2 DRILLING

2.1 INTRODUCTION

The process of generating/producing the holes using multipoint cutting tool is called drilling. The multipoint cutting tool is called drill. Drilling machine is one of the oldest machine tools which is being used from the beginning of civilization. These days, it is one of the indispensable machine tools for repair shop, production and tool room.

Drilling is a metal cutting process carried out by a rotating cutting tool to make circular holes in solid materials. The cutting tool is called twist drill. It has sharp twisted edges formed around a cylindrical tool provided with a helical groove along its length to allow the cut material to escape through it.

A liquid coolant is generally used while drilling to remove the heat of friction and to obtain a better finish for the hole.

2.2 PRINCIPLE OF DRILLING

Drilling machine is used to produce holes in the workpiece. The end cutting tool used for drilling holes in the workpiece is called the drill.

The drill is mounted on a spindle and when the machine is 'on', the drill starts rotating at certain speed (r.p.m.), whereas workpiece is held rigidly on machine table. The linear motion is given to the drill towards the workpiece which is called feed. In order to remove the chips from the hole, drill is taken out from the hole. So the combination of rotary and linear motion produces the hole in the workpiece. The working principle of drilling machine is illustrated in fig. 2.1

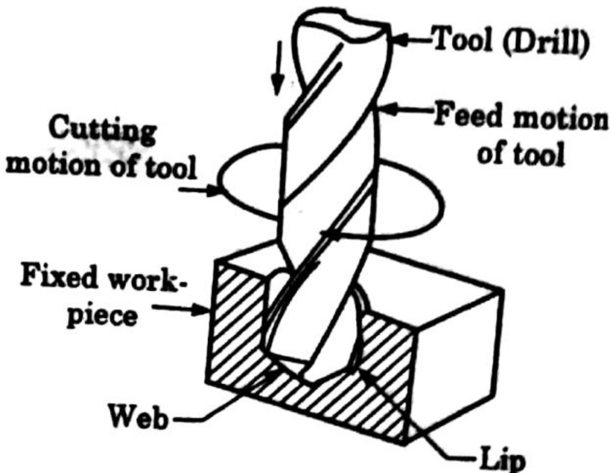


Fig. 2.1 : Principle of Drilling Machine

2.3 CLASSIFICATION OF DRILLING MACHINES

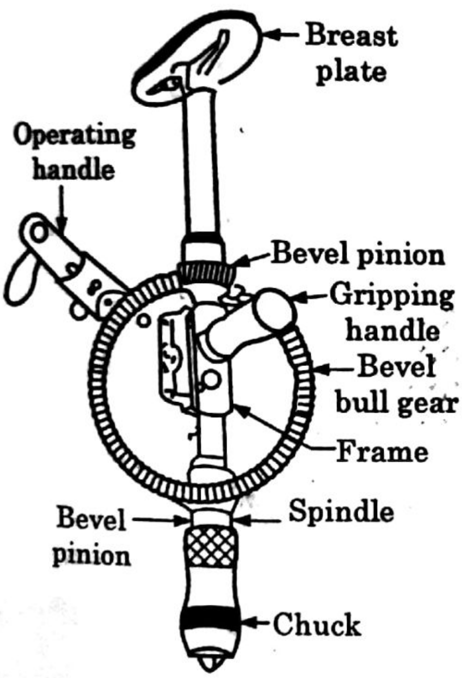
Drilling machines are classified according to the construction and the work performed as follow :

1. Portable drilling machine,
2. Sensitive or bench drilling machine,

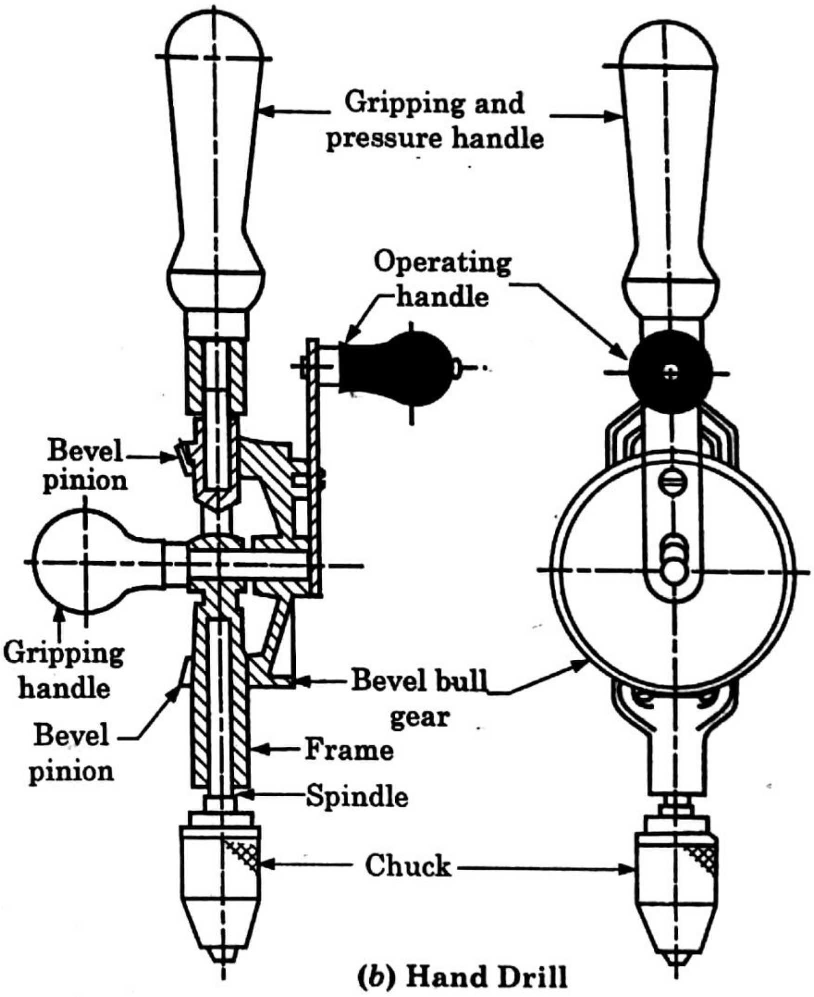
3. Upright drilling machine,
4. Radial drilling machine,
5. Multiple drill-head drilling machine,
6. Gang drilling machine,
7. Deep hole drilling machine,
8. Automatic drilling machine.

1. **Portable Drilling Machine :** This is a small drilling machine which can be easily carried to workplace. *It is generally employed for drilling holes in light classes of work such as structural fabrications, fitting work in assemblies and also in cases, where high accuracy is not desired.* They are available in different sizes and can drill holes upto 12 mm. Depending upon the source of power, this machine may be of various types which are explained as follow.

(*i*) **Manual Drilling Machine :** *This drilling machine is used for light work such as making small holes in wood.* This is driven by hand. Fig. 2.2 shows a hand operated drilling machine called breast drill.



(*a*) Breast Drill



(*b*) Hand Drill

Fig. 2.2

(*ii*) **Electric Drilling Machine :** *This machine is very useful and can be used for fitting in homes, at bridges, buildings and in other erection works.* This is fitted with small electric motor from 0.5 H.P. upto 2 H.P. The maximum drilling size is 12 mm. (See. fig. 2.3).

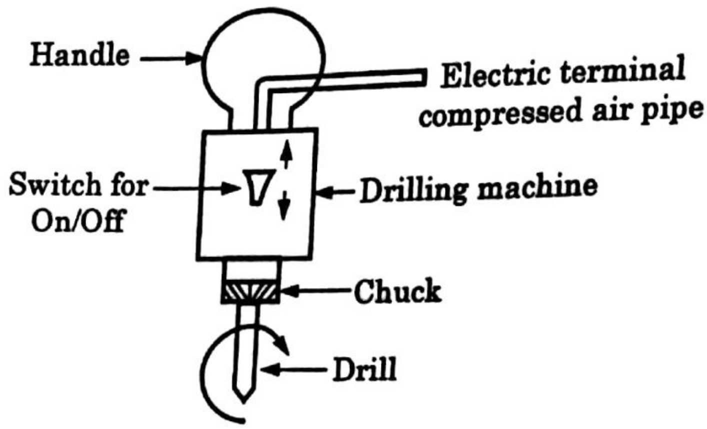


Fig. 2.3 : Electric or Preumetic Drilling Machine

(iii) **Pneumatic Drilling Machine :** This machine is very much similar to above mentioned electric machine. However, it gets power from compressed air and can run very smoothly at quite high speed. (See fig. 2.3).

2. Sensitive or Bench Drilling Machine : It is a light and simple drilling machine of small height. It is usually fitted on a bench and hence, it is called bench drilling machine. (See fig. 2.4).

The downward feed is given by the operator himself who senses the feed required and hence, it is called sensitive drilling machine.

It is usually supplied with a friction drive to give an infinite speed ratio. Such a machine can give the speed of 800 r.p.m. to 9000 r.p.m.

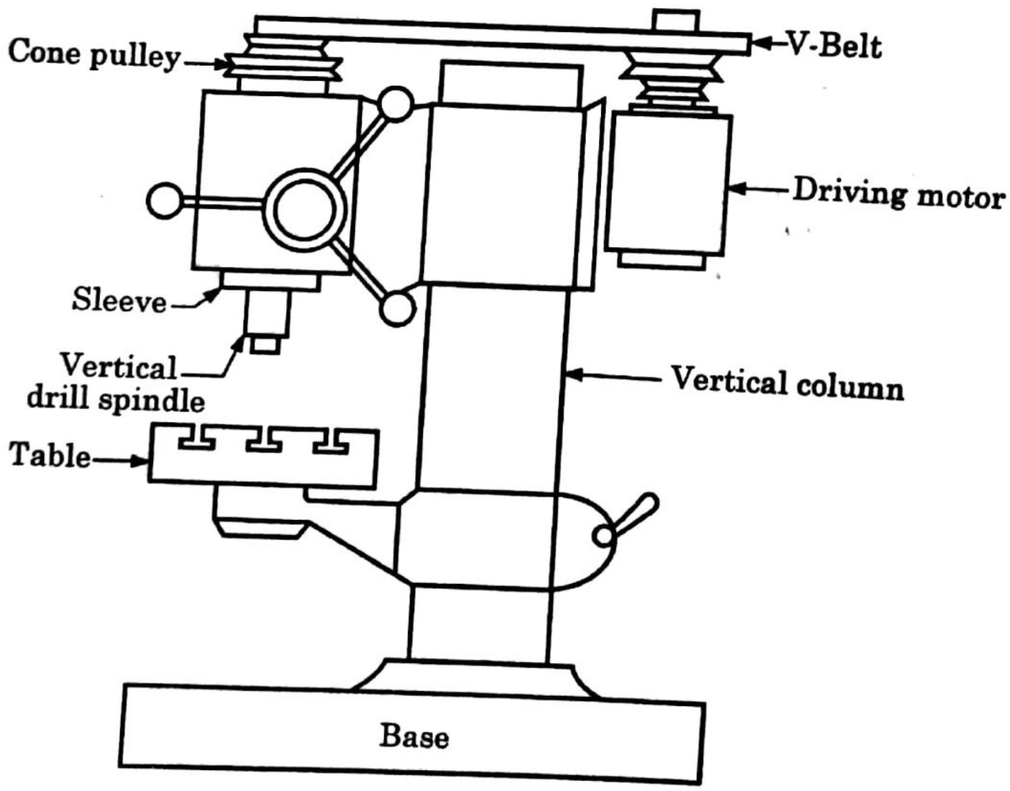


Fig. 2.4 : Sensitive Drilling Machine

The major components of this machine are as follow :

(*i*) Base,

(*ii*) Column,

(*iii*) Adjustable table,

(*iv*) Spindle and spindle sleeve assembly,

(*v*) Head,

(*vi*) Drill chuck.

(*i*) **Base :** It supports the column, which in turn, supports the table, head etc. It is heavy structure with holes for mounting the machine to the bench.

