DRILLING MACHINE

INTRODUCTION

Drilling is an operation of making a circular hole by removing a volume of metal from the job by cutting tool called drill. A drill is a rotary end-cutting tool with one or more cutting lips and usually one or more flutes for the passage of chips and the admission of cutting fluid. A drilling machine is a machine tool designed for drilling holes in metals. It is one of the most important and versatile machine tools in a workshop. Besides drilling round holes, many other operations can also be performed on the drilling machine such as counter- boring, countersinking, honing, reaming, lapping, sanding etc.

TYPES OF DRILLING MACHINE

Drilling machines are classified on the basis of their constructional features, or the type of work they can handle. The various types of drilling machines are:

(1) Portable drilling machine
(2) Sensitive drilling machine
    (*a*) Bench mounting
    (*b*) Floor mounting
(3) Upright drilling machine
(4) Radial drilling machine
(5) Gang drilling machine

Portable Drilling Machine

A portable drilling machine is a small compact unit and used for drilling holes in work pieces in any position, which cannot be drilled in a standard drilling machine. It may be used for drilling small diameter holes in large castings or weldments at that place it where they are lying. Portable drilling machines are fitted with small electric motors, which may be driven by both A.C. and D.C. power supply. These drilling machines operate at fairly high speeds and accommodate drills up to 12 mm in diameter.

Sensitive Drilling Machine

It is a small machine used for drilling small holes in light jobs. In this drilling machine, the work piece is mounted on the table and drill is fed into the work by purely hand control. High rotating speed of the drill and hand feed are the major features of sensitive drilling machine. As the operator senses the drilling action in the work piece, at any instant, it is called sensitive drilling machine. A sensitive drilling machine consists of a horizontal table, a vertical column, a head supporting the motor and driving mechanism, and a vertical spindle. Drills of diameter from 1.5 to 15.5 mm can be rotated in the spindle of sensitive drilling machine. Depending on the mounting of base of the machine, it may be classified into following types:

1. Bench mounted drilling machine, and
2. Floor mounted drilling machine

Upright Drilling Machine

The upright drilling machine is larger and heavier than a sensitive drilling machine. It is designed for handling medium sized work pieces and is supplied with power feed arrangement. In this machine a large number of spindle speeds and feeds may be available for drilling different types of work. Upright drilling machines are available in various sizes and with various drilling capacities (ranging up to 75 mm diameter drills). The table of the machine also has different types of adjustments. Based on the construction, there are two general types of upright drilling machine:

(1) Round column section or pillar drilling machine.

(2) Box column section.

The round column section upright drilling machine consists of a round column whereas the upright drilling machine has box column section. The other constructional features of both are same. Box column machines possess more machine strength and rigidity as compared to those having round section column.

Radial Drilling Machine

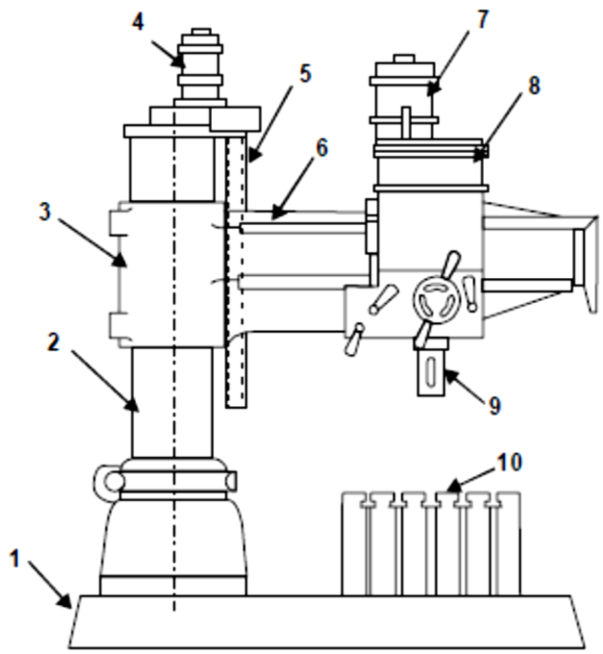
Fig. 22.2 illustrates a radial drilling machine. The radial drilling machine consists of a heavy, round vertical column supporting a horizontal arm that carries the drill head. Arm can be raised or lowered on the column and can also be swung around to any position over the work and can be locked in any position. The drill head containing mechanism for rotating and feeding the drill is mounted on a radial arm and can be moved horizontally on the guide-ways and clamped at any desired position. These adjustments of arm and drilling head permit the operator to locate the drill quickly over any point on the work. The table of radial drilling machine may also be rotated through 360 deg. The maximum size of hole that the machine can drill is not more than 50 mm. Powerful drive motors are geared directly into the head of the machine and a wide range of power feeds are available as well as sensitive and geared manual feeds. The radial drilling machine is used primarily for drilling medium to large and heavy work pieces. Depending on the different movements of horizontal arm, table and drill head, the upright drilling machine may be classified into following types-

