5

DRILLING MACHINE

5.1 INTRODUCTION

The drilling machine is one of the most important machine tools in a workshop. As regards its importance it is second only to the lathe. Although it was primarily designed to originate a hole, it can perform a number of similar operations. In a drilling machine holes may be drilled quickly and at a low cost. The hole is generated by the rotating edge of a cutting tool known as the drill which exerts large force on the work clamped on the table. As the machine tool exerts vertical pressure to originate a hole it is loosely called a "drill press".

Holes were drilled by the Egyptians in 1200 B.C. about 3000 years ago by bow drills. The bow drill is the mother of present day metal cutting drilling machine.

5.2 TYPES OF DRILLING MACHINE

Drilling machines are made in many different types and sizes, each designed to handle a class of work or specific job to the best advantage. The different types of drilling machines are :

1. Portable drilling machine.
2. Sensitive drilling machine.
   (a) Bench mounting, (b) Flour mounting
3. Upright drilling machine.
   (a) Round column section, (b) Box column section
4. Radial drilling machine.
   (a) Plain (b) Semiuniversal
   (c) Universal
5. Gang drilling machine.
6. Multiple spindle drilling machine.
7. Automatic drilling machine.
8. Deep hole drilling machine.
   (a) Vertical (b) Horizontal

5.3 PORTABLE DRILLING MACHINE

As the name implies this type of drilling machine can be operated with ease any where in the workshop and is used for drilling holes in workpieces in any position which can not be drilled in a standard drilling machine. Some of the portable machines are operated by hand power, but most of the machines are driven by individual motor. The entire drilling mechanism including the motor is compact and small in size. The motor is usually of universal type which may be driven by both A.C. and D.C. The maximum size of the drill that it can accommodate is not more than 12 to 18 mm. The machine is operated at high speed as smaller size drills are only used. Some of the portable machines are driven by pneumatic power.

5.4 SENSITIVE DRILLING MACHINE

The sensitive drilling machine is a small machine designed for drilling a small holes at high speed in light jobs. The base of the machine may be mounted on a bench or on the floor. It consists of a vertical column, a horizontal table, a head supporting the motor and driving mechanism, and a vertical spindle for driving and rotating the drill. There in no arrangement for any automatic feed of the drill spindle. The drill is fed into the work by purely hand control. High speed and hand feed are necessary for drilling small holes. High speeds are necessary to attain required cutting speed by small diameter drill. Hand feed permits the operator to feel or sense the progress of the drill into the work, so that if the drill becomes worn out or jams on any account, the pressure on the drill may be released immediately to prevent it from

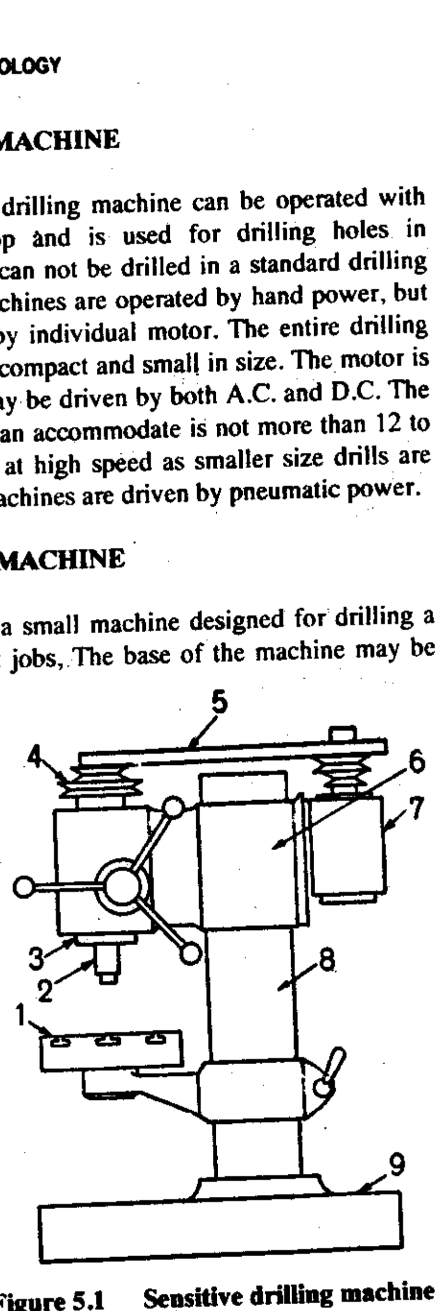


Figure 5.1 Sensitive drilling machine
1. Table, 2. Vertieal drill spindle, 3. Sleeve, 4. Cone pulley, 5. V-belt, 6. Head, 7. Driving motor, 8. Vertical column, 9. Base.

breaking. As the operator senses the cutting action, at any instant, it is called sensitive drilling machine. Sensitive drilling machines are capable of rotating drills of diameter from 1.5 to 15.5 mm. Super sensitive drilling machines are designed to drill holes as small as 0.35 mm in diameter and the machine is rotated at a high speed of 20,000 r.p.m. or above. Fig.5.1 illustrates a sensitive drilling machine.

5.5 UPRIGHT DRILLING MACHINE

The upright drilling machine is designed for handling medium sized workpieces. In construction the machine is very similar to a sensitive drilling machine for having a vertical column mounted upon the base. But this is larger and heavier than a sensitive drill and is supplied with power feed arrangement. In an upright drilling machine a large number of spindle speeds and feeds may be available for drilling different types of work. The table of the machine also have different types of adjustments. There are two general classes of upright drilling machine:

1. Round column section or pillar drilling machine.
2. Box column section.

Round column section or pillar drilling machine : The round column section upright drilling machine or pillar drilling machine consists of a round column that rises from the base which rests on the floor, an arm and a round table assembly, and a drill head assembly.

The arm and the table have three adjustments for locating workpieces under the spindle. The arm and the table may be moved up and down on the column for accommodating workpieces of different heights. The table and the arm may be moved in an arc upto 180° around the column and may be clamped at any position. This permits setting of the work below the spindle. Moreover, heavy and odd-size work may be supported directly on the base of the machine and drilled after the arm is swung out of the way. The table may be rotated 360° about its own centre independent of the position of the arm for locating workpieces under the spindle.