(*ii*) **Column :** It is a vertical round or box section, which rests on the base and supports the head and the table.

(*iii*) **Adjustable Table :** It is supported on the column of the drilling machine and can be moved vertically and horizontally. It is used for supporting the workpiece and work piece holding device. It also carries slots for clamping bolts.

(*iv*) **Spindle and Spindle Sleeve Assembly :** Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve which slides on bearings. A spindle sleeve assembly is used in sensitive drilling machine as shown in fig. 2.5

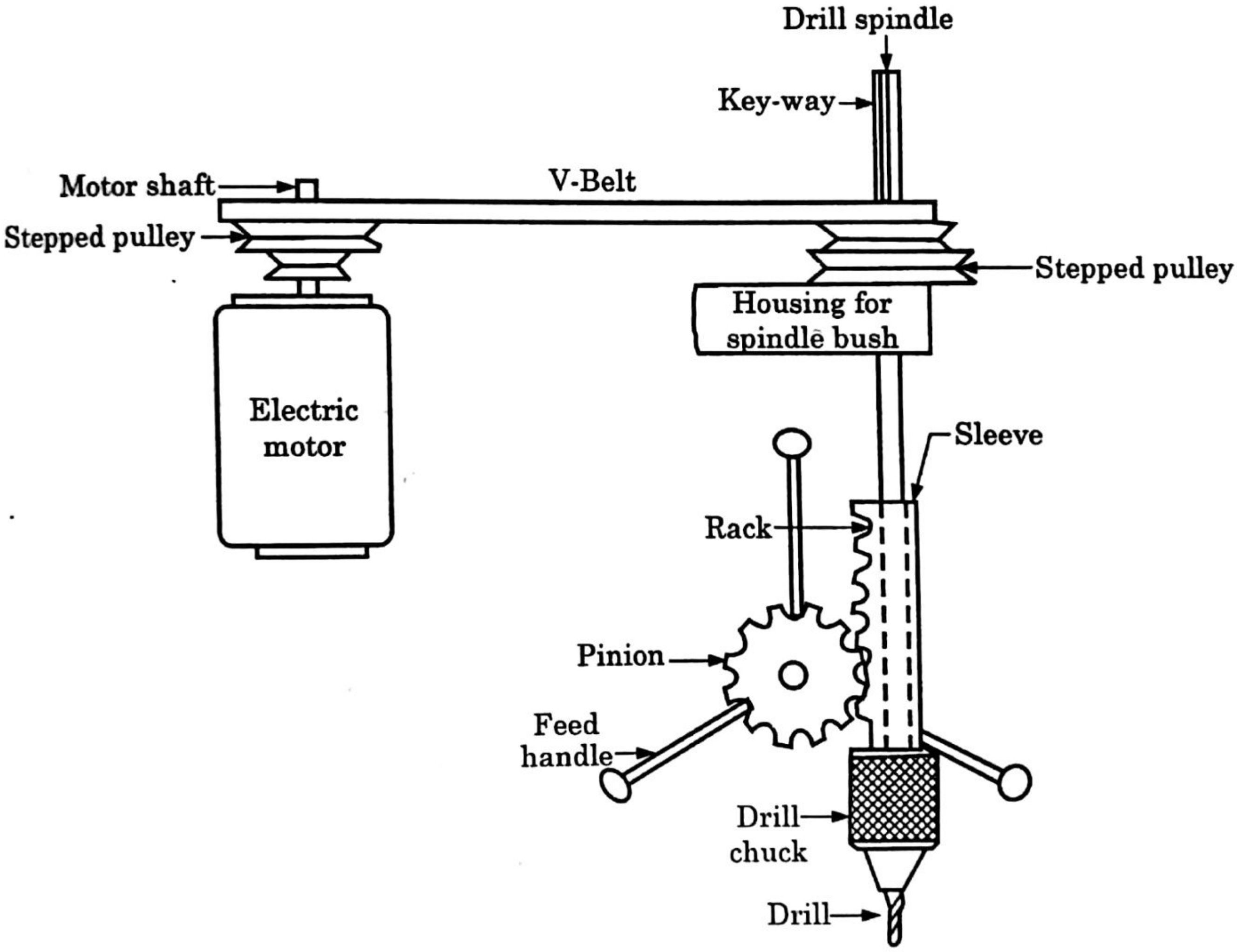


Fig. 2.5 : Drive Mechanism of a Sensitive Drilling Machine

(*v*) **Head :** It contains the electric motor, V-pulleys and V-belt which transmit rotary motion to the drill spindle at a number of speeds.

(*vi*) **Drill Chuck :** It is held at the end of the drill spindle and in turn, it holds the drill bit.

3. Upright Drilling Machine : This machine derives its name from the fact that it has got considerable height and table seems to be standing quite above the base. It is similar to sensitive drilling machine except that it has power feeding mechanism for rotating the drill and designed for heavier work.

This drilling machine has a heavy and rigid column which may be either round or of square cross-section and accordingly, it can be further sub-classified as follows :

(*i*) **Pillar Upright Drilling Machine :** Pillar upright drilling machines are generally employed for both medium and heavy duty. It is used for drilling holes upto 50 mm diameter. The machine has round column on which table base can be raised or lowered. The table can be rotated around the column through 180° as well as around its own axis. Other fitting of stepped cone pulley, drilling head and gear system is there. A pillar upright drilling machine is shown in fig. 2.6.

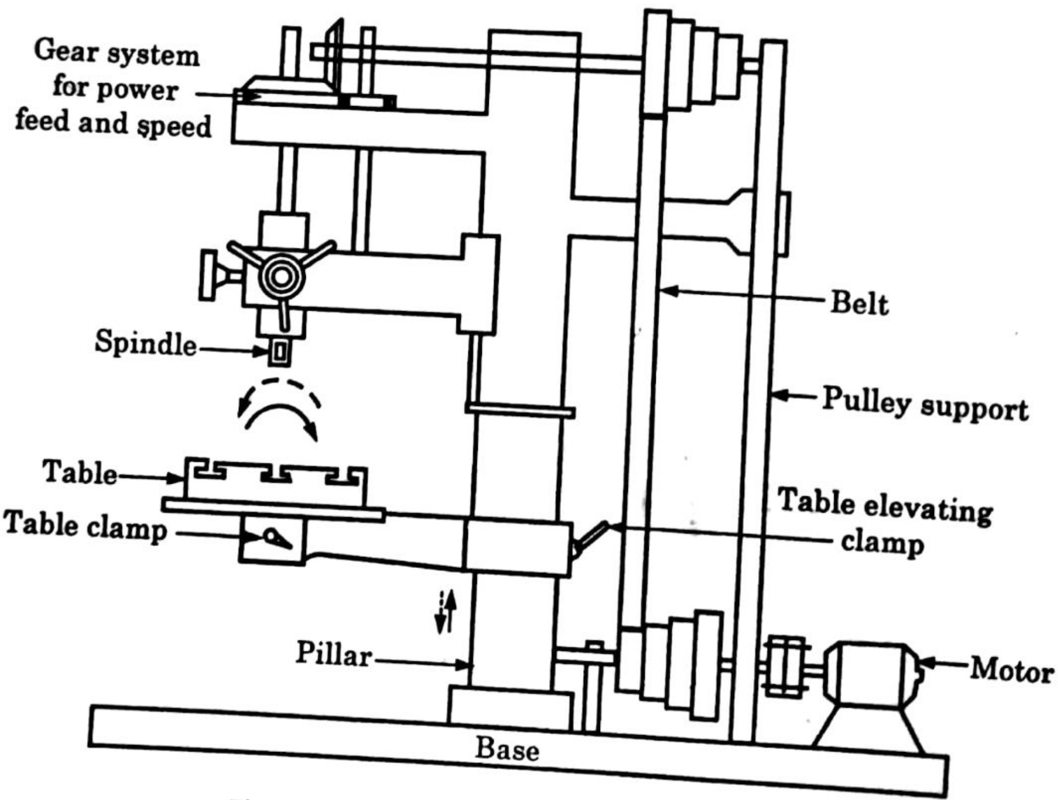


Fig. 2.6 : Pillar Upright Drilling Machine

(*ii*) **Box-Column Upright Drilling Machine :** This drilling machine has quite heavy and rigid column of square cross-section. The working table can be moved up and down. This machine is used for heavier jobs. The drilling capacity is more than 50 mm diameter hole. Fig. 2.7 shows a box-column upright drilling machine.

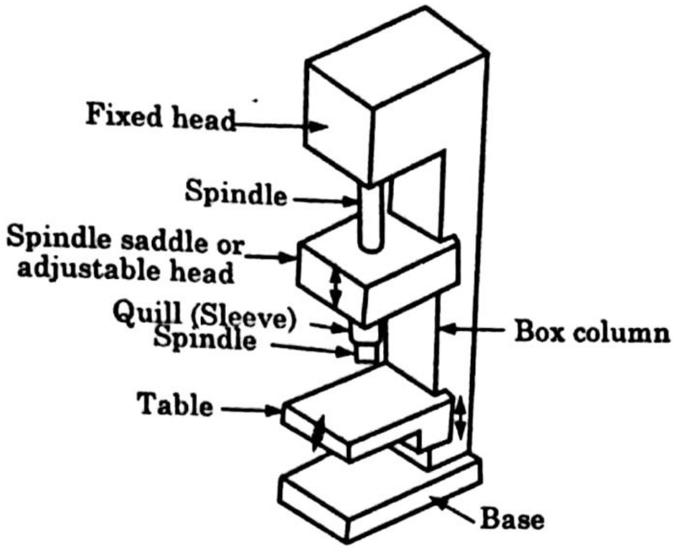


Fig. 2.7 : Box-Column Upright Drilling Machine

4. Radial Drilling Machine : Radial drilling machine derives its name from the fact that drilling head can be rotated radially and accordingly, can be adjusted in any radial position.

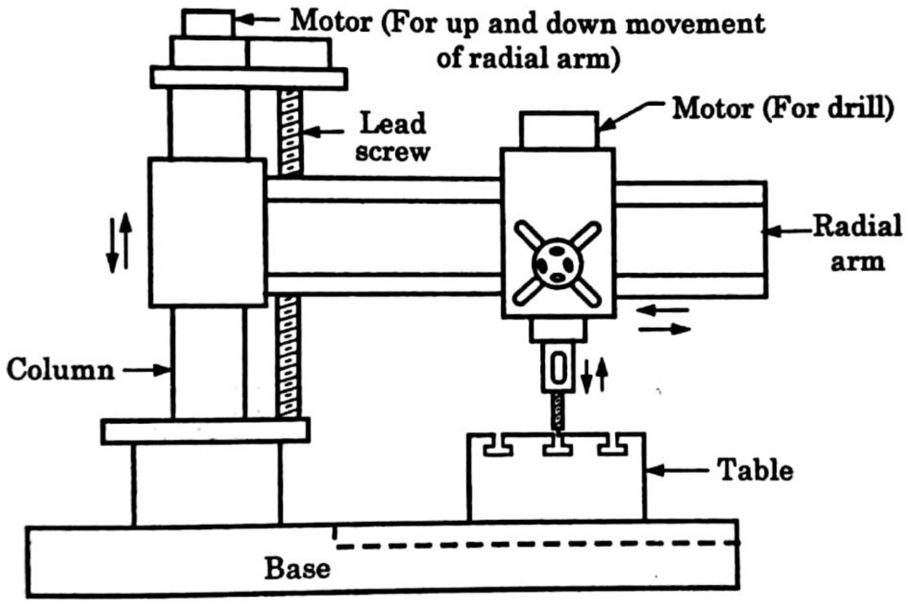


Fig. 2.8 : Radial Drilling Machine

It is the largest and most versatile drilling machine and is very well suited for drilling large number of holes. A *radial drilling machine shown in fig. 2.8 is used to perform the drilling operations on the workpieces which are too heavy and also may be too large to mount them on the table of the vertical spindle drilling machine*. This machine may be of medium type or heavy type as per the requirement of the job. It consists of follow parts :

(*i*) Base, (*ii*) Column,

(*iii*) Radial arm, (*iv*) Drilling head.