1. Plain radial drilling machine
2. Semi universal drilling machine, and
3. Universal drilling machine.

In a plain radial drilling machine, provisions are made for following three movements -

1. Vertical movement of the arm on the column,
2. Horizontal movement of the drill head along the arm, and
3. Circular movement of the arm in horizontal plane about the vertical column.

In a semi universal drilling machine, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. In universal machine, an additional rotatory movement of the arm holding the drill head on a horizontal axis is also provided for enabling it to drill on a job at any angle.



Parts name

1. Base
2. Column
3. Radial arm
4. Motor for elevating arm
5. Elevating screw
6. Guide ways
7. Motor for driving drill spindle
8. Drill head
9. Drill spindle
10. Table

Fig. 22.2 Radial drilling machine

Gang Drilling Machine

In gang drilling machine, a number of single spindle drilling machine columns are placed side by side on a common base and have a common worktable. A series of operation may be performed on the job by shifting the work from one position to the other on the worktable. This type of machine is mainly used for production work.

CONSTRUCTION OF DRILLING MACHINE

In drilling machine the drill is rotated and fed along its axis of rotation in the stationary work piece. Different parts of a drilling machine are shown in Fig. 22.1 and are discussed below: (*i*) The head containing electric motor, V-pulleys and V-belt which transmit rotary motion to the drill spindle at a number of speeds. (*ii*) Spindle is made up of alloy steel. It rotates as well as moves up and down in a sleeve. A pinion engages a rack fixed onto the sleeve to provide vertical up and down motion of the spindle and hence the drill so that the same can be fed into the work piece or withdrawn from it while drilling. Spindle speed or the drill speed is changed with the help of V-belt and V-step-pulleys. Larger drilling machines are having gear boxes for the said purpose. (*iii*) Drill chuck is held at the end of the drill spindle and in turn it holds the drill bit. (*iv*) Adjustable work piece table is supported on the column of the drilling machine. It can be moved both vertically and horizontally. Tables are generally having slots so that the vise or the work piece can be securely held on it. (*v*) Base table is a heavy casting and it supports the drill press structure. The base supports the column, which in turn, supports the table, head etc.

(*vi*)Column is a vertical round or box section which rests on the base and supports the head and the table. The round column may have rack teeth cut on it so that the table can be raised or lowered depending upon the work piece requirements. This machine consists of following parts