The construction of the machine being not very rigid and the table being supported on a horizontal arm, this is particularly intended for lighter work. The maximum size of holes that the machine can drill is not more than 50 mm.

Box column section upright drilling machine : The upright drilling machine with box column section has the square table fitted on the slides at the front face of the machine column. Heavy box column gives the machine strength and rigidity. The table is raised or lowered by an elevating screw that gives additional support to the table. These special features permit the machine to work with heavier workpieces, and holes more than 50 mm in diameter can be drilled by it.

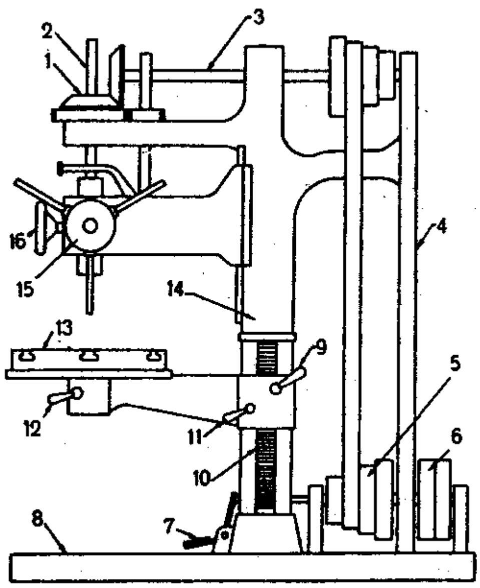


Figure 5.2 Upright pillar drilling machine
1. Bevel gear drive to spindle, 2. Spindle, 3. Overhead shaft, 4. Back stay, 5. Counter shaft cone pulley, 6. Fast and loose pulley, 7. Table elevating handle, 8. Foot pedal, 9. Base, 10. Rack on column, 11. Table elevating clamp handle, 12. Table clamp, 13. Table, 14. Column, 15. Handwheel for quick hand feed, 16. Handwheel for sensitive hand feed.

5.6 RADIAL DRILLING MACHINE

The radial drilling machine is intended for drilling medium to large and heavy workpieces. The machine consists of a heavy, round, vertical column mounted on a large base. The column supports a radial arm which can be raised and lowered to accommodate workpieces of different heights. The arm may be swung around to any position over the work bed. 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 three movements in a radial drilling machine when combined together permit the drill to be located at any desired point on a large workpiece for drilling the hole. When several holes are drilled on a large workpiece, the position of the arm and the drill head is altered so that the drill spindle may be moved from one position to the other after drilling the hole without altering the setting of the work. This versatility of the machine allows it to work on large workpieces. The work may be mounted on the table or when the work is very large it may be placed on the floor or in a pit. Fig.5.3 illustrates a radial drilling machine.

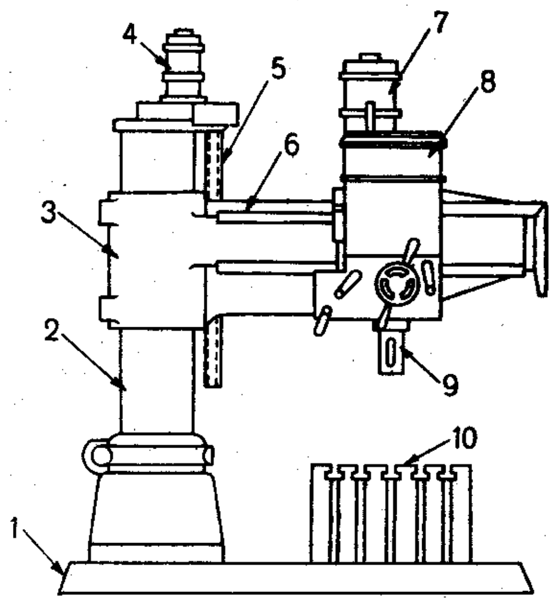


Figure 5.3 Radial drilling machine

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

Plain radial drilling machine : In a plain radial drilling machine provisions are made for vertical adjustment of the arm, horizontal movement of the drill head along the arm, and circular movement of the arm in horizontal plane about the vertical column.

Semiuniversal machine : In a semiuniversal machine, in addition to the above three movements, the drill head can be swung about a horizontal axis perpendicular to the arm. This fourth movement of the drill head permits drilling hole at an angle to the horizontal plane other than the normal position.

Universal machine : In a universal machine, in addition to the above four movements, the arm holding the drill head may be rotated on a horizontal axis. All these five movements in a universal machine enables it to drill on a workpiece at any angle.

5.7 GANG DRILLING MACHINE

When a number of single spindle drilling machine columns are placed side by side on a common base and have a common worktable, the machine is known as the gang drilling machine. In a gang drilling machine four to six spindles may be mounted side by side. In some machines the drill spindles are permanently spaced on the work table, and in others the position of the columns may be adjusted so that the space between the spindles may be varied. The speed and feed of the spindles are controlled independently. This type of machine is specially adapted for production work. A series of operations may be performed on the work by simply shifting the work from one position to the other on the work table. Each spindle may be set up properly with different tools for different operations.

5.8 MULTIPLE SPINDLE DRILLING MACHINE

The function of a multiple spindle drilling machine is to drill a number of holes in a piece of work simultaneously and to reproduce the same pattern of holes in a number of identical pieces in a mass production work. Such machines have several spindles driven by a single motor and all the spindles holding drills are fed into the work simultaneously. Feeding motion is usually obtained by raising the work table. But the feeding motion may also be secured by lowering the drill heads. The spindles are so constructed that their centre distance may be adjusted in any position as required by various jobs within the capacity of the drill head. For this purpose, the drill spindles are connected to the main drive by universal joints. Drill jigs may be used for guiding the drills in mass production work.