(*i*) **Base :** This machine is provided with a broad steel base having a big tee-slot which is integral with the shop floor. Sometimes, a rigid table can be mounted on this base to hold the smaller and lighter work pieces.

(*ii*) **Column :** It is a vertical cylindrical structure that rests on the base. It consists of a radial arm that can be swung through an arm of 180° or more.

(*iii*) **Radial Arm :** It is mounted on the column and projected horizontally over the base at a sufficient height. It can be rotated either normally or with the help of a motor provided for this purpose. It can move up and down over the column to accomodate workpieces of different heights which are set up on the machine.

(*iv*) **Drilling Head :** It is mounted on the radial arm. It is provided with a separate motor. It can be moved and adjusted in a desired position according to the job lying on the base. The whole assembly of radial arm and drill head can be raised or lowered along the drill column.

Based upon the type and number of movements possible, the radial drilling machines can be broadly grouped as under :

(*i*) **Plain Radial Drilling Machine :** In this type of drilling machine, three types of movements are possible *i.e.* vertical movement of the arm along the column, horizontal movement of the drilling head and radial swing of the arm in a horizontal plane.

(*ii*) **Semi-Universal Radial Drilling Machine :** These machines, in addition to the above three movements, carry provision for swinging of the spindle head about a horizontal axis which is normal to the arm. Due to this movement, the drilling head permits drilling hole at any angle to the horizontal plane other than the normal position.

(*iii*) **Universal Radial Drilling Machine :** In this type of machine, the arm itself can be rotated through a desired angle along a horizontal axis. This is in addition to the four possible movements available on a semi-universal machine. All these five movements permit the machine to drill holes at any angle.

5. Multiple Drill-Head Drilling Machine : This drilling machine may be provided with many spindles or drill heads. e.g. four, six, eight or twelve and so on, all driven from one spindle drive gear in one head (which is provided with one motor) so that at a time, four, six, eight or twelve holes can be drilled, reamed or tapped (See fig. 2.9). These machines are also called cluster drilling machines.

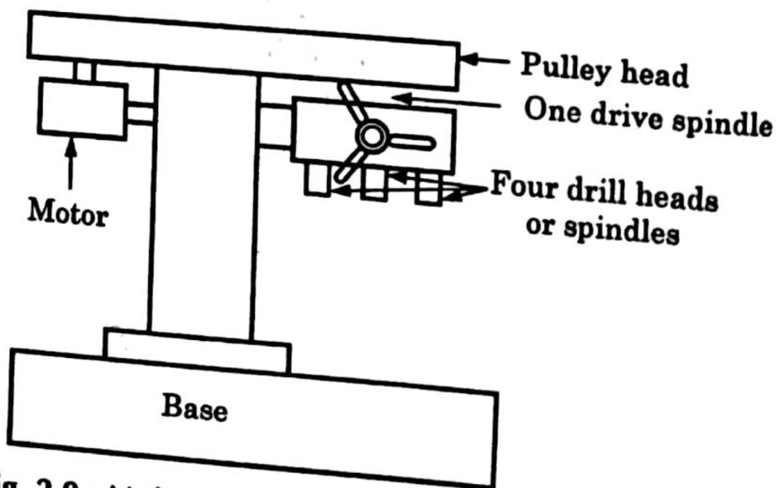


Fig. 2.9 : Multiple Drill Head Drilling Machine

These machine are subdivided into two groups :

(*i*) Non-adjustable spindle machine,

(*ii*) Adjustable spindle machine.

(*i*) **Non-Adjustable Spindle Drilling Machine :** In this machine, the motion is transmitted to the drilling spindle by an electric motor and appropriate gearing. The multiple spindle head can move up and down. The worktable can also move up and down along the ways on the column. The drilling spindles have a fixed position in the head designed for drilling the holes in a definite work piece. The spindle head can be replaced by another head designed for some other workpiece or to perform some other operations. Different spindles in such a head may run at different speeds, but they all have the same feed. A non-adjustable multi-spindle machine is shown in fig. 2.10.

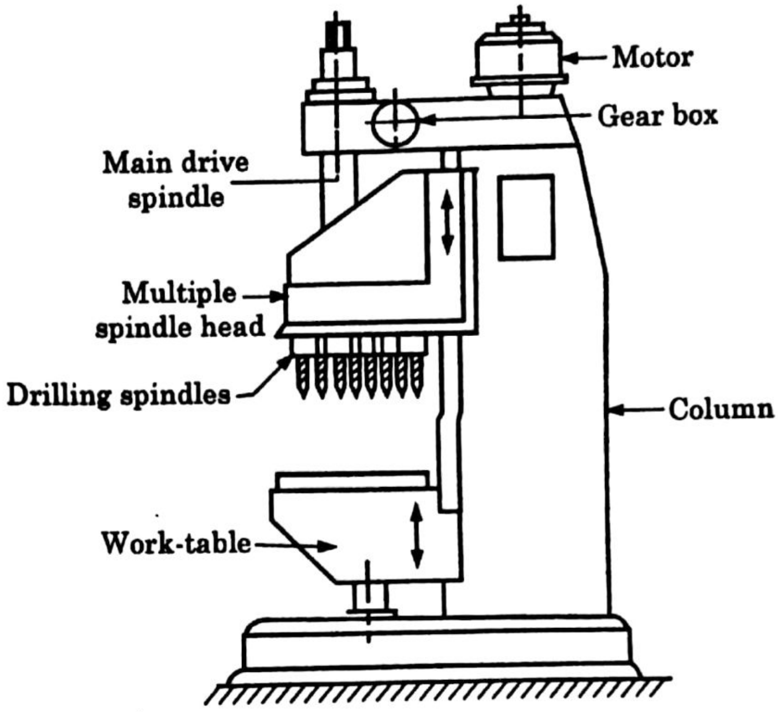


Fig. 2.10 :Non-Adjustable Multi-Spindle Drilling Machine

(*ii*) **Adjustable Spindle Drilling Machine:** The drilling head of a multiple spindle machine with adjustable spindle is shown fig. 2.11.

These types of machines are used for batch-production work. The drill spindles are driven from the main drive spindle through A_1, A_2 and through the universal joints and telescopic shaft as shown in fig. 2.11. This arrangement enables the offset spindles to be driven. The drill spindles are mounted in a plate which has slots in various directions along which the spindles can be adjusted. Consequently, drill spindles can be positioned in the plate as required for a certain workpiece. They can be readjusted to other position for drilling some other workpiece.

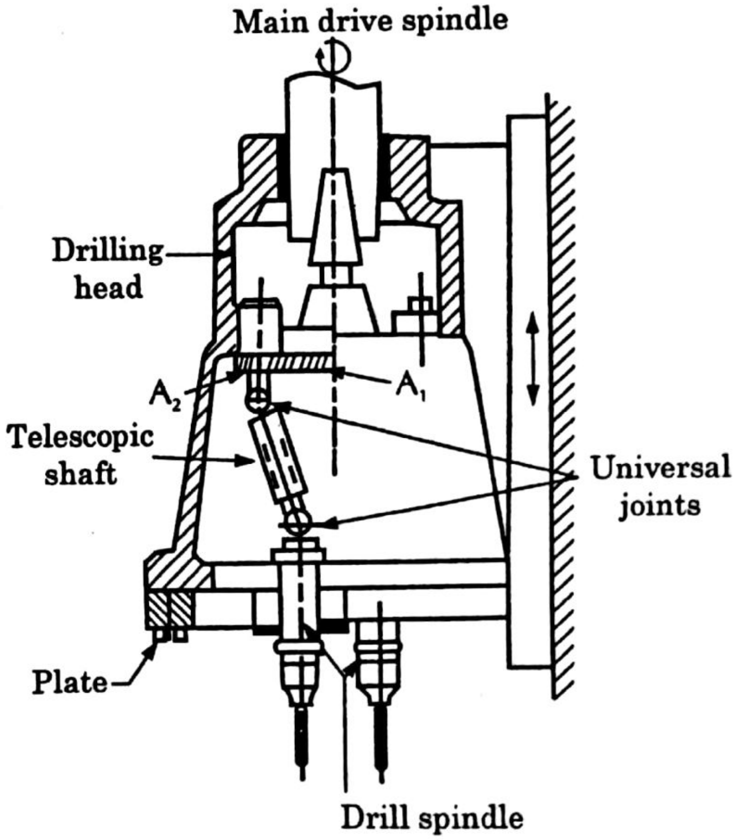


Fig. 2.11 : Adjustable Multiple-Spindle Drilling Machine

6. Gang Drilling Machine : This drilling machine derives its name from the fact that drilling machines are in gang *i.e.* three or more drilling machines of bench type are mounted in a line on a common table. Each drilling machine is provided with individual motor so that speed and feed of each drill spindle can be controlled independently. This drilling machine is a modification of a sensitive or upright drilling machine and used for mass production.

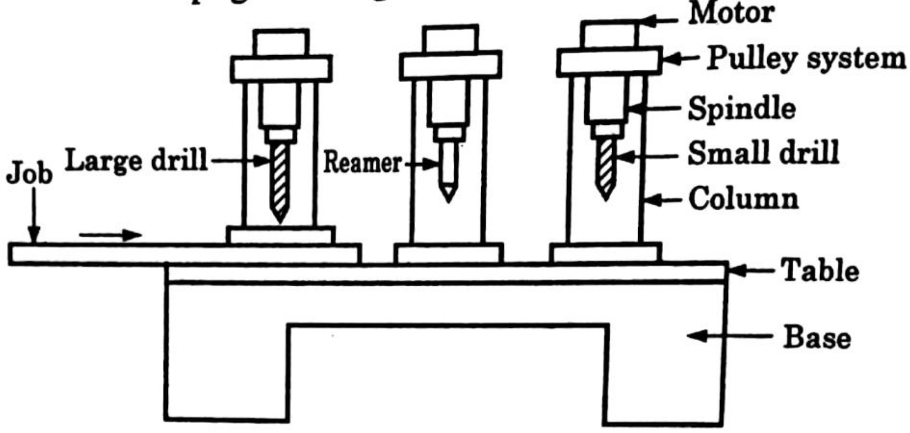


Fig. 2.12 : Gang Drilling Machine

The different spindles can be provided with different tools. e.g. one with a twist drill, another with a reamer and another with a small drill. A gang drilling machine with job is shown in fig. 2.12.

7. Deep Hole Drilling Machine : This is used where very long holes of relatively smaller diameter are required on jobs such as long shafts, long spindles and rifle barrels. This machine may be horizontal or vertical. However, horizontal machine is in common use. This machine may be compared to a lathe used for long jobs. Accordingly, job is held between head stock supported by a carriage so that no deflection takes place and rotated. The drill is also rotated and fed into the job and a good amount of lubricant is applied to flush away the chips. Fig. 2.13 shows the deep hole drilling machine.

