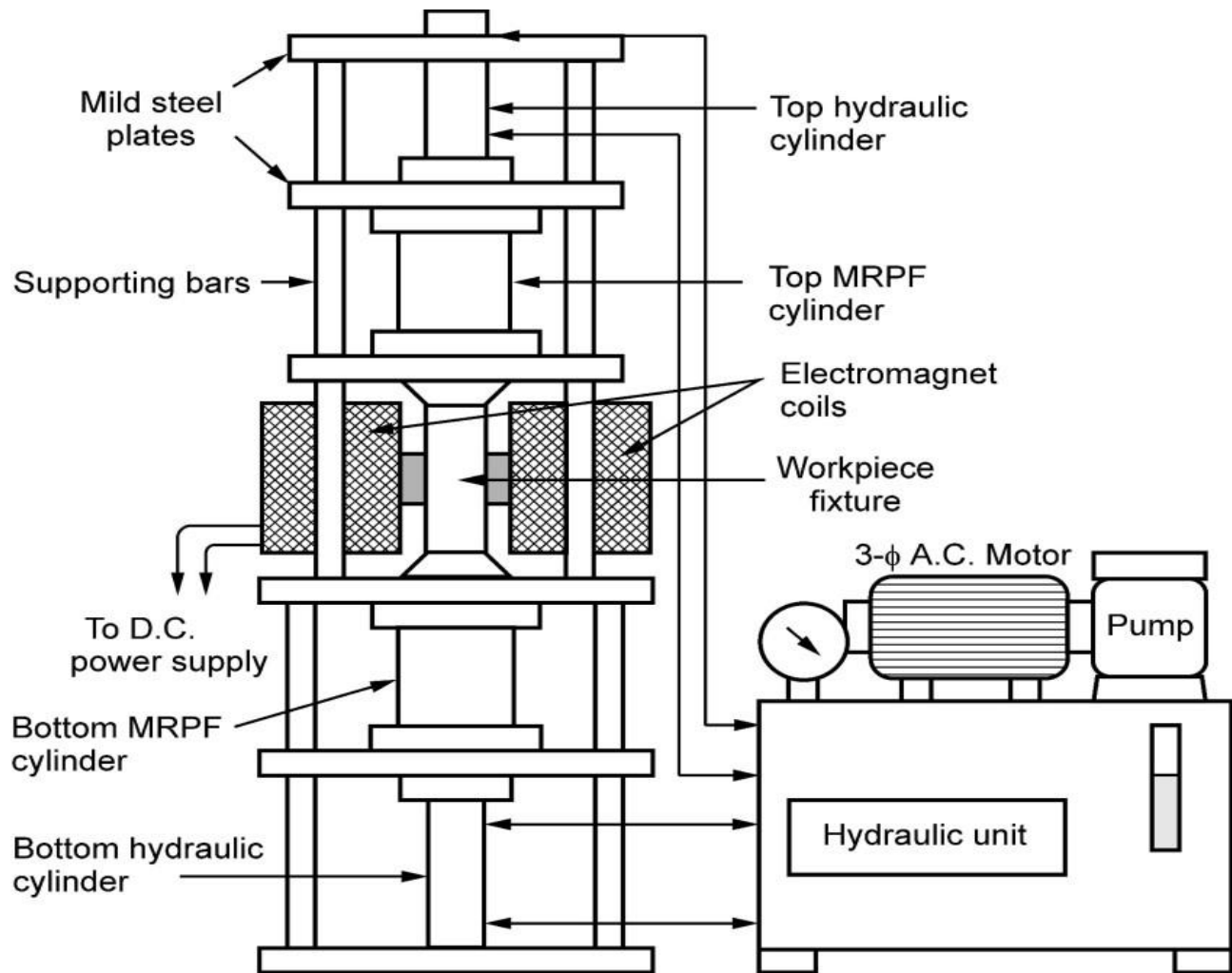
Abrasion occurs selectively only where the magnetic field is applied across the work piece surface, keeping the other areas unaffected. The mechanism of the process is shown in Fig. The rheological behavior of polishing fluid changes from nearly Newtonian to Bingham plastic upon entering and Bingham to Newtonian upon exiting the finishing zone.

MRAFF Machine

A hydraulically powered experimental setup is designed to study the process characteristics and performance. The setup consists of two MR-polishing fluid cylinders, two hydraulic actuators, electromagnet, fixture and supporting frame.

Experiments were conducted on stainless steel work pieces at different magnetic field strength to observe its effect on final surface finish. No measurable change in surface roughness is observed after finishing at zero magnetic field. In MRAFF process, MRPF is extruded through the workpiece passage to be finished utilizing two opposed cast iron cylinders under the presence of external magnetic field.

The viscosity of smart magnetorheological polishing fluid (MRPF) is a function of applied magnetic field strength, and it is varied according to the desire finishing characteristics.



The shearing of the Bingham plastic polishing fluid near the workpiece surface contributes to the material removal and hence finishing. Extrusion of the MRP-fluid through the passage formed in the workpiece fixture is accomplished by driving two opposed pistons in MRPF cylinders using hydraulic actuators operated in desired manner with the help of designed hydraulic circuit. The MRAFF setup consists of MRPF cylinders with pistons, workpiece fixture, electromagnet, hydraulic drive and controls, and supporting frame.

Advantages

- High machining versatility
- The surface finish improvement by this process is several times better than that of the original surface finish.
- The cutting activity can be easily controlled

- Process is simple
- Complex structures can be easily machined.
- Localized finishing is possible
- Negligible thermal distortion

Disadvantage

- Machining setup is complex and cost is high.