5.9 AUTOMATIC DRILLING MACHINE

Automatic machine can perform a series of machining operations at successive units and transfer the work from one unit to the other automatically. Once the work is loaded at the first machine, the work will move from one machine to the other where different operations can be performed and the finished work comes out from the last unit without any manual handling. This type of machine is intended purely for production purposes and may be used for milling, honing and similar operations in addition to drilling and tapping.

5.10 DEEP HOLE DRILLING MACHINE

Special machines and drills are required for drilling deep holes in rifle barrels, crank shafts, long shafts, etc. The machine is operated at high speed and low feed. Sufficient quantity of lubricant is pumped to the cutting points for removal of chips and cooling the cutting edges of the drill. A long job is usually supported at several points to prevent any deflection. The work is usually rotated while the drill is fed into the work. This helps in feeding the drill in a straight path. In some machines both the work and the drill are rotated for accurate location.

The machine may be horizontal or vertical type. In some machines step feed is applied. The drill is withdrawn automatically each time when it penetrates into the work to a depth equal to its diameter. This process permits the chip to clear out from the work.

5.11 THE SIZE OF A DRILLING MACHINE

The size of a drilling machine varies with the type of machine being considered.

A portable drilling machine is specified by the maximum diameter of the drill that it can hold.

The sensitive and upright drilling machines are specified by the diameter of the largest piece that can be centered under the spindle. Thus in the case of a 600 mm size upright drilling machine, the spindle placed at a distance is slightly greater than 300 mm from the front face of the column.

To specify a drilling machine fully further particulars such as the maximum size of drill that the machine can operate, table diameter, the maximum spindle travel, numbers of spindle speeds and feeds available, Morse taper number of the drill spindle, power input, floor space required, net weight of the machine, etc. are all needed.

The size of a radial drilling machine is specified by the diameter of the column and length of the arm. Other particulars such as maximum drilling radius, minimum drilling radius, spindle speeds and feeds, etc. should also be stated to specify the machine fully.

5.12 UPRIGHT DRILLING MACHINE PARTS

The different parts of an upright drilling machine is shown in Fig.5.2. They are as follows :

1. Base
2. Column
3. Table
4. Head
5. Spindle, quill and drill head assembly
6. Spindle drive and feed mechanism

Base : The base is that part of the machine on which vertical column is mounted. In a belt driven machine the countershaft consists of a fast and a loose pulley and cone pulley is fitted to the base of the machine. The top of the base in round column section type upright drilling machine is accurately machined and has T-slots on it so that large work pieces and work holding devices may be set up and bolted to it.

Column : The column is the vertical member of the machine which supports the table and the head containing all the driving mechanism. The column should be sufficiently rigid so that it can take up the entire cutting pressure of the drill. The column may be made of box section or of round section. Box column is a more rigid unit. In some of the round column machines, rack teeth are cut on the face of the column for vertical movement of the arm and the table. The vertical movement is effected by rotating the table elevating handle which causes a pinion mounted within the arm to rotate on the rack teeth. In box column type, the front face of the column is accurately machined to form guideways on which the table can slide up and down for vertical adjustment.

Table : The table is mounted on the column and is provided with T-slots for clamping the work directly on its face. The table may be round or rectangular in shape. For centering work below the spindle, the table of a pillar drilling machine may have three types of adjustments : vertical adjustment, radial adjustment about the column, and circular adjustment about its own axis. After the required adjustments have been made the table and the arm are clamped in position.

Head : The drill head is mounted on the top of the column and houses the driving and feeding mechanism for the spindle. In some of the machines the drill head may be adjusted up or down for accommodating different heights of work in addition to the table adjustment. In lighter machines, the driving motor is mounted at the rear end of the head counterbalancing the weight of the drill spindle.

Spindle and drill head assembly : A drill spindle assembly is illustrated in Fig.5.4. The spindle is a vertical shaft which holds the drill. It receives its motion from the top shaft through bevel gears. A long key-way is cut on the spindle and the bevel gear is connected to it by a sliding key. This construction is made to allow the spindle to be connected with the top shaft irrespective of its position when the spindle is raised or lowered for feeding the drill into the work. The spindle rotates within a non-rotating sleeve which is known as the quill. Rack teeth are cut on the outer surface of the sleeve, and in precision machines a block having rack teeth cut on it is bolted to the vertical face of the sleeve. The sleeve may be moved up or down by rotating a pinion which meshes with the rack and this movement is imparted to the spindle to give the required feed. The downward movement of the spindle is effected by rotating the pinion which causes the quill to move downward exerting pressure on the spindle through a thrust bearing and washer. The spindle is moved upward by the upward pressure exerted by the quill acting against a nut attached to the spindle through the thrust bearing. The lower end of the spindle is provided with Morse taper hole for accommodating taper shank drill. A slot is provided at the end of the taper hole for holding the tang of the drill to impart it a positive drive. A drift or key may be pushed

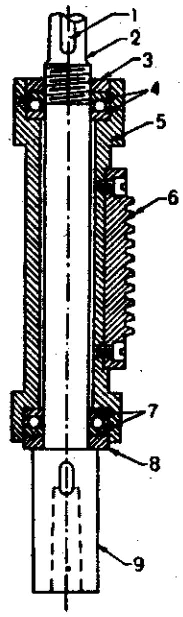


Figure 5.4 Drill spindle assembly
1. Key way on the spindle, 2. Spindle, 3. Nut, 4, 7. Thrust bearing, 5. Quill or sleeve, 6. Rack, 8. Washer, 9. Lower end of the spindle.

through the slot for removing the drill. For holding drills of smaller size, a Morse taper socket or a drill chuck having a taper shank is put on the taper hole of the spindle.