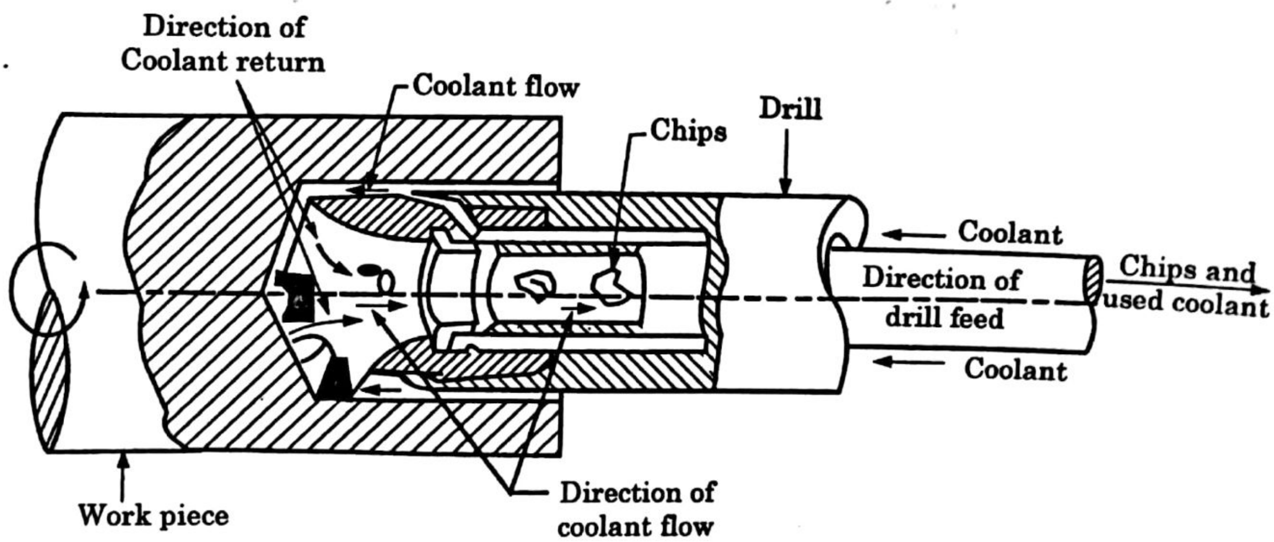


Fig. 2.13 : Deep Hole Drilling on a Horizontal Machine

8. **Automatic Drilling Machine :** These machines are used for mass production. These are arranged in series to perform a number of different operations in sequence at successive work station. The workpieces, after completion of an operation at one station, are automatically transferred to the next station for another operation. Different operations like drilling, boring, tapping, milling etc. can be performed on a job in succession on these machines. It works as a transfer line.

2.4 SIZE AND SPECIFICATION OF A DRILLING MACHINE

Size : *The size of a portable drilling machine is the maximum diameter of the drill in mm which it will hold. In case of radial drilling machine, the size is the length of the radial arm in mm.*

Specifications : The various parameters considered while selecting the drilling machine are as follow :

1. Size of drilling tool (maximum and minimum).
2. Maximum size of table and base.
3. Spindle size and feed.
4. Maximum distance between spindle nose and table or base.
5. Taper size in the spindle socket.
6. Number of components to be machined.
7. Maximum power of the main drive motor.
8. Maximum axial travel and swivel of spindle.

2.5 VARIOUS OPERATIONS ON DRILLING MACHINE

There are various operations which can be performed on a drilling machine in addition to the drilling operation for which a drilling machine is primarily made. The operations which are performed most frequently on a drilling machine are given as below :

1. Drilling,
2. Spot facing,
3. Reaming,
4. Boring,
5. Counter boring,
6. Counter-sinking
7. Hole milling,
8. Tapping,
9. Grinding,
10. Trepanning,
11. Buffing,
12. Core drilling,
13. Step drilling.

1. **Drilling :** *It is the process of generating the holes in a workpiece by removing the solid metal from it.* (See fig. 2.14).

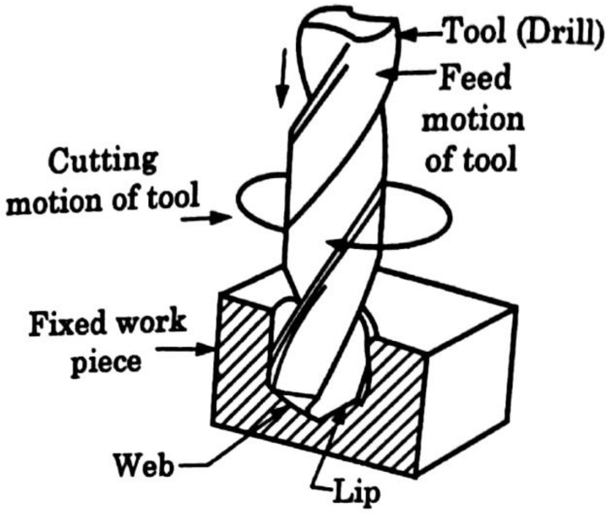


Fig. 2.14 : Drilling

2. **Spot Facing :** *Spot facing is the operation of producing a flat round surface usually around a drilled hole to give a good bearing surface for a screw or bolt head.* The spot that is faced may be a circular raised pad on a casting or merely the surface around a bolt hole. Spot facing may be done by special spot facing tool shown in fig. 2.15.

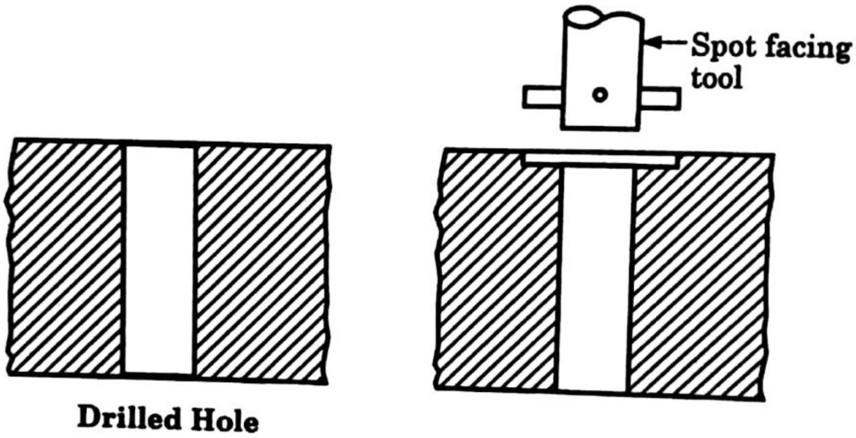


Fig. 2.15 : Spot Facing

3. **Reaming :** After drilling, reaming is the most common operation performed on a drilling machine. A reamer is similar to the twist drill, but has straight flutes. *Reaming is done to bring the already drilled hole to a proper and accurate size, because accurate hole is rarely obtained by drilling alone and chances are there that the hole may become oversize.* (See fig. 2.16).

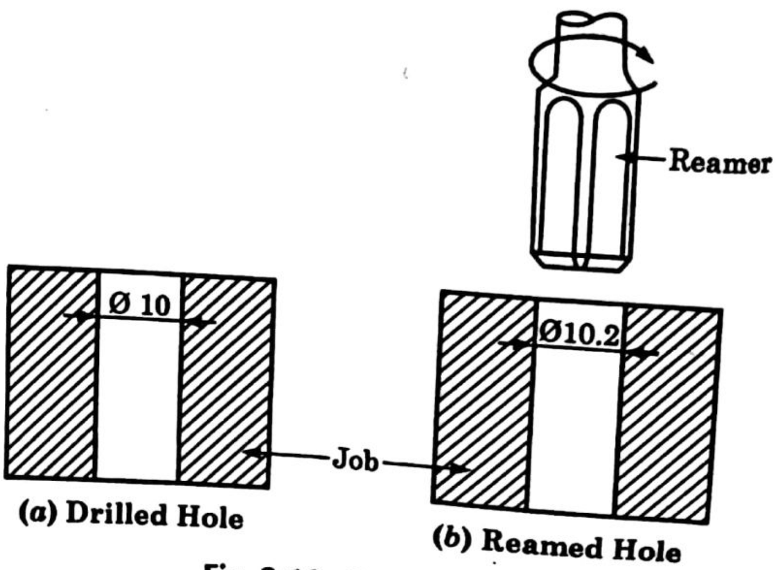
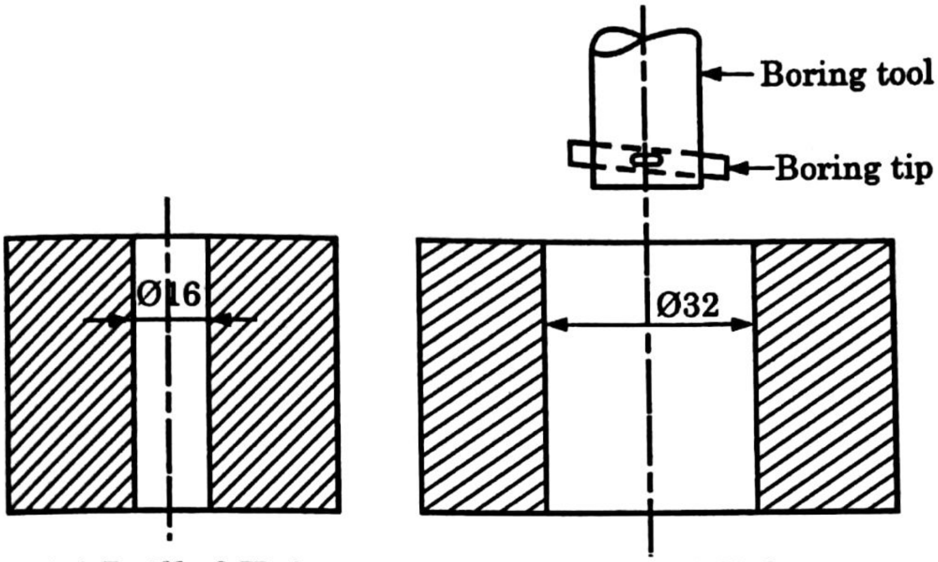


Fig. 2.16 : Reaming

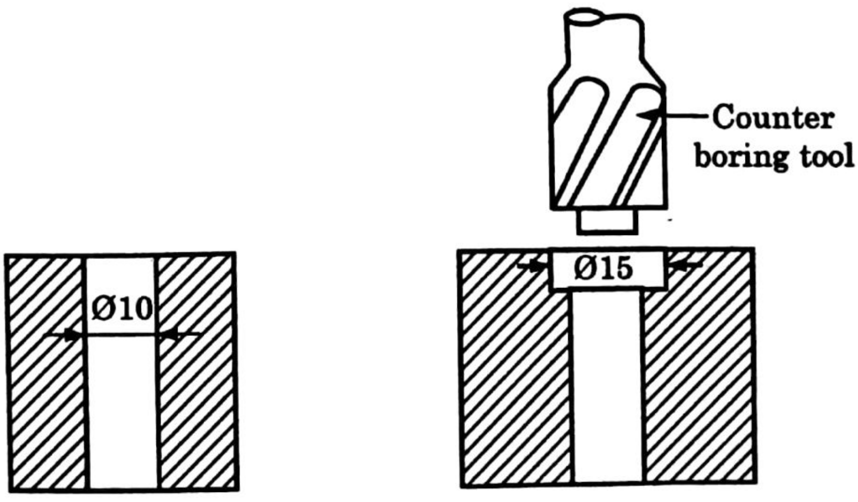
4. **Boring :** *Boring is done on a drilling machine to increase the size of an already drilled hole.* If the drill of very large diameter is used, it is very costly and accordingly, will require heavy duty drilling machine. However, by making use of boring tool, the hole can be enlarged to a good extent without any significant increase in cost. The operation is shown in fig. 2.17.



(*a*) Drilled Hole (*b*) Bored Hole

Fig. 2.17 : Boring

5. **Counter-boring :** *Counter-boring is done to increase the size of a hole at one end only through a small depth* as shown in fig. 2.18. This is used for enabling the bolt/screw/ stud head to sit properly so that it does not interfere with the job when it is assembled with other mating surface.



(*a*) Drilled Hole (*b*) Counter Bored Hole

Fig. 2.18 : Counter-boring

6. **Counter Sinking :** *It is the operation used for enlarging the end of hole to give it a conical shape for a short distance.* It is done by using a countersunk tool shown in fig. 2.19. The countersunk holes are used when the counter-sunk screws are to be screwed into the holes so that their top faces have to be in flush with the top surface of the workpiece.