1. Base
2. Pillar
3. Main drive
4. Drill spindle
5. Feed handle
6. Work table

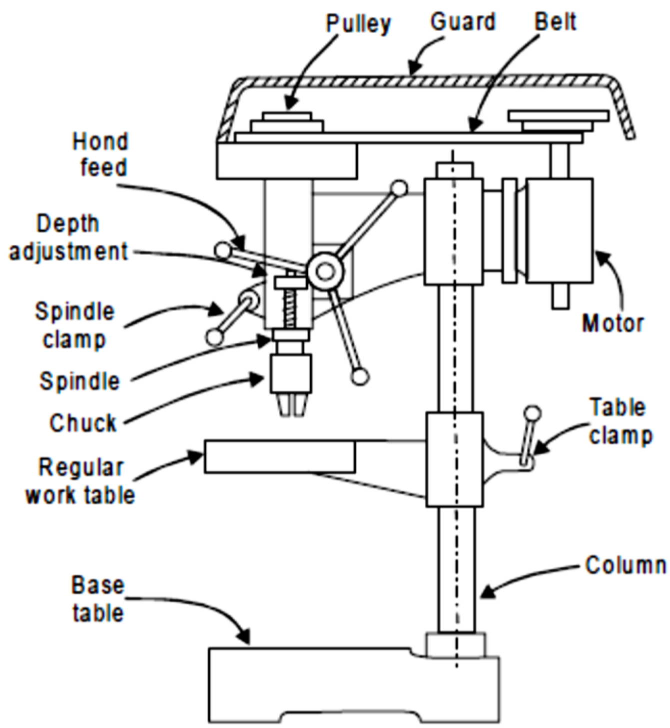


Fig. 22.1 Construction of drilling machine

5.13 RADIAL DRILLING MACHINE PARTS

The different parts of a radial drilling machine have been illustrated in Fig.5.3. They are as follows :

1. Base
2. Column
3. Radial arm
4. Drill head
5. Spindle speed and feed mechanism

Base : The base of a radial drilling machine is a large rectangular casting that is finished on its top to support a column on its one end and to hold the work table at the other end. In some machines T- slots are provided on the base for clamping work when it serves as a table. In some machines two or more number of bases are provided. When drilling is done on a job supported on any one of the bases, another job may be set up on the other for a continuous production.

Column : The column is a cylindrical casting that is mounted vertically at one end of the base. It supports the radial arm which may slide up or down on its face. An electric motor is mounted on the top of the column which imparts vertical adjustment of the arm by rotating a screw passing through a nut attached to the arm.

Radial arm : The radial arm that is mounted on the column extends horizontally over the base. It is a massive casting with its front vertical face accurately machined to provide guide ways on which the drill head may be made to slide. The arm may be swung round the column. In some machines this movement is controlled by a separate motor.

Drill head : The drill head is mounted on the radial arm and drives the drill spindle. It encloses all the mechanism for driving the drill at multiple speed and at different feed. All the mechanisms and controls are housed within a small drill head which may be made to slide on the guide ways of the arm for adjusting the position of drill spindle with respect to the work. After the spindle has been properly adjusted in position the drill head is clamped on the radial arm.

Spindle drive and feed mechanism : There are two common methods of driving the spindle. A constant speed motor is mounted at the extreme end of the radial arm which balances partially the weight of the overhanging arm. The motor drives a horizontal spindle which runs along the length of the arm and the motion is transmitted to the drill head through bevel gears. By train of gearing within the drill head, the speed of the spindle may be varied. Through another train of gearing within the drill head, different feeds of the spindle are obtained. In some machines, a vertical motor is fitted directly on the drill head and through gear box multiple speed and the feed of the spindle can be obtained.

CUTTING SPEED

The cutting speed in a drilling operation refers to the peripheral speed of a point on the surface of the drill in contact with the work. It is usually expressed in meters/min. The cutting speed (Cs) may be calculated as:

$Cs = ((22/7) \times D \times N)/1000$

Where, D is the diameter of the drill in mm and

N is the rpm of the drill spindle.

FEED

The feed of a drill is the distance the drill moves into the job at each revolution of the spindle. It is expressed in millimeter. 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. The feed per minute may be calculated as:

$F = Fr \times N$

Where, F = Feed per minute in mm.