Spindle drive mechanism : The spindle drive mechanism of a drilling machine incorporates an arrangement for obtaining multiple speed of the spindle similar to a lathe to suit to various machining conditions. Multiple speed of the spindle may be obtained as follows :

1. By step cone pulley drive.
2. By step cone pulley drive with one or more back gears.
3. By gearing.

Step cone pulley drive : Fig.5.2 illustrates a spindle driving mechanism incorporating a step cone pulley. The motion is transmitted from an overhead line shaft to the countershaft mounted on the base of the machine. The countershaft may be started or stopped by shifting the belt from loose pulley to fast pulley or vice versa by operating the foot-pedal 7. The step cone pulley mounted on the head of the machine receives power from the countershaft step cone pulley *5* through the belt. The drill spindle *2* receives power from the overhead shaft *3* through bevel gears *1* and the speed of the spindle may be varied by shifting the belt on different steps of the cone pulley *5*. The number of spindle speeds available is dependent upon the number of steps on the cone pulley.

Step cone pulley drive with back gear : In order to obtain larger number of spindle speeds backgears are incorporated in the machine in addition to the step cone pulley.

As shown in Fig.5.5 the countershaft mounted on the base of machine receives power from the overhead line shaft. The belt on the fast and the loose pulley may be shifted to start or stop the countershaft. The countershaft cone pulley *18* and the top shaft cone pulley *16* are connected by a belt *17*. Gear Z_1 and the pulley *16* are attached together on the hollow shaft *15* and they rotate freely on the shaft *10*. The clutch *13* is keyed to the shaft *10* and the clutch may be shifted towards the right to be engaged with gear Z_1. Gear Z_4 is keyed to the shaft *10*. Back gears Z_2 and Z_3 are joined together by a sleeve 25 in the centre of which a groove is turned to receive a 'C' shaped shifter attached to the lever *21*. This lever has a similar connection with the clutch *13* and is fulcrumed on the frame below the gears.

The back gears Z_2 and Z_3 are in mesh with the gears Z_1 and Z_4 respectively. The motion is transmitted from the bottom cone pulley *18* to the top cone pulley *16*, through gears Z_1, Z_2, Z_3, and Z_4 to the shaft *10* which rotates at a slower speed. The shaft *10* transmits motion to the drill spindle *8* through bevel gear *9*. In order to change the spindle speed, the belt may be shifted on different steps of the cone pulley and the number of single speeds with the back gears "in" position is equal to the number of steps on the cone pulley. The spindle speed with back gears "in" position may be derived as follows :

$$\frac{\text{Speed of the spindle } 8}{\text{Speed of the pulley } 16} = \frac{Z_1}{Z_2} \times \frac{Z_3}{Z_4} \qquad 5.1$$

To obtain additional speeds, the lever *21* is shifted towards the left. This will cause gears Z_2 and Z_3 to be disengaged with gears Z_1 and Z_4 and

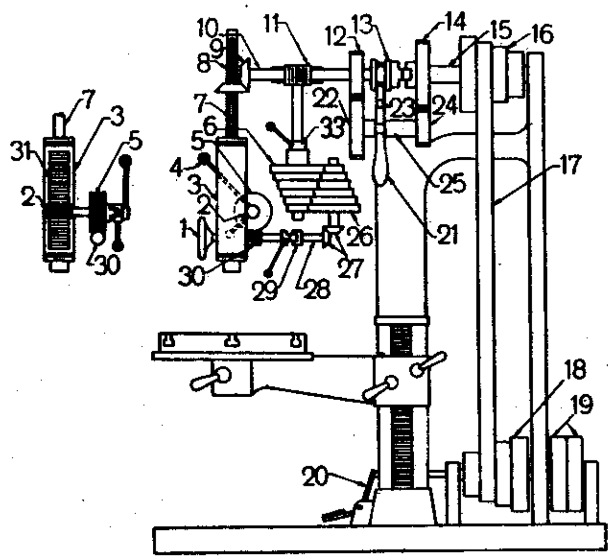


Figure 5.5 Drilling machine mechanism

1. Sensitive feed handwheel, 2. Pinion, 3. Quill, 4. Quick feed handwheel, 5. Worm gear, 6. Feed gears on worm gear shaft, 7. Key way on drill spindle, 8. Drill spindle, 9. Bevel gear, 10. Top shaft, 11. Worm and worm gear drive for automatic feed, 12. Gear Z_4, 13. Sliding clutch, 14. Gear Z_1, 15. Hollow shaft, 16. Top shaft cone pulley, 17. Belt, 18. Countershaft cone pulley, 19. Fast and loose pulley, 20. Foot pedal, 21. Lever, 22. , 24. Back gears Z_3 and Z_2, 23. Fulcrum, 25. Back gears sleeve, 26. Feed gears on driven shaft, 27. Bevel gears, 28. Shaft, 29. Clutch, 30. Worm, 31. Rack, 33. Sliding key.

will cause the clutch *13* to be engaged with the gear Z_1. The motion is now transmitted from the pulley *16* to the gear Z_1 and from gear Z_1 to the shaft *10* through the clutch *13*. The spindle *8* now receives motion directly from the pulley *16* and the speed of the spindle is equal to the speed of the pulley *16*. The speed may be altered by shifting the belt on different steps. Thus 4 direct speeds are obtained with back gears "out" and 4 indirect speeds with back gears "in" making altogether 8 spindle speeds.

With backgears "out" the speed of the spindle is increased and the machine is used for drilling smaller holes. For drilling larger diameter holes or for tapping, the spindle speed is reduced by engaging the backgears.

Spindle drive by gearing : Modern heavy duty drilling machines are driven by individual motor mounted on the frame of the machine. The multiple speeds may be obtained by sliding gear or sliding clutch mechanism or by the combination of the above two methods. The sliding gear and sliding clutch mechanism in drilling is similar to that described in Art. 3.7.

Feed mechanism : In a drilling machine, the feed is effected by the vertical movement of the drill into the work. The feed movement of the drill may be controlled by hand or power. The hand feed may be applied by two methods :

1. Quick traverse hand feed
2. Sensitive hand feed

The *quick traverse feed* is used to bring the cutting tool rapidly to the hole location or for withdrawing the drill when the operation is completed. The sensitive hand feed is applied for trial cut and for drilling small holes.