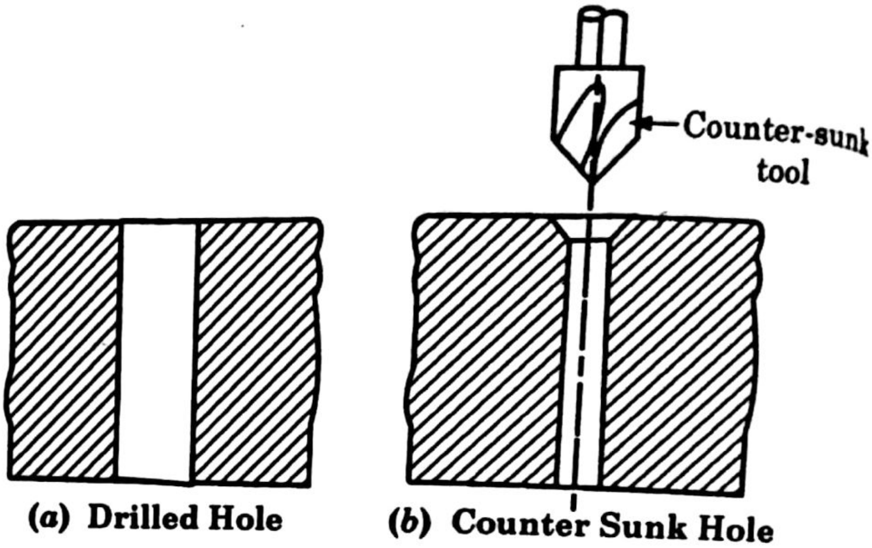


Fig. 2.19 : Counter Sinking

7. **Hole Milling :** It is done by mounting an end mill in the spindle of the machine and holding the work properly. Hole milling operation can also be done in a drilling machine.

8. **Tapping :** The tapping shown in fig. 2.20. *It is the process of cutting internal threads with thread cutting tool called tap. A tap is a fluted threaded tool used for cutting internal threads.* Before tapping, a hole slightly smaller than the tap is drilled. For cutting the threads, the tap is fitted in the tapping attachment which in turn is mounted in the drilling machine spindle and the threads are cut in the same way as drilling.

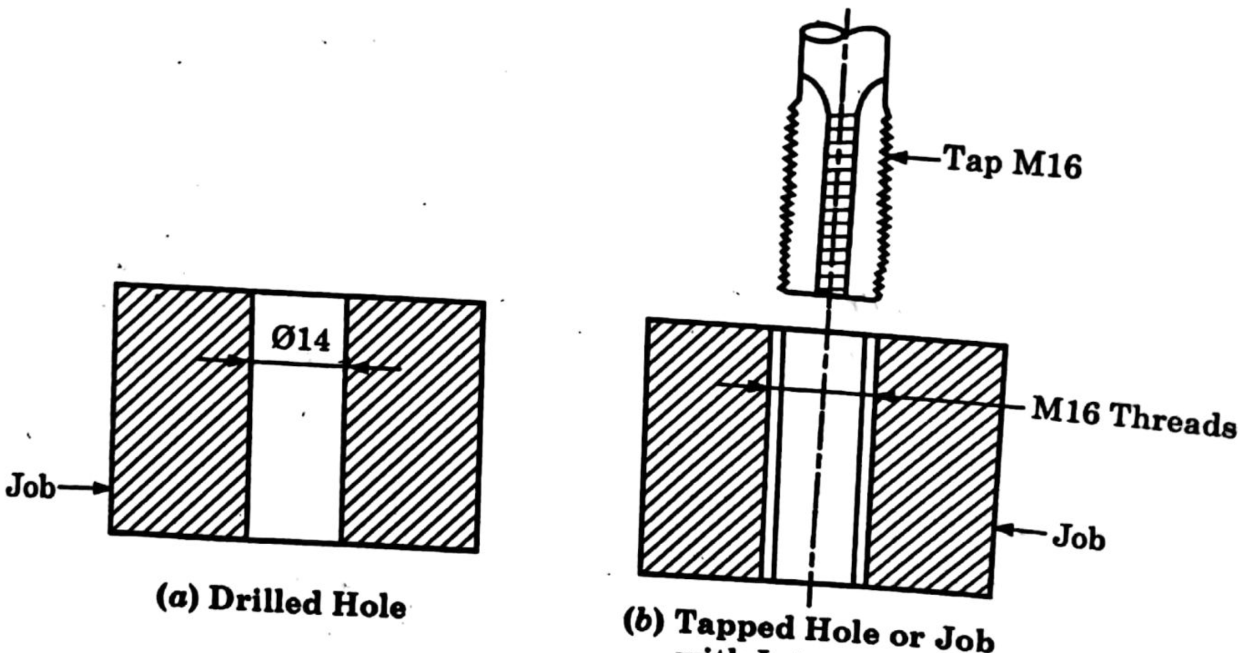


Fig. 2.20 : Tapping

9. **Grinding :** Grinding operation can be done on the drilling machine. For this, a cup grinding wheel is mounted in the drill chuck. The work is held in vice. This arrangement helps in performing simple surface grinding operation.

10. Trepanning : It is also known as circle cutting operation. *In this operation, an annular groove is produced leaving a solid cylindrical base in the centre.* A cutter consisting of one or more cutting edges placed along the circumference of a circle is used to produce the annular groove as shown in fig. 2.21. It is used for holes more than 50 mm in diameter.

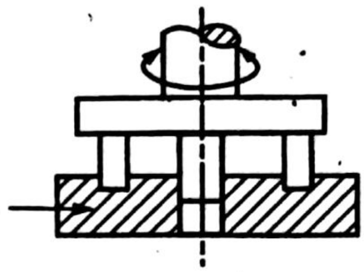


Fig. 2.21 : Treppanning

11. Buffing : It is done with the help of a buffing tool. In this operation, a buffing wheel is mounted in drill chuck in the spindle of the drilling machine. Holding the work properly on the machine table, buffing/polishing operation can be done.

12. Core Drilling : *It is the operation of enlarging an already existing hole with the help of a drilling tool* as shown in fig. 2.22.

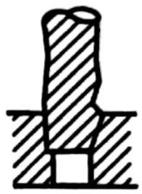


Fig. 2.22 : Core Drilling

13. Step Drilling : *When a hole of two or more diameters is cut by one drill, the operation is called step drilling.* For this, multiple diameter drills are used as shown in fig. 2.23.

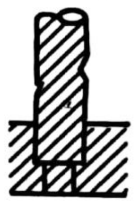


Fig. 2.23 : Step Drilling

2.6 CUTTING PARAMETERS IN DRILLING

1. Cutting Speed : *Cutting speed of drill is the speed at which it revolves which is expressed in r.p.m.* This can be converted into linear speed also. Cutting speed is zero at the tool centre and maximum at the periphery of the tool. The amount of feed per revolution usually varies between 0.05 mm to 0.38 mm upto 25 mm diameter drills. The cutting speed is given by

$$V = \frac{\pi DN}{1000} \text{ m/min.}$$

where D = Diameter of drill in mm,

N = Rotational speed of drill (r.p.m.).

The cutting speed depends upon many factors as follow :

(*i*) Material to be cut.

(*ii*) Material of the cutting tool.

(*iii*) Type of finishing required.

(*iv*) Type of coolant used etc.

Table 2.1 shows the different cutting speeds for different materials with H.S.S. drill.

Table 2.1: Cutting Speeds for Drilling with H.S.S. Drill

Material	Cutting Speed (m/min.)
1. Aliminum and its alloys	60 – 90
2. Bronze and brass (Soft)	60 – 90
3. Bronze (High tensile)	20 – 45
4. Cast iron (Soft)	30 – 45
5. Cast iron (Hard)	20 – 30
6. Magnesium and its alloys	80 – 125
7. Malleable iron	25 – 30
8. Mild steel (0.2 to 0.3 % C)	25 – 35
9. Steel (0.4 to 5% C)	20 – 25
10. Steel (1.2 % C)	15 – 20
11. Stainless steel	8 – 12
12. Glass (With carbide drills)	5 – 10

2. Feed : *Feed is the distance travelled by a drill along its axis into the work piece during its one revolution.* This is usually expressed in mm/rev. If N is the number of revolutions made per minute by the drill, then

Feed in mm/min. = Feed in mm/revolution × N

The following factors govern the amount of feed to be provided :

(*i*) Workpiece material.
(*ii*) Depth of drilling.
(*iii*) Speed of the drill.
(*iv*) Drill size.
(*v*) Power of the motor.
(*vi*) Degree of surface finish required.

Table 2.2 shows the different feeds for different diameters.

Table 2.2 : Feed For Drilling

Diameter of Drill (mm)	Feed (mm/revolution)
Under 3	0.025 to 0.05
3 to 6	0.05 to 0.1
6 to 12	0.1 to 0.175
12 to 25	0.175 to 0.375
25 and over	0.375 to 0.625

3. **Depth of Cut :** *It is the distance measured at right angle to the axis of the drill i.e. the direction of feed and is numerically equal to one-half of the diameter of the drill.* It can be expressed as under :

$$\text{Depth of cut, } t = \frac{\text{Drill diameter}}{2} = \frac{D}{2} \text{ mm}$$

If the process is hole enlarging, then

$$t = \frac{D_1 - D_2}{2}$$

where D_1 = Diameter after enlargement,

D_2 = Diameter before enlargement.

4. **Machining Time :** This can be calculated as follows :

Let N = Speed of the drill (r.p.m.),

d = Diameter of the drill in mm,

f = Feed in mm/rev.,

T_m = Machining time in min.,

L = Length of axial travel of drill in mm,

l = Depth or thickness of workpiece,

a = Approach of drill = 0.3 d.

$$\therefore \quad T_m = \frac{L}{N.f} \text{ min} .$$

2.7 TYPES OF DRILLS

A cutting tool generally fluted used to generate or enlarge a hole in a solid material is known as a drill. There are various types of drills in order to meet the various requirements of domestic and industrial nature. The various drills are listed and explained as follow :

1. Flat or spade drill.
2. Straight fluted drill.
3. Twist drills :
   (*i*) Standard twist drill,
   (*ii*) Multi-fluted drill or core drill,
   (*iii*) Oil drill.
4. Centre drill.
5. Special drills :
   (*i*) Gun drill,

(*ii*) Square drill,

(*iii*) Step drill.

1. Flat or Spade Drill : This drill resembles with double edged knife. In the beginning of civilization, it was used and now it has become almost obsolete, because it does not give true size of drilled hole and very frequent grinding of the nose is needed. A flat drill is shown in fig. 2.24.

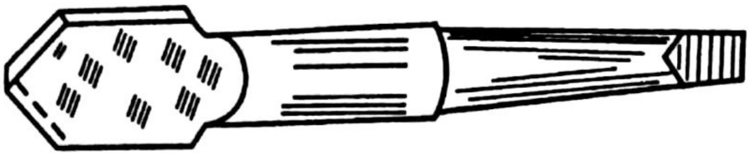


Fig. 2.24 : Flat Drill

2. Straight Fluted Drill : Fig. 2.25 shows a straight fluted drill. This drill is provided with two flutes (back to back) which are straight and run parallel to the drill axis.

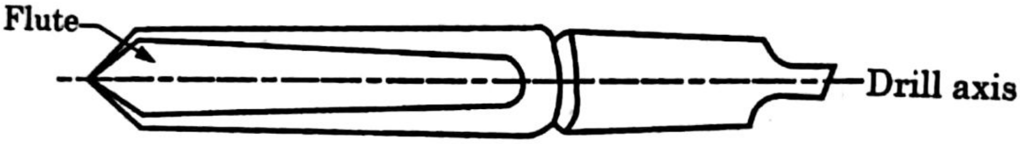


Fig. 2.25 : Straight Fluted Drill

This drill is used for the following types of jobs :

(*i*) Jobs of soft material like brass, aluminium, copper etc.

(*ii*) Sheet metal jobs which cannot be worked upon by generally used twist drill as they dig in and try to lift the sheet, thus spoiling the job.

3. Twist Drill :

(*i*) Standard Twist Drill : This drill is provided with two spiral flutes running around the drill body so that the drill looks as if it has been twisted.