Fr = Feed per revolution in mm.

N = R.P.M. of the drill.

5.30 DEPTH OF CUT

The depth of cut in drilling is equal to one half of the drill diameter. Thus if *d* be the diameter of the drill, the depth of cut *(t)* may be expressed as :

$$t = \frac{d}{2} mm$$

55

5.15 TOLL HOLDING DEVICES

The revolving spindle of a drilling machine can hold different cutting tools for different operations. The different methods used for holding tools in a drill spindle are :

1. By directly fitting in the spindle.
2. By a sleeve.
3. By a socket.
4. By chucks.

Directly holding the tool : All general purpose drilling machines have the spindle bored out to a standard taper to receive the taper shank of the tool. The taper used in a drill spindle is usually Morse standard taper which is approximately 1:20. While fitting the tool the shank is forced into the tapered hole and the tool is gripped by friction. The tool may be rotated with the spindle by friction between the tapered surface and the spindle ; but to ensure a positive drive the tang or tongue of the tool fits into a slot at the end of the taper hole. The tool may be removed by pressing a tapered wedge known as the *drift* into the slotted hole of the spindle. Fig.5.17 illustrates a drill fitted directly into the spindle through a sleeve. Fig.5.18 shows a drift or key. It can be noted that sleeve used in drill spindle should not be affected while the drift is pushed to take out the drill bit. Usually a mallet should be used instead of a hammer. The operator must be ensure that the tool is not dropped while removing it. The taper should be standardised to the Mourse standard taper and non-standard taping should not be allowed for drill spindle sleeve. Unmatched drill spindle and sleece may cause inconvenience during machine running.

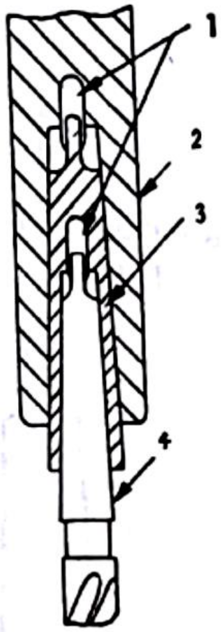


Figure 5.17 Drill inserted in drill spindle.
1. Slots for inserting drifts,
2. Drill spindle 3. Sleeve,
4. Drill.

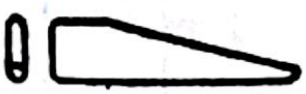


Figure 5.18 Drift

Sleeve : The drill spindle is suitable for holding only one size of shank. If the taper shank of the tool is smaller than the taper in the spindle hole, a taper sleeve is used. The outside taper of the sleeve conforms to the drill spindle taper and the inside taper holds the shanks of smaller size tools or smaller sleeves. The sleeve fits into the taper hole of the spindle and holds tool shanks of smaller sizes in the tapered hole. The sleeve has a flattened end or tang which fits into the slot of the spindle. The tang of the tool fits into a slot provided at the end of the taper hole of the sleeve. The sleeve with the tool may be removed by forcing a drift within the slot of the spindle and the tool may be separated from the sleeve by the similar process. Different sizes of tool shanks may be held in the spindle by using different sizes of sleeve. The taper on the outer surface does not change but that on the inner surface varies with the different sizes of the tool shanks. Fig.5.19 illustrates a drill sleeve.

Figure 5.19 Drill sleeve
1. Inside taper.

Socket : When the tapered tool shank is larger than the spindle taper drill sockets are used to hold the tool. Drill sockets are much longer in size than the drill sleeves.

A socket consists of a solid shank attached to the end of a cylindrical body. The taper shank of the socket conforms to the taper of the drill spindle and fits into it. The body of the socket has a tapered hole larger than the drill spindle taper into which the taper shank of any tool may be fitted. The tang of the socket fits into the slot of the spindle and the tang of the tool fits into the slot of the socket. Fig.5.20 illustrates a drill socket.