The automatic feed is applied while drilling larger diameter holes as the cutting pressure required is sufficiently great. Fig.*5.5* illustrates the automatic feed mechanism. The automatic feed motion is derived from the top shaft *10* through the worm gearing *11* to a six speed feed box. The feed changes are effected by the lever *33* operating a sliding key mechanism. In the feed box, six gears mounted on the worm gear shaft are constantly in mesh with another six gears mounted on the driven shaft. Gears on the driven shaft are all keyed to the shaft and rotate with it. Gears on the worm gear shaft are all free to rotate, but may be keyed to the shaft by a sliding key only by one gear at a time. When the sliding key is in the first gear, it causes the gear to rotate with the shaft and the motion is transmitted to the driven shaft through the corresponding gear keyed to the shaft. Other gears on the worm shaft revolve freely with their mating gears on the driven shaft. Thus six different speeds of driven shaft are obtained by sliding the key to engage with six different gears on the worm gear shaft. The motion of the driven shaft is transmitted to the shaft *28* through two mating bevel gears *27* and the clutch *29*. The worm *30* mounted on the shaft *28* operates the worm gear *5* mounted on a shaft. A small pinion *2* fitted at the end of this shaft meshes with the rack *31* which is bolted to the quill *3*. The rotation of the pinion *2* causes the quill *3* to move up and down giving spindle feed.

When the *sensitive hand feed* is applied, the clutch *29* is disconnected. The sensitive feed hand wheel *1* is attached to the rear end of the worm shaft *28*. Rotation of the hand wheel *1* will cause the worm and worm gear to rotate and a slow but sensitive feed is obtained.

Quick hand feed is obtained by rotating the hand wheel *4* and operating the clutch mounted on the worm gear shaft. One turn of the hand wheel *4* will cause the pinion *2* to rotate through one complete revolution giving quick hand feed movement of the spindle.

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.

5.14 WORK HOLDING DEVICES

Before performing any operation in a drilling machine it is absolutely necessary to secure the work firmly on the drilling machine table. The work should never be held by hand, because the drill while revolving exerts so much of torque on the workpiece that it starts revolving along with the tool and may cause injuries to the operator.

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

1. T-bolt and clamps.
2. Drill press vise.
3. Step block.
4. V-block.
5. Angle plate.
6. Drill jigs.

T-bolts and clamps : One of the most common methods of holding the work directly on the drilling machine table is by means of T-bolt and clamps. Drilling machine tables are provided with T-slots into which T-bolts may be fitted. Fig.5.6 shows different views of T-bolts. The diameter of T-bolts usually ranges from 15 to 20 mm. The clamps or straps are made of mild steel flats 12 to 20 mm thick and 45 to 70 mm wide. A slot or opening is cut at the centre of the strap to allow the T-bolt to pass through it. The clamp is made to rest horizontally on the work surface and a clamping block and the nut is then tightened. The T-bolt must remain as close to the work as possible. Some of the common types of clamps are :

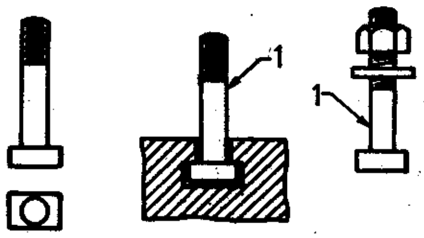


Figure 5.6 Different views of "T" bolts
1. T-bolt.

Plain slot clamp : The clamps are made of mild steel flat having a central slot through which a T-bolt is made to pass. This is a general purpose clamp. Fig.5.13 illustrates a plain slot clamp in use.

Goose neck clamp : The clamp is used for holding work of sufficient height. Smaller size of T-bolts and packing pieces can clamp the work securely due to the typical shape of the clamp. The clamps are sufficiently strong and are usually manufactured by forging. Fig.5.7 illustrates a goose neck clamp in use.

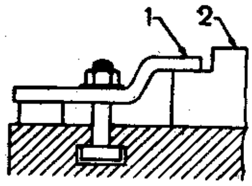


Figure 5.7 Use of goose neck clamp
1. Goose neck clamp, 2. Work.

U-clamp : U-clamps are very useful for quick adjustment of the work. The clamp can be removed without removing the nut. Fig.5.8 illustrates a U-clamp.

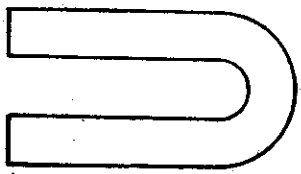


Figure 5.8 U Clamp

Finger clamp : The finger clamps have a round or flat extension which may be fitted in a hole of the workpiece for clamping. Fig.5.9 illustrates a finger clamp.

Adjustable step clamp : The adjustable step clamp has a screw at its one end which is used to level the clamp when its other end rests against the work. The work may be quickly set up without any packing pieces. Fig.5.10 illustrates an adjustable step clamp.

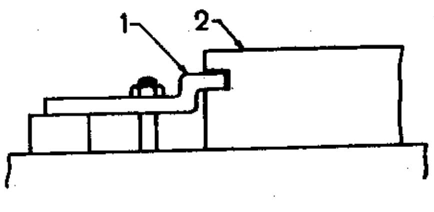


Figure 5.9 Use of finger clamp
1. Finger clamp, 2. Work.

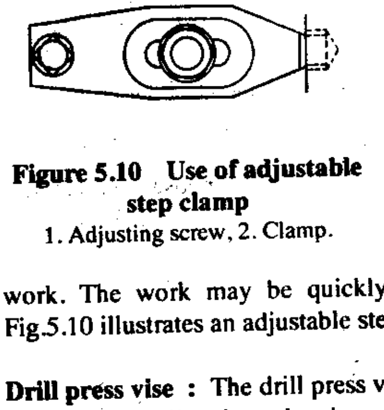


Figure 5.10 Use of adjustable step clamp
1. Adjusting screw, 2. Clamp.