This drill works on the principle of single point cutting tool and is very widely used. It is usually made of high speed steel. However, a cheaper variety is made of high carbon steel also. It is made in various sizes to suit the work and is provided with either a tapered shank or parallel shank.

The flutes (grooves) of a twist drill perform the following functions :

(*a*) It allows the cutting fluid to reach the cutting edges.

(*b*) It is helpful in the removal of chips.

(*c*) It forms correct and efficient lips at the point.

Fig. 2.26 shows a twist drill.

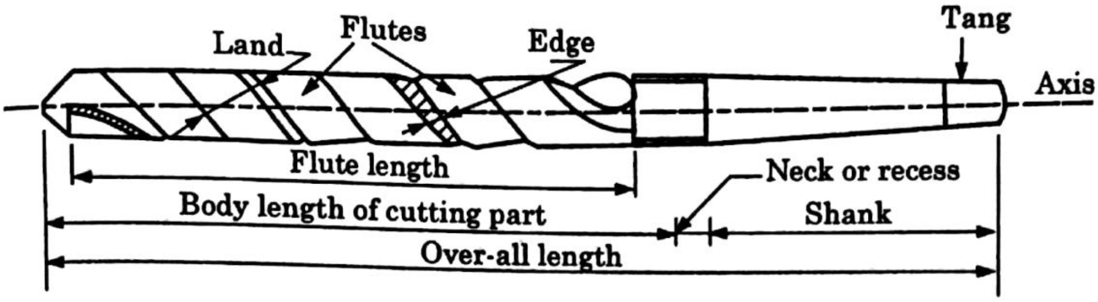


Fig. 2.26 :Twist Drill (Shown with its Principal Parts)

(ii) **Multi Fluted or Core Drill :** This drill is provided with three or more spiral flutes and is needed for widening the cored, punched or drilled holes. Fig. 2.27 shows a core drill. Core drills are not in common use.

Fig. 2.27 : Core Drill

The core drill has the following characteristics :

(*a*) It is used for machining cored holes in casting and forging.

(*b*) It is used for enlarging previously drilled holes.

(*c*) It has three or four flutes.

(*d*) It is made of carbon steel.

(iii) **Oil Hole Drill :** Fig. 2.28 shows an oil hole drill. This drill is similar to two flute twist drill. However, there is a provision of hole which starts from the shank and ends till the tip. In this, oil can be supplied which keep the drill cool when this drill is used for deep holes.

Fig. 2.28 : Oil Hole Drill

These drill are made for cutting deep holes and are used in drilling machines, lathes and special deep-hole drilling machines.

4. Centre Drill : It is a small drill used for drilling and counter sinking each end of the job (specially shaft, stud, axle etc.) which is to be turned between lathe centres. Fig. 2.29 shows a centre drill. The hole so made at the end functions as a bearing surface for the lathe centres.

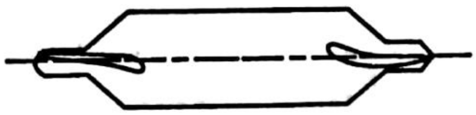
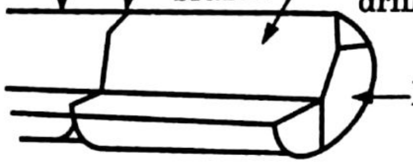


Fig. 2.29 : Centre Drill

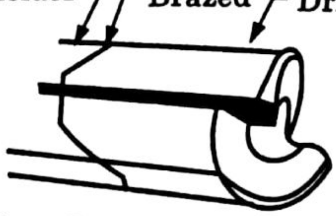
5. Special Drill :

(*i*) **Gun Drill** : Fig. 2.30(*a*) illustrates two types of gun drills. In single flute gun drill, a hole is provided for the passage of pressurised cutting fluid, which is used for cooling and also flush out the chips. These drills are effective for low-carbon steel or other tough materials.

Two-fluted pin-cutting gun drill has an off centre coolant through hole in the moulded carbide tip which generates a pin. Gun drills are used to produce true holes to depths and tolerances not obtainable with ordinary drills.



(*i*) **Single Fluted Gun Drill**



(*ii*) **Two Flute Pin-Cutting Gun Drill**

Fig. 2.30 (*a*) : Gun Drills

(*ii*) **Square Drill** : Fig. 2.30(*b*) shows such a type of drill. Holes of any symmetrical shape such as hexagonal, octagonal, triangular or square may be drilled with the help of these drills. In case of blind holes or where the cost of broaching operation would be very high, drilling may be used for making symmetrical holes.

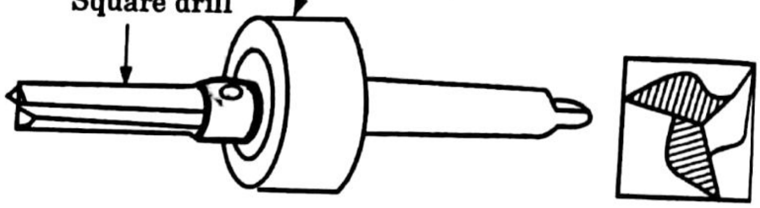


Fig. 2.30(*b*) : Square Drill

The square drill is a three-sided drill. This consists of a special floating chuck, a guide plate and the special drill. Generally, a pilot hole is drilled first to reduce the load on the square drill. The drill cuts on the end like a conventional drill.

(*iii*) **Carbide-Tipped Drills.** For drilling small size holes, solid carbide drills are used as these are very rigid, have high resistance to vibrations and these produce true and clean holes. In bigger size, these are made by brazing the carbide tip to the drill body of hardened alloy steel. These drills are used for drilling cast and malleable iron, non ferrous metals like aluminium and magnesium, copper and brass alloys and non-metallic compounds like rubber and fibre.

2.8 NOMENCLATURE OF A TWIST DRILL

Twist drill is the most widely used in modern drilling practice. It consists of a cylindrical body carrying two spiral flutes cut on it. Fig. 2.31 shows the principle parts of a twist drill and nomenclature of twist drill. The principle parts of a twist drill are as follow :

1. Body,
2. Shank,

3. Point,
4. Tang,
5. Lips,
6. Margin,
7. Flutes,
8. Dead centre,
9. Web.

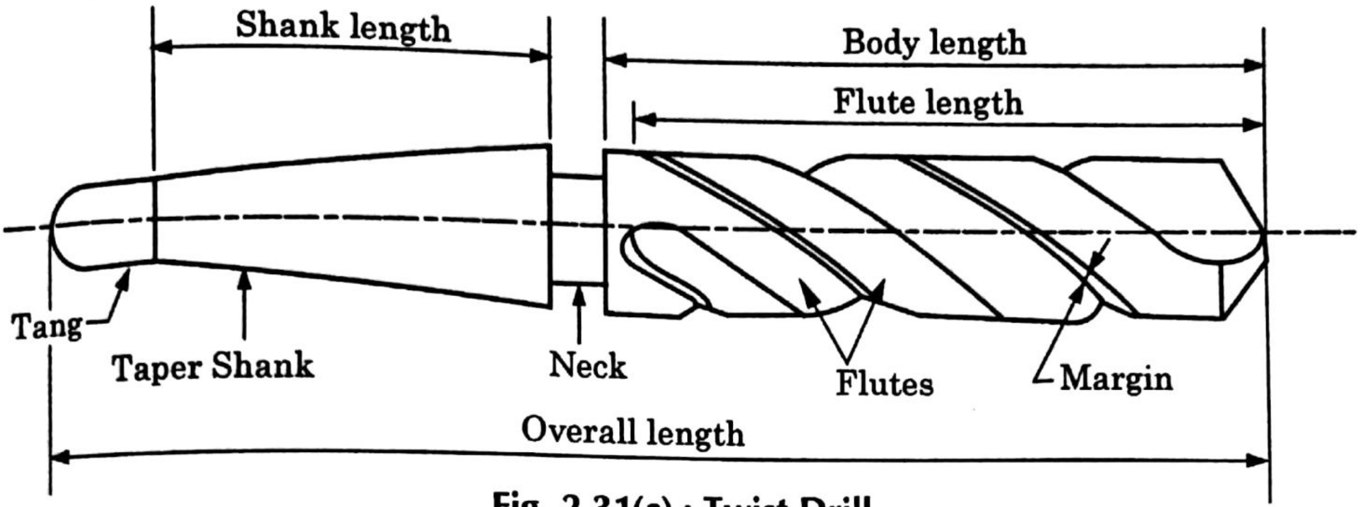


Fig. 2.31(a) : Twist Drill

1. **Body :** *It is the part of the drill that is fluted and relieved.*
2. **Shank :** *It is the part of drill which is gripped in the drill chuck or sleeve.*
3. **Point :** *It is the conical part of the drill. Cutting lips are ground on the point.*
4. **Tang :** *The flattened end of the taper shank is known as tang.*
5. **Lips :** *The cutting edges of the drill are known as lips.* Both lips should have equal length, same angle of inclination, correct clearance and should be symmetrical with the axis of the drill for efficient cutting.
6. **Margin :** *It is the narrow surface along the groove that determines the size of the drill and keeps the drill aligned.* The diameter of the margin at the shank end of the drill is 0.01 to 0.05 mm which is smaller than the diameter at the points. This allows the drill to revolve without bending while drilling deep holes.
7. **Flutes :** *These are the helical grooves cut or formed in the body of the drill to provide cutting edges and permit the removal of chips.* There also allow the cutting fluid to reach the cutting edges.
8. **Dead Centre :** *It is the sharp edge at the extreme tip end of the drill.*
9. **Web :** *It is the metal column in the drill which separates the flutes.* It runs through the entire length of the drill between the flutes and the supporting section of the drill. It is, in fact, is the back bone of the drill. It gradually increases in thickness towards the shank. This thickness provides the rigidity to the drill.