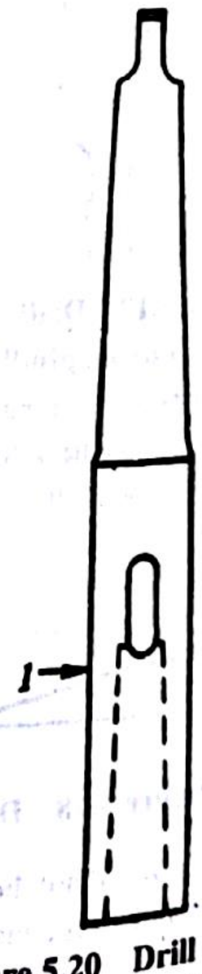


Figure 5.20 Drill socket
1. Socket body.

Drill chucks : The chucks are especially intended for holding smaller size drills or any other tools. A sleeve or socket can hold one size of tool shank only but a chuck may be used to hold different sizes of tool shanks within a certain limit. Drill chucks have tapered shanks which are fitted into the drilling machine spindle. Different types of drill chucks are manufactured for different purposes. The most common types of chucks are :

OPERATIONS PERFORMED ON DRILLING MACHINE

A drill machine is versatile machine tool. A number of operations can be performed on it. Some of the operations that can be performed on drilling machines are:

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

The operations that are commonly performed on drilling machines are drilling, reaming, lapping, boring, counter-boring, counter-sinking, spot facing, and tapping. These operations are discussed as under.

Drilling

This is the operation of making a circular hole by removing a volume of metal from the job by a rotating cutting tool called drill as shown in Fig. 22.6. Drilling removes solid metal from the job to produce a circular hole. Before drilling, the hole is located by drawing two lines at right angle and a center punch is used to make an indentation for the drill point at the center to help the drill in getting started. A suitable drill is held in the drill machine and the drill machine is adjusted to operate at the correct cutting speed. The drill machine is started and the drill starts rotating. Cutting fluid is made to flow liberally and the cut is started. The rotating drill is made to feed into the job. The hole, depending upon its length, may be drilled in one or more steps. After the drilling operation is complete, the drill is removed from the hole and the power is turned off.

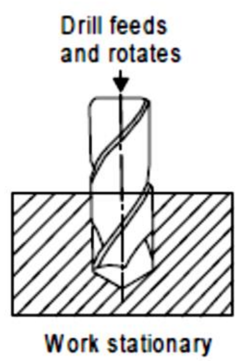


Fig. 22.6 Drilling operation

Reaming

This is the operation of sizing and finishing a hole already made by a drill. Reaming is performed by means of a cutting tool called reamer as shown in Fig. 22.7. Reaming operation serves to make the hole smooth, straight and accurate in diameter. Reaming operation is performed by means of a multi tooth tool called reamer. Reamer possesses several cutting edges on outer periphery and may be classified as solid reamer and adjustable reamer.

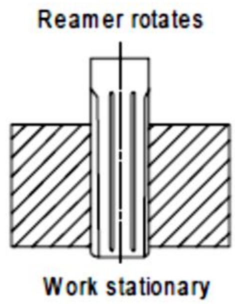


Fig. 22.7 Reaming operation

Boring

Fig. 22.8 shows the boring operation where enlarging a hole by means of adjustable cutting tools with only one cutting edge is accomplished. A boring tool is employed for this purpose.

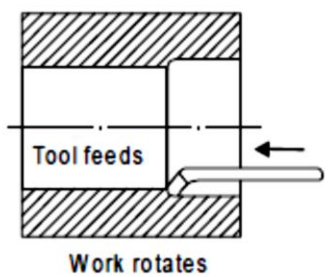


Fig. 22.8 Boring operation

Counter-Boring

Counter boring operation is shown in Fig. 22.9. It is the operation of enlarging the end of a hole cylindrically, as for the recess for a counter-sunk rivet. The tool used is known as counter-bore.