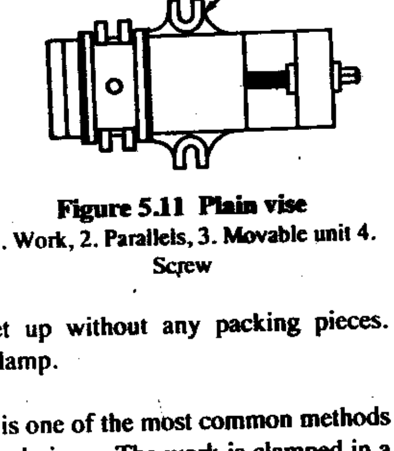


Figure 5.11 Plain vise
1. Work, 2. Parallels, 3. Movable unit 4. Screw

Drill press vise : The drill press vise is one of the most common methods of holding small and regular shaped workpieces. The work is clamped in a vise between a fixed jaw and a movable jaw. Extra slip jaws are supplied for holding cylindrical or hexagonal bars. The screw of the vise rotates in a fixed nut in the movable jaw. The screw of the vise may be square or acme threaded. While clamping the work in a vise, parallel blocks are placed below the work so that the drill may completely pass through the work without damaging the vise table. The drill press vise may be plain or universal type. In a universal vise the base may be swiveled at any angle about the vertical axis and it may be tilted in a vertical plane to drill hole in a work at different angles. Two lugs are provided at the base of the vise for clamping it securely on the work table. Fig.5.11 illustrates a plain vise and Fig.5.12 a universal vise.

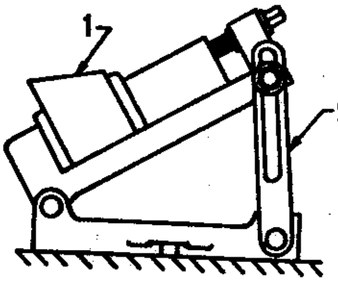


Figure 5.12 Universal vise
1. Work, 2. Slotted arm.

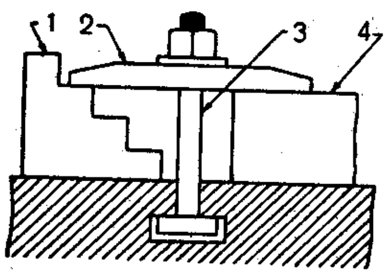


Figure 5.13 Use of step block
1. Step block, 2. Plain slot clamp, 3. T-bolt, 4. Work

Step blocks : The step blocks are used in conjunction with T-bolts and clamps for holding the work directly on the table. The step block provides support for the other end of the clamp. The different steps of the step blocks are used for leveling the clamp while handling workpieces of different heights. The stepblocks are made of mild steel. Fig.5.13 illustrates the use of step block.

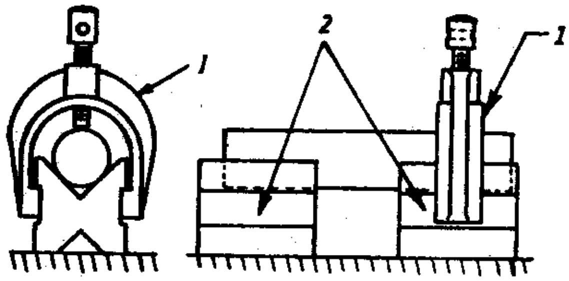


Figure 5.14 Use of V-block
1. Clamp, 2. V-blocks.

V-blocks : The V-blocks are used for holding round workpieces. The work may be supported on two or three blocks and clamped against them by straps and bolts. V-blocks are accurately machined cast iron or steel blocks. Fig.5.14 illustrates the use of a V-block.

Angle plates : The angle plates are usually made of cast iron having two faces at right angles to each other. The faces are accurately finished and are provided with holes and slots for clamping the work on one of its face while the other face rests upon the table and is bolted to it. Angle plates are used when it is necessary to drill a hole parallel to another surface. Fig.5.15 illustrates the use of an angle plate.

Figure 5.15 Use of an angle plate

Drill jigs : The drill jigs are used for holding the work in a mass production process. A jig can hold the work securely, locate the work, and guide the tool at any desired position. The work may be clamped and unclamped quickly. Jigs are specially designed for each type of work where quantity production is desired. Holes may be drilled at the same relative positions on each of the identical workpieces without marking the work individually. Fig.5.16 illustrates a drill jig. The work is clamped below the jig and the holes are located. The drill is guided by the bushing, and when the work is completed the second work is clamped below the jig and the process is repeated.

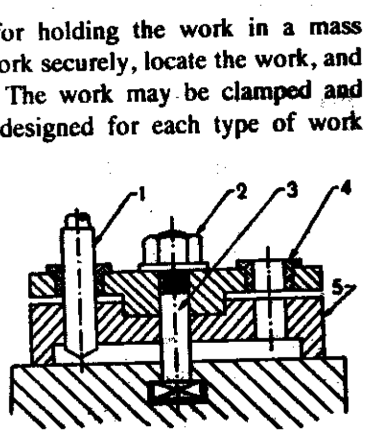


Figure 5.16 Use of drill jig
1. Drill, 2. Clamping nut, 3. T-bolt, 4. Drill bush, 5. Work.

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.
5. By special attachments.
   a. Tapping attachment.
   b. Floating holder.

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.

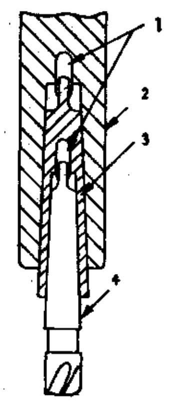


Figure 5.17 Drill inserted in drill spindle.
1. Slots for inserting drifts, 2. Drill spindle 3. Sleeve, 4. Drill.

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.

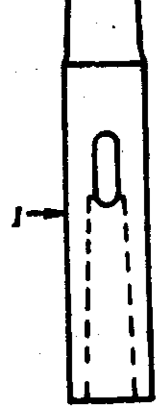


Figure 5.20 Drill socket
1. Socket body.

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 :

1. Quick change chuck.
2. Three-jaw self-centering chuck

Quick change chuck : The quick change chuck also known as magic chuck illustrated in Fig.5.21 is particularly useful in production work. The chuck is used for locating a series of tools one after another for machining a hole without stopping the spindle. This reduces much of machining time.