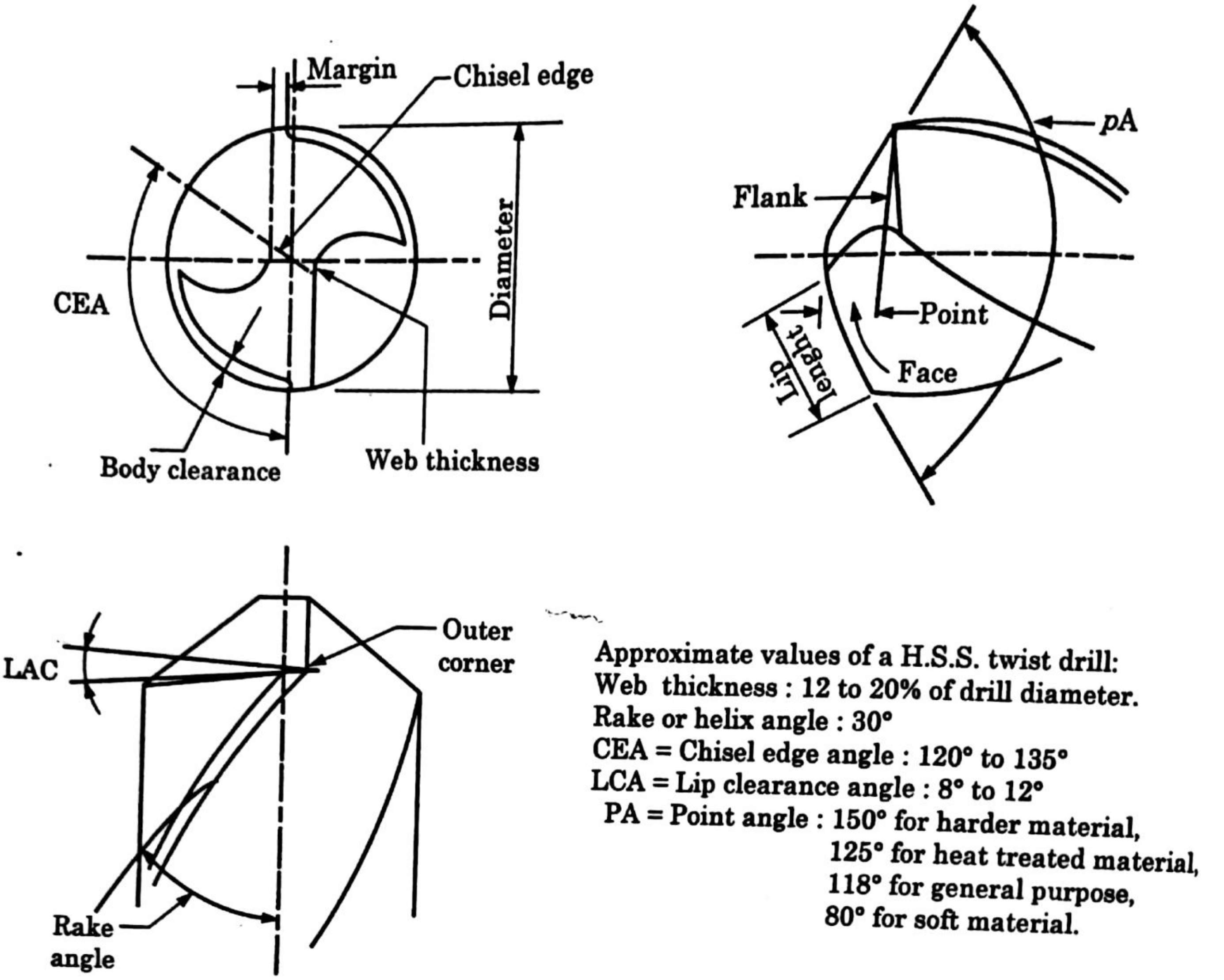


Fig. 2.31 (*b*) : Twist Drill Nomenclature

2.9 TERMINOLOGY RELATING TO A TWIST DRILL

1. **Axis :** *It is the longitudinal center line of the drill.*

2. **Body Clearance :** *A small reduction in the diameter of the body is provided on a drill adjacent to the land. This is called body clearance.*

3. **Heel :** *An edge is formed where the body clearance and flute of the drill intersect. This edge is known as heel.*

4. **Face :** *It is that portion of the flute surface adjacent to the lip on which the chip emerges as it is cut from the work.*

5. **Flank :** *It is the curved surface on either side of dead centre which is confined between the cutting edge on its one side and the face of the other flute on the other side.*

6. **Lead of Helix :** *It is defined as the axial distance measured between two corresponding points on a flute in its one complete turn.*

7. Lip length : *The distance between the chisel edge corner and the outer corner is called lip length.*

8. Diameter of the Drill : *It is the measurement across the cylindrical margins (lands) at the outer corners of the drill.*

2.10 IMPORTANT ANGLES OF A DRILL

1. Rake Angle : *It is the angle between the face and line parallel to the drill axis and is equal to the helix angle at the periphery .*

2. Helix Angle : *The angle between the drill axis and the leading edge of the land is called helix angle.*

3. Lip Relief Angle : *It is the angle formed by the flank and a plane at right angle to the drill axis. This angle is generally measured at the periphery of the drill.* Its value varies from 8° to 15° for most of the drill, but 12° is the most common value.

4. Point Angle : It is also known as cutting angle. *It is the included angle of the cone formed by the lip.* For general work, it is 118° on a standard twist drill. However, it varies from 80° to 140°. Smaller point angle is used for brittle materials and the larger one for harder and tougher materials.

5. Chisel Edge Angle : *When a drill is viewed from its end, it appears to be an obtuse angle formed between the lip and the chisel edge. This angle is called chisel edge angle.*

Table 2.3 gives important drill angles for different materials.

Table 2.3 : Recommended Values of Principal Drill Angles

Material to be Drilled	Included Cutting Angle or Point Angle	Lip Clearance Angle	Helix Angle or Rake Angle	Chisel Edge Angle
Aluminum (Pure)	80° – 120°	8° – 12°	24° – 48°	120° – 135°
Cast iron (Soft)	118°	8° – 12°	24° – 32°	120° – 135°
Cast iron (Hard)	118°	8° – 12°	24° – 32°	120° – 135°
Brass	118°	8° – 15°	0° – 18°	120° – 135°
Copper	120° – 140°	8° – 15°	28° – 40°	120° – 135°
Steel	118°	8° – 12°	24° – 32°	120° – 135°
Stainless steel	120° – 140°	10° – 12°	24° – 32°	120° – 135°
Aluminium alloys	140°	8° – 12°	20° – 40°	120° – 135°
Plastics and hard rubber	80°	8° – 12°	24° – 32°	120° – 135°
Pure nickel	118°	10° – 12°	24° – 32°	120° – 135°

2.15 DRILL HOLDING METHODS AND DEVICES

Various methods and devices of holding drills in the drilling machine are as follow :

1. **Direct Fitting :** The drill may be held directly in the spindle of the machine. The spindle of drilling machine is provided with a Morse standard taper hole of the size in proportion to the drilling size of the machine. The bigger size drills have shanks which will fit in the spindles. Fig. 2.32 shows an assembly of socket, drill, spindle and drift.

2. **Sleeve and Socket :** The shank of the drill is too small to fit in the taper hole in the spindle. It is first held in the sleeve which has a taper hole and then the shank of the sleeve fits into the spindle hole.

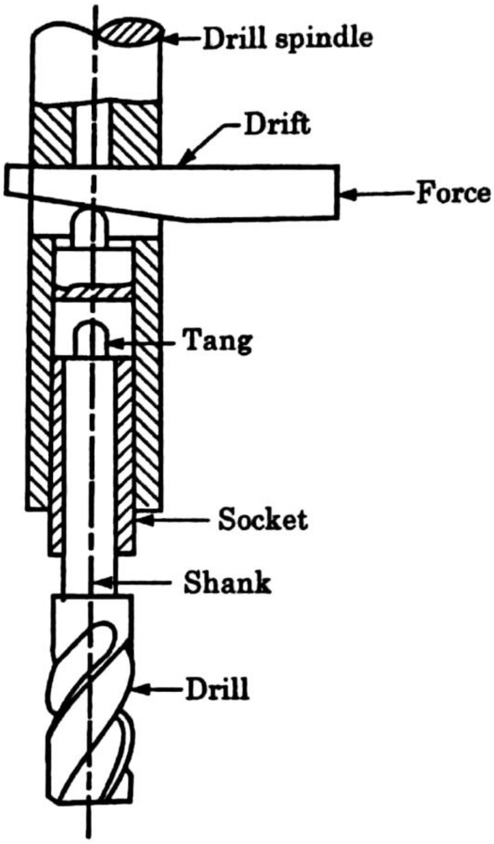


Fig. 2.32 : An Assembly Showing Drill, Socket and Drill Spindle With drift

The sleeve can be forced into spindle taper of same size and after drilling, it can be removed by using drift through key slot.

When taper shank is larger than the spindle taper, then drill socket is used to hold the tool. The shank of socket fits into spindle of drilling machine and same can be removed out by forcing the drift. Fig. 2.33 shows the drill sleeve, socket and drift.

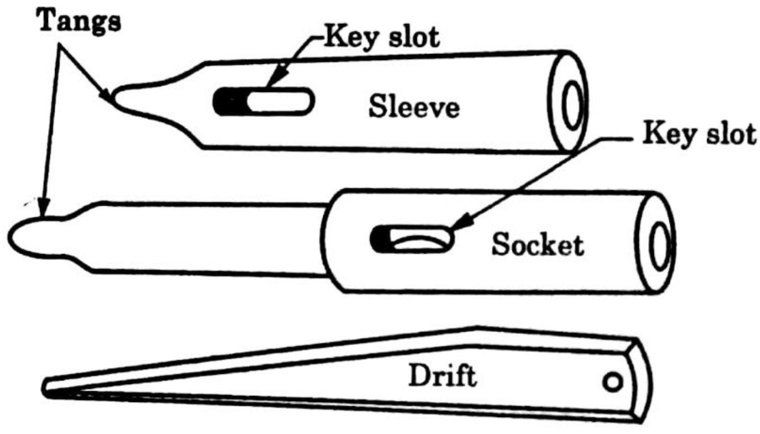


Fig. 2.33 : Drill Sleeve, Socket and Drift

3. Collet Chuck : A type of collet chuck is shown in fig. 2.34. This chuck consists of a body with a taper shank at one end for holding the chuck in the drilling machine spindle and a threaded and taper-bored cylindrical section of larger diameter at the other end. A collet which has internal threads is screwed into the threaded portion of the chuck body. The leaves of the spring collet are contracted, thereby clamping the drill shank. The drill is released by turning the clamping collar in the opposite direction.

4. Drill Chuck : A drilling chuck is a gripping device with two or more adjustable jaws set radially to hold straight shank drills or other cutting tools and is provided with a taper shank which fits in the taper hole of the spindle. It is popular with the name of Jacop's chuck. Fig. 2.35 shows a drill chuck.

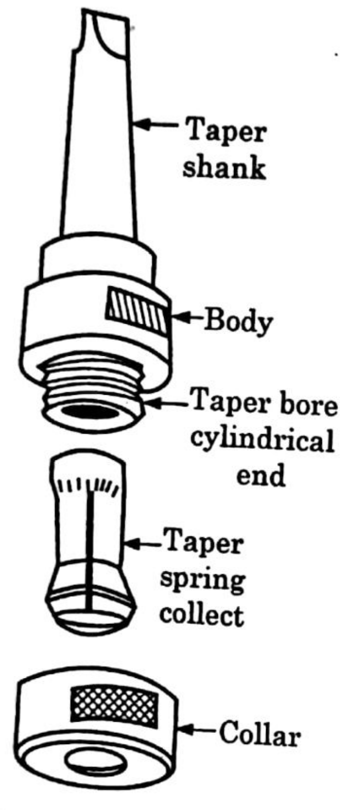


Fig. 2.34 : Collect Chuck

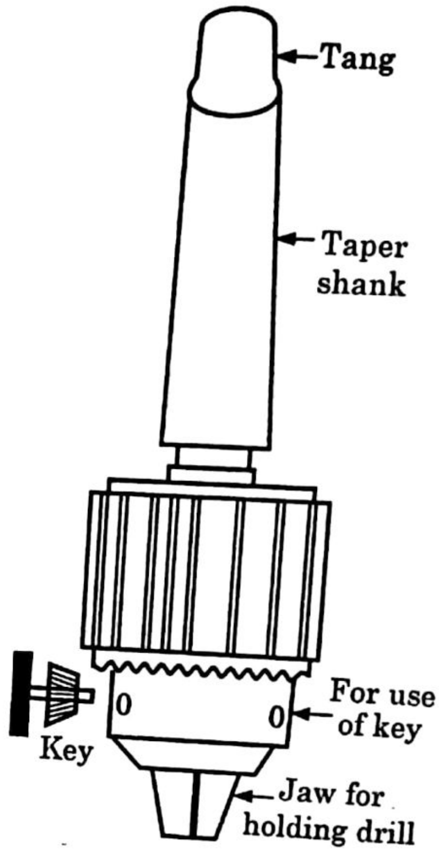


Fig. 2.35 : Drill Chuck

5. Self Centering Chuck : The straight shank drill can be held in a drill chuck and the taper shank of the chuck fits into the spindle taper. A self centering drill chuck is particularly adopted for straight shank tools. Three slots are cut at 120° apart in the chuck body which houses three jaws having threads cut at the back that meshes with a ring nut. Ring nut is attached to the sleeve. Bevel teeth are cut all around the sleeve body. The sleeve can be rotated by a key having bevel teeth on its face. This rotation of the sleeve causes the ring nut to rotate in the fixed position and all the three

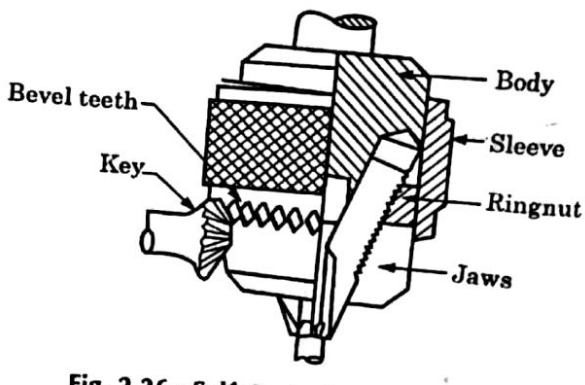


Fig. 2.36 : Self Centering Drill Chuck

jaws close or open by the same amount from the centre holding or releasing the shank of the tool. A self centering drill chuck is shown in fig. 2.36.