JIGS AND FIXTURES BASICS

Introduction

The successful running of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand a fast and easy method of positioning work for accurate operations on it.

JIGS

It is a work holding device that holds, supports and locates the work piece and guides the cutting tool for a specific operation. Jigs are usually fitted with hardened steel bushings for guiding or other cutting tools. a jig is a type of tool used to control the location and/or motion of another tool. A jig's primary purpose is to provide repeatability, accuracy, and inter-changeability in the manufacturing of products. A device that does both functions (holding the work and guiding a tool) is called a jig.

FIXTURES

It is a work holding device that holds, supports and locates the work piece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device, what makes a fixture unique is that each one is built to fit a particular part or shape. The main purpose of a fixture is to locate and in some cases hold a work piece during either a machining operation or some other industrial process. A jig differs from a fixture in that a bit guides the tool to its correct position in addition to locating and supporting the work piece.

DIFFERENCE BETWEEN JIGS & FIXTURE

1. jigs are work holding device that holds, supports and locates the work piece and guides the cutting tool for a specific operation but. fixtures are also work holding device that holds, supports and locates the work piece for specific operation, does not guide the cutting tool.
2. Jigs are not clamped to the drill press but Fixtures should be securely clamped to table unless large diameters to be drilled.
3. The jigs are special tools particularly in drilling, reaming, tapping and boring but Fixtures are specific tools used particularly in milling machine, shapers and operation. slotting machine and operation.
4. Gauge blocks are not necessary with jig but Gauge blocks may be provided for effective handling in case of fixture.
5. Jigs are Lighter in construction but fixtures are Heavier in construction.

ADVANTAGES OF JIGS & FIXTURE: -

PRODUCTIVITY:

Jigs and fixtures increases the productivity by eliminating the individual marking, positioning and frequent checking. The operation time is also reduced due to increase in speed, feed and depth of cut, because of high clamping rigidity.

INTERCHANGEABILITY AND QUALITY:

Jigs and fixtures facilitate the production of articles in large quantities with high degree of accuracy, uniform quality and inter-changeability at a competitive cost.

SKILL REDUCTION:

There is no need for skill-full setting of work on tool. Jigs and fixtures makes possible to employ unskilled or semi-skilled machine operator to make savings in labour cost.

COST REDUCTION:

Higher production, reduction in scrap, easy assembly and savings in labour cost results in ultimate reduction in unit cost. Fundamental principles of Jigs and Fixtures design

LOCATING POINTS:

Good facilities should be provided for locating the work. The article to be machined must be easily inserted and quickly taken out from the jig so that no time is wasted in placing the work piece in position to perform operations. The position of work piece should be accurate with respect to tool guiding in the jig or setting elements in fixture.

Full PROOF:

The design of jigs and fixtures should be such that it would not permit the work piece or the tool to inserted in any position other than the correct one.

REDUCTION OF IDLE TIME:

Design of Jigs and Fixtures should be such that the process, loading, clamping and unloading time of the work piece takes minimum as far as possible.

WEIGHT OF JIGS AND FIXTURES:

It should be easy to handle, smaller in size and low cost in regard to amount of material used without sacrificing rigidity and stiffness.

JIGS PROVIDED WITH FEET:

Jigs sometimes are provided with feet so that it can be placed on the table of the machine.

MATERIALS FOR JIGS AND FIXTURES:

Usually made of hardened materials to avoid frequent damage and to resist wear. Example-MS, Cast iron, Die steel, CS, HSS.

CLAMPING DEVICE:

It should be as simple as possible without sacrificing effectiveness. The strength of clamp should be such that not only to hold the work piece firmly in place but also to take the strain of the cutting tool without springing when designing the jigs and fixtures.

Essential features of Jigs and Fixtures

- Reduction of idle time – Should enable easy clamping and unloading such that idle time is minimum

- Cleanliness of machining process – Design must be such that not much time is wasted in cleaning of scarfs, burrs, chips etc.
- Replaceable part or standardization – The locating and supporting surfaces as far as possible should be replaceable, should be standardized so that their interchangeable manufacture is possible
- Provision for coolant – Provision should be there so that the tool is cooled and the swarfs and chips are washed away
- Hardened surfaces – All locating and supporting surfaces should be hardened materials as far as conditions permit so that they are not quickly worn out and accuracy is retained for a long time
- Inserts and pads – Should always be riveted to those faces of the clamps which will come in contact with finished surfaces of the work piece so that they are not spoilt
- Fool-proofing – Pins and other devices of simple nature incorporated in such a position that they will always spoil the cutting tool until the latter are in correct position.
- Economic soundness – Equipment should be economically sound, cost of design and manufacture should be in proportion to the quantity and price of producer.
- Easy manipulation – It should be as light in weight as possible and easy to handle so that workman is not subjected to fatigue, should be provided with adequate lift aids.
- Initial location – Should be ensured that work piece is not located on more than 3 points in anyone plane test to avoid rocking, spring loading should be done.
- Position of clamps – Clamping should occur directly above the points supporting the work piece to avoid distortion and springing.
- Clearance – Sufficient amount of clearance should be provided around the work so that operator's hands can easily enter the body for placing the work piece and any variations of work can be accommodated
- Ejecting devices – Proper ejecting devices should be incorporated in the body to push the work piece out after operation
- Rigidity and stability – It should remain perfectly rigid and stable during operation. Provision should be made for proper positioning and rigidly holding the jigs and fixtures.
- Safety – The design should assure perfect safety of the operator.