It consists essentially of a body *1* having taper shank which is fitted into the spindle. A sliding collar *4* is fitted loosely on the rotating body. The collar *4* may be raised or lowered by hand without stopping the spindle. The sleeve *2* has a taper hole which holds the tool shank. The sectional view of the sleeve is shown in Fig.5.22. There are several sleeves which are used for holding different tools required for different machining operations. The sleeve *2* holding the tool may be fitted into the body *1*. Holes are provided on the body *1* of the chuck in which balls *3* are placed and recesses are cut on the corresponding surface of the sleeve where the balls are placed when it is fitted into the chuck. When the collar *4* is raised with one hand the sleeve with its tool may be fitted in the chuck body with the other hand. The sleeve causes the balls to come out from the recess. When the collar *4* is lowered it forces the balls into the recesses and the sleeve *2* is locked by the balls 3 with the body

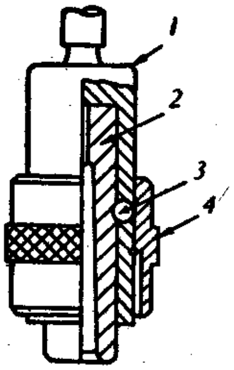


Figure 5.21 Quick change chuck
1. Chuck body, 2. Sleeve, 3. Balls, 4. Sliding collar

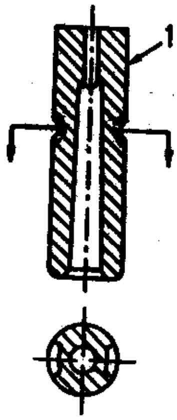


Figure 5.22 Quick change chuck sleeve
1. Sleeve.

of the chuck *1*. The driving motion is transmitted to the tool from the chuck body through the balls *3*. To remove the sleeve with the tool, the collar is lifted by hand and the sleeve drops out from the chuck body.

Three-jaw self-centering chuck : A self-centering drill chuck is illustrated in Fig.5.23. This type of chuck is particularly adapted for holding tools having straight shanks. Three slots are cut 120° apart in the chuck body which houses three jaws having threads cut at the back that meshes with a ring nut. The ring nut is attached to the sleeve. Bevel teeth are cut all round the sleeve body. The sleeve may be rotated by rotating a key having bevel teeth cut on its face which meshes with the bevel teeth on the sleeve. The rotation of the sleeve causes the ring nut to rotate in a fixed position and all the three jaws close or open by the same amount from the centre holding or releasing the shank of a tool.

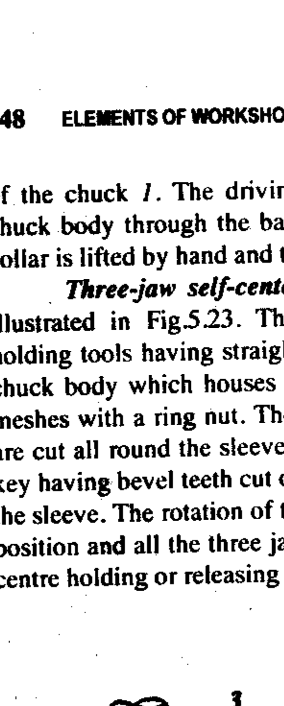


Figure 5.23 Self centering drill chuck
1. Key, 2. Bevel teeth on sleeve, 3. Body, 4. Sleeve, 5. Ring nut, 6. Jaw

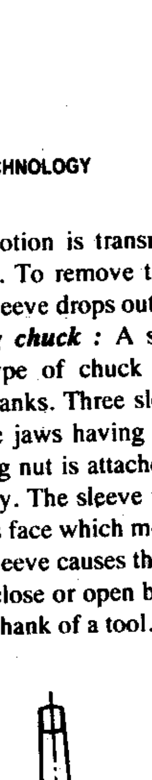


Figure 5.24 Tapping attachment
1. Nut, 2. Spring, 3.,4. Clutch plates.

Tapping attachment : This is a special attachment used for tapping operation in a drilling machine. Hand tapping is a slow process and in mass production work the tap must be driven by a machine. The tapping attachment serves as a flexible connection between the drill spindle and the tap. The principle of working is that when the tap reaches at the bottom or jams in the hole, the driving torque on the tap is released immediately. This prevents any damage to the tap. Fig. 5.24 illustrates a tapping attachment. The taper shank of the attachment is fitted into the drill spindle. The clutch plate *3* having bevel teeth cut on its face rests against the clutch plate *4* having similar teeth cut on its face. The tap is attached to the body of the clutch plate *4*. The clutch plate *3* exerts sufficient pressure on the clutch plate *4* due to he compression in the spring. 2. The spring tension may be adjusted by rotating the nut *1* while using different sizes of taps to regulate the permissible torque on the tap in each case. The motion is transmitted from the drill spindle to the tap through the spring *2* and two clutch plates *3* and *4*. The teeth on the clutch plate 3 pressing against the bevel teeth on the clutch plate *4* ensures the drive. When the tap reaches the bottom of the hole or jams due to any other reason, the frictional torque is no longer sufficient to run the clutch plate *4* and the plate *4* with the tap becomes stationary. The plate *3* continues to revolve with the spindle and the bevel teeth on 3 slips over the bevel teeth on *4* giving a peculiar sound. When this so happens the machine should be reversed. The main difficulty of using a tap in drill machine is the damaging of a tool. The operator must be careful in sensing if the tap reaches the bottom. If the hole is blind, the operator must keep a stopper to prevent the tap to reach the end point.