2.16 REAMERS

A reamer is a multi-point rotary cutting tool used for enlarging or finishing a hole previously formed to accurate dimensions. Reamers have two or more flutes which may be parallel to axis or in a right or left-hand helix. The material removed by the process of reaming should be around 0.5 mm and for accurate work should not exceed 0.15 mm.

The size of the reamer is specified by the diameter measured across two margins at the cutting edge on a diametral line. Reamers may be made from high carbon steel, H.S.S., cast alloys and cemented carbide. All common forms of reamers consist of the shank, body and angle of chamfer as shown in fig. 2.37.

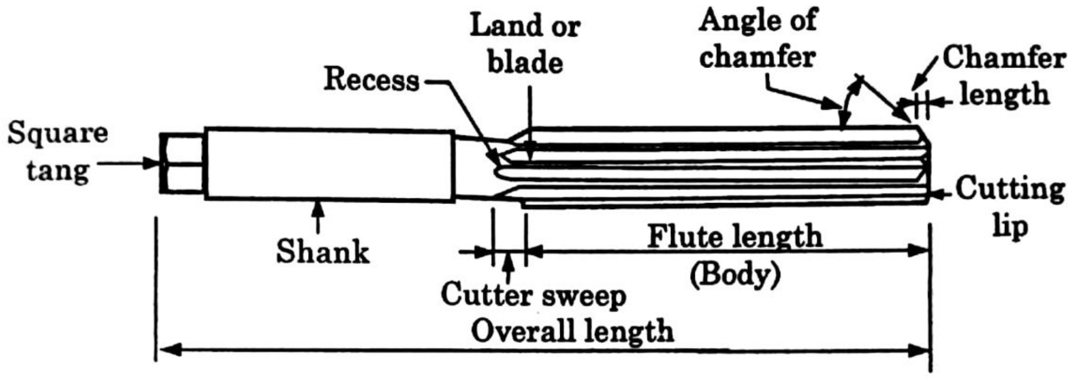


Fig. 2.37 : Reamer

2.17 TYPES OF REAMERS

The commonly used reamers are as follow :

1. Hand reamers,
2. Taper reamers,
3. Machine reamers or chucking reamers,
4. Taper pin reamers,
5. Adjustable reamers,
6. Shell reamers,
7. Expansion reamers,
8. Carbide tipped reamers.

1. Hand Reamers : Hand reamers are fluted reamers. They have a slight taper on the cutting end to facilitate entering a hole properly. They have parallel shank and square tang as shown in fig. 2.37. The tang is used to hold the reamer. Hand reamers may be solid or expandable. The teeth have clearance along their edges and thus may cut along their entire length. It should be noted that these reamers are not to be used for machine reaming in any case. In case of hand reaming, the material to be removed should not be more than 0.125 mm.

2. **Taper Reamers :** These reamers are available in different standard sizes. These are used for finishing hole to an exact taper. These are made in sets of two, one is used for roughing and other is used for finishing. These are available in both hand and machine types. Hand taper reamers have parallel shank, while the machine taper reamers may have a straight or taper shank and the tang is bevelled as usual.(See fig. 2.38).

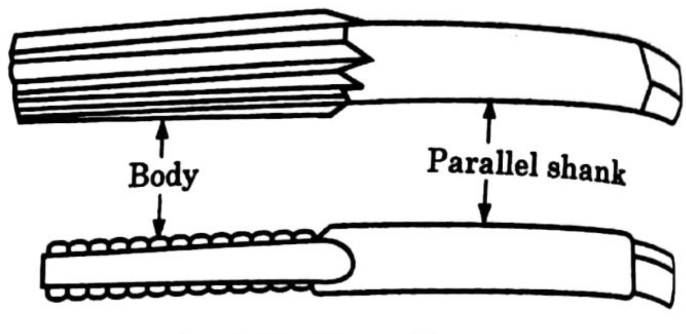


Fig. 2.38 : Taper Reamers

3. **Machine Reamers :** Two types of reamers come in this category, namely fluted reamers and rose reamers. The fluted reamers differ from the rose reamers. Fluted reamer carries more number of cutting teeth than the rose reamer for the same diameter. Mostly machine reamers have taper shank. But, these reamers may have straight flutes. Generally, machine reamers are cut with a left-hand helix, the angle made by flute with the length of the reamer varying from 4° to 8°. Fig. 2.39 shows machine reamers.

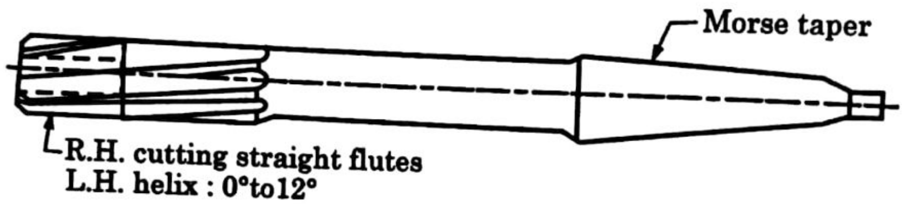


Fig. 2.39 : Fluted Machine Reamer

4. **Taper Pin Reamers :** A straight flute taper pin reamer is shown in fig. 2.40. It carries a standard taper of about 20 mm per metre along its body. These reamers are used for finishing taper pin holes of standard sizes.

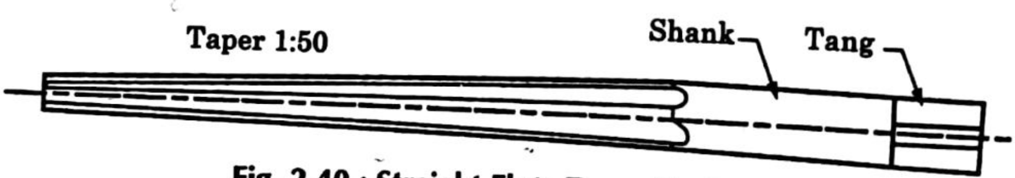


Fig. 2.40 : Straight Flute Taper Pin Reamer

5. **Adjustable Reamers :** These reamers have cutting edges in the form of blades which are locked in a body. These are available in both straight shank and taper shank types. The blades can be adjusted over a considerable large range than in the case of expansion reamers. Its blades can be easily sharpened and adjusted and have longer life. Both, high speed steel and carbides blades are used. Fig. 2.41 shows a shell type adjustable reamer.

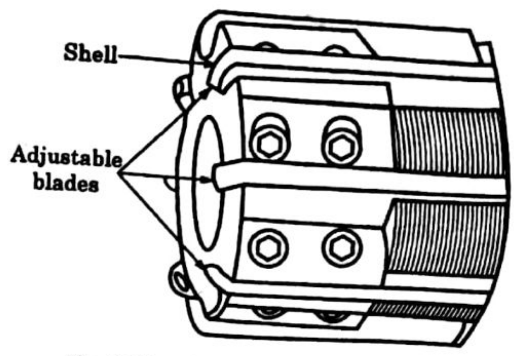


Fig. 2.41 : Shell Type Adjustable Reamer

6. Shell Reamers : These reamers are different from the solid type reamers. They do not possess the shank. Such reamers are frequently used for size over 20 mm in order to save on cutting tool material. The same arbor may be used with any number of shells and only the shell is subjected to wear and requires to be replaced when worn. The arbor may have a straight or taper shank. Two standard types of arbors and a straight fluted shell reamer are shown in fig. 2.42. The shell is usually made of high speed steel.

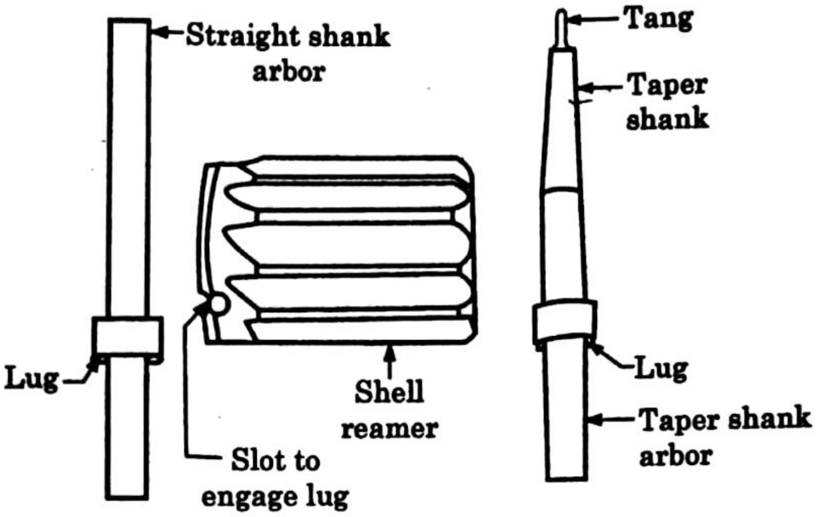


Fig. 2.42 : Shell Reamer with Arbors

7. Expansion Reamers : Expansion reamer consists of two parts : Main body and a taper plug. The main body carries the cutting teeth/flutes and a slightly taper hole inside and is slitted longitudinally to allow expansion. The taper plug is fitted at the end which, when screwed on, creates the desired expansion. The flutes may be straight or spiral (See fig. 2.43). These reamers are made both in hand and machine types. Hand reamers are oftenly used to enlarge a hole slightly in order to secure the necessary fit.

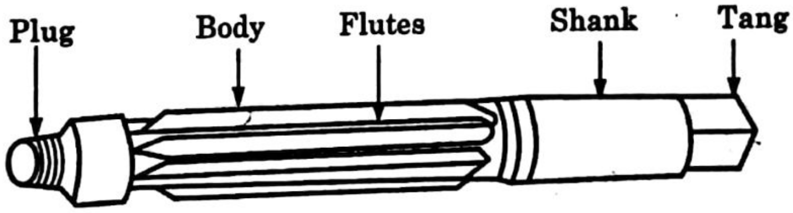
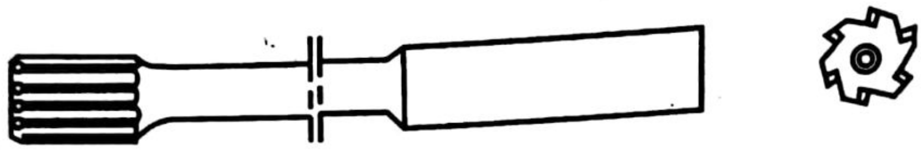
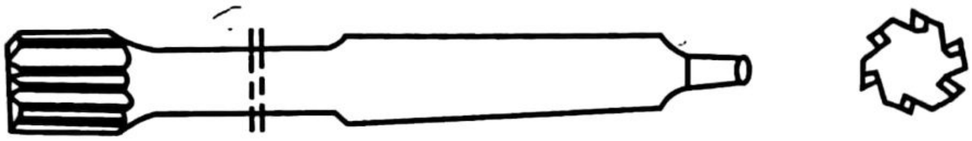


Fig. 2.43 : Straight Flute Expansion Reamer

8. Carbide Tipped Reamers : The use of carbide reamers results in high resistance to abrasion, thereby, giving longer tool life and superior finish. These are operated at 1.5 times the speed used for H.S.S. reamers. Solid carbide reamers generate a true hole around their own axis instead of following previously drilled hole. Large size reamers are made with carbide tips which are either brazed or held on a steel body. Some representive forms of carbide tipped reamers are shown in fig. 2.44.



A Parallel Shank Carbide Tipped Reamer



A Taper Shank Carbide Tipped Reamer

Fig. 2.44