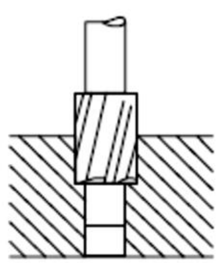


Fig. 22.9 Counter boring operation

Counter-Sinking

Counter-sinking operation is shown in Fig. 22.10. This is the operation of making a cone shaped enlargement of the end of a hole, as for the recess for a flat head screw. This is done for providing a seat for counter sunk heads of the screws so that the latter may flush with the main surface of the work.

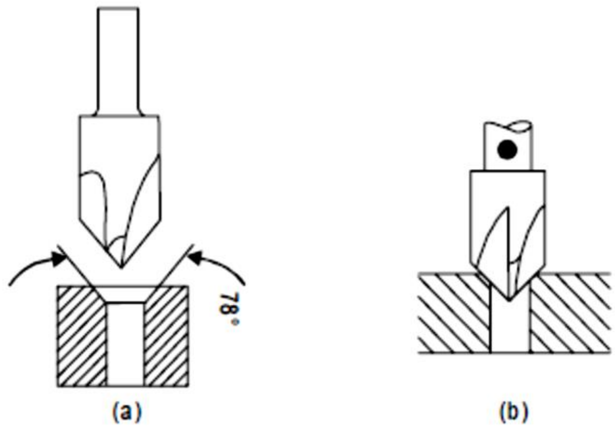


Fig. 22.10 Counter sinking operation

Tapping

It is the operation of cutting internal threads by using a tool called a tap. A tap is similar to a bolt with accurate threads cut on it. To perform the tapping operation, a tap is screwed into the hole by hand or by machine. The tap removes metal and cuts internal threads, which will fit into external threads of the same size. For all materials except cast iron, a little lubricate oil is applied to improve the action. The tap is not turned continuously, but after every half turn, it should be reversed slightly to clear the threads. Tapping operation is shown in Fig.22.11

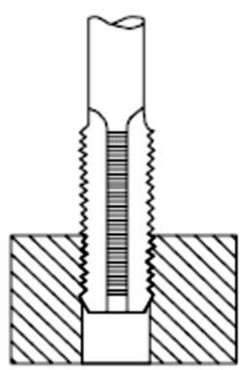


Fig. 22.11 Tapping operation

Twist Drill Geometry

Twist drill geometry and its nomenclature are shown in Fig. 22.5. A twist drill has three principal parts:

(*i*) Drill point or dead center
(*ii*) Body
(*iii*) Shank.

Body is that portion of the drill nomenclature, which extends from the extreme cutting end to the beginning of the shank.

Shank is that portion of the drill by which it is held and driven.

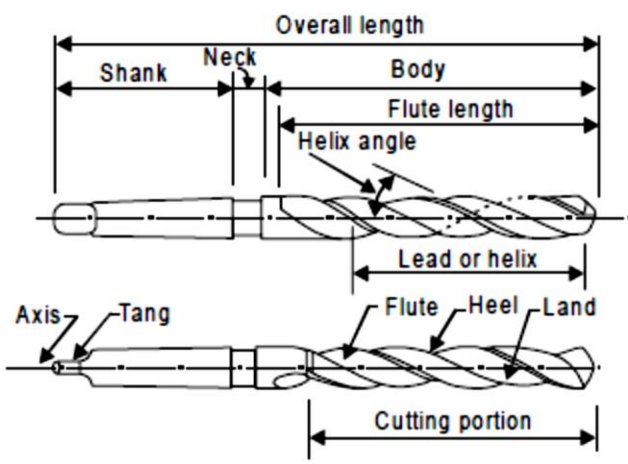
Lands are the cylindrically ground surfaces on the leading edges of the drill flutes. The width of the land is measured at right angles to the flute.