Floating holder : When a reamer or tap needs to follow a previously drilled or bored hole a floating holder is used to compensate for out of alignment of drill spindle with work and permits self alignment of the tool. When an ordinary reamer or a tap has to follow a drilled hole it is almost impossible to locate the reamer exactly in line with the axis of the hole. Fig.5.25 illustrates a floating holder. The taper shank of the holder fits into the spindle taper. A slot is cut at the cylindrical end of the shank across its diameter. The cylindrical plate *2* has a key type projection on one of its face which fits into the slot of the shank body. Another short key-type projection on the other face of the plate *2* fits into the slot provided at the boss like extension of the sleeve *1*. The two projections on the face of the plate *2* are at right angles to each other and the length of the projections are slightly shorter than the length of the slots. The sleeve and the shank body are held

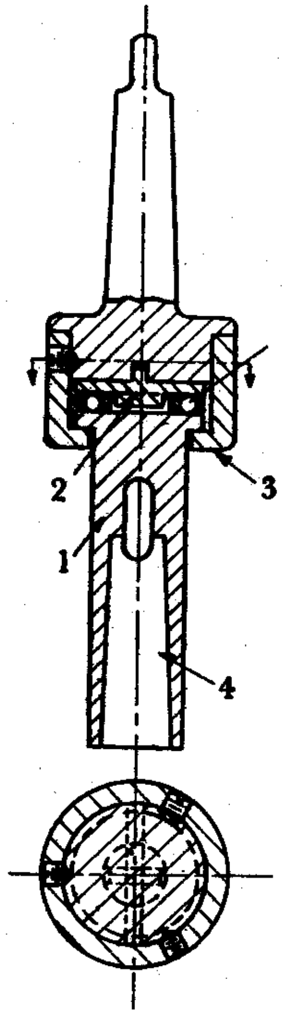


Figure 5.25 Floating holder
1. Sleeve, 2. Cylindrical plate, 3. Coupling, 4. Taper hole.

together by the coupling *3* screwed to the shank body. The rotation of the spindle is communicated to the sleeve through the shank body and the plate *2*. The sleeve may be adjusted in four directions by the sliding of the plate *2*. The sleeve may be adjusted in four directions by the sliding of the plate 2 in either of the slots of the shank body or sleeve at right angles to each other. The tool thus automatically aligns itself with the drilled hole.

5.16 DRILLING MACHINE OPERATIONS

The different operations that can be performed in a drilling machine are :

1. Drilling.
2. Reaming.
3. Boring.
4. Counterboring.
5. Countersinking.
6. Spot facing.
7. Tapping.
8. Lapping.
9. Grinding.
10. Trepanning.

Drilling : Drilling is the operation of producing a cylindrical hole by removing metal by the rotating edge of a cutting tool called the drill. The drilling is one of the simplest methods of producing a hole. Before drilling the centre of the hole is located on the workpiece by drawing two lines at right angles to each other and then a centre punch is used to produce an indentation at the centre. The drill point is pressed at this centre point to produce the required hole. Drilling does not produce an accurate hole in a workpiece and the hole so generated by drilling becomes rough and the hole is always slightly oversize than the drill used due to the vibration of the spindle and the drill. A 12 mm drill may produce a hole as much as

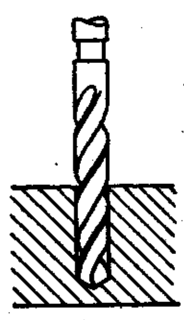


Figure 5.26 Drilling operation

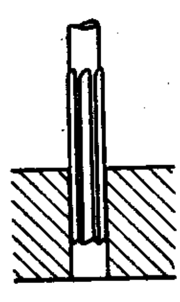


Figure 5.27 Reaming operation

0.125 mm oversize and a 22 mm drill may produce one as much as 0.5 mm oversize. Fig. 5.26 illustrates a drilling operation.

Reaming : Reaming shown in Fig. 5.27 is an accurate way of sizing and finishing a hole which has been previously drilled. In order to finish a hole and to bring it to the accurate size, the hole is drilled slightly undersize. The speed of the spindle is made half that of drilling and automatic feed may be employed The tool used for reaming is known as the reamer which has multiple cutting edges. Reamer cannot originate a hole. It simply follows the path which has been previously drilled and removes a very small amount of metal. For this reason a reamer cannot correct a hole location. The material removed by this process is around 0.375 mm and for accurate work this should not exceed 0.125 mm.

Boring : Boring illustrated in Fig.5.28 is performed in a drilling machine for reasons stated below :

1. To enlarge a hole by means of an adjustable cutting tool with only one cutting edge. This is necessary where suitable sized drill is not available or where hole diameter is so large that it cannot be ordinarily drilled.
2. To finish a hole accurately and to bring it to the required size.
3. To machine the internal surface of a hole already produced in casting.
4. To correct out of roundness of the hole.
5. To correct the location of the hole as the boring tool follows an independent path with respect to the hole.

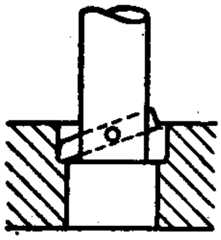


Figure 5.28 Boring operation

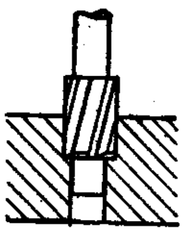


Figure 5.29 Counterboring operation

The cutter is held in a boring bar which has a taper shank to fit into the spindle socket. For perfect finishing a hole, the job is drilled slightly undersize. In precision machines, the accuracy is as high as ± 0.00125 mm. It is a slow process than reaming and requires several passes of the tool.

Counterboring : Counterboring shown in Fig.5.29 is the operation of enlarging the end of a 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 counterboring is called a counterbore. The counterbores are made with straight or tapered shank to fit in the drill spindle. The cutting edges may have straight or spiral teeth. The tool is guided by a pilot which extends beyond the end of the cutting edges. The pilot fits into the small diameter hole having running clearance and maintains the alignment of the tool. These pilots may be interchanged for enlarging different size of holes. Counterboring can give an accuracy of about ± 0.050 mm. The cutting speed for counterboring is 25% less than that of drilling operation.

Countersinking : Countersinking shown in Fig.5.30 is the operation of making a cone-shaped enlargement of the end of a hole to provide a recess for a flat head screw or countersunk rivet fitted into the hole. The tool used for countersinking