Flutes are the grooves in the body of the drill, which provide lips, allow the removal of chips, and permit cutting fluid to reach the lips.

Lip or cutting edge is the edge formed by the intersection of the flank and face
Lip length is the minimum distance between the outer corner and the chisel-edge corner of the lip.

Point angle is the included angle of the cone formed by the lips.

Drill point is the sharpened end of the drill body consisting of all that part which is shaped to produce lips, faces and chisel edge.



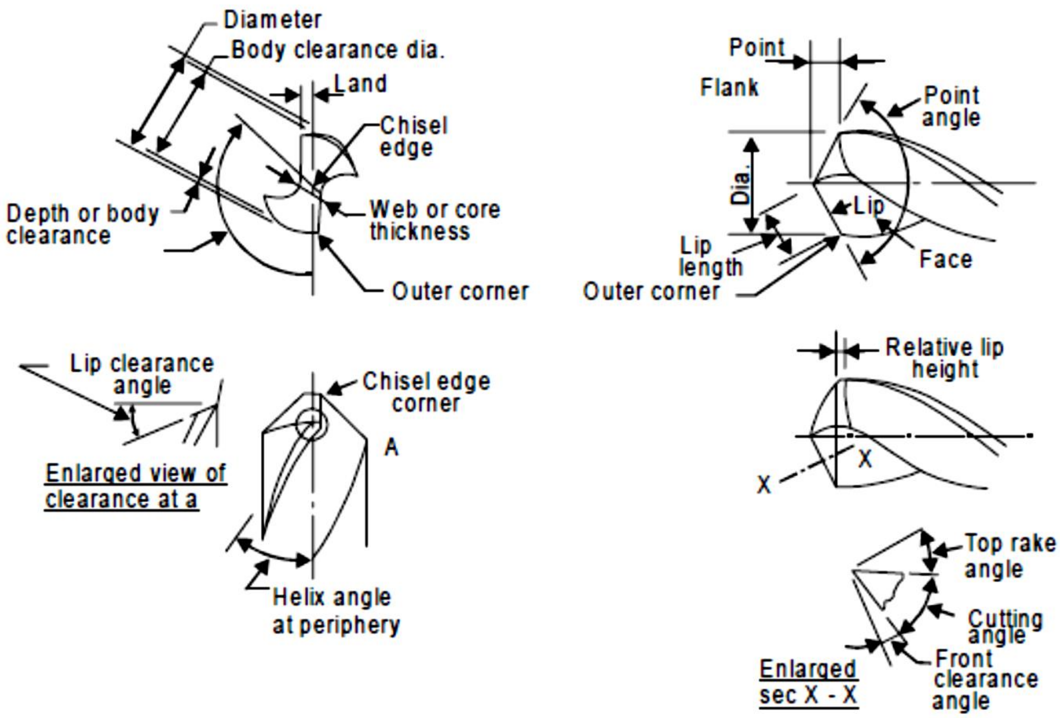


Fig. 22.5 Geometry and nomenclature of twist drill

5.19 DRILL SIZE

In metric system, drills are commonly manufactured from 0.2 to 100 mm. In British system the drills are manufactured in three different sizes. The sizes are :

Number sizes : The drill sizes range from No. 1 to No. 80. Number 80 is the smallest having diameter equal to 0.0135 inch and the number 1 is the largest having diameter equal to 0.228 inch. Number 1 to number 60 are the standard set of drills. The numbers 61 to 80 sizes drills are not so commonly used. The diameter of drills increases in steps of approximately by 0.002 inch.

Letter sizes : The drill sizes range from *A* to *Z*, *A* being the smallest having diameter equal to 0.234 inch and *Z* being the largest having diameter equal to 0.413 inch, increasing in steps of approximately 0.010 inch.

Drill Material

Drills are made are made up of high speed steel. High speed steel is used for about 90 per cent of all twist drills. For metals more difficult to cut, HSS alloys of high cobalt series are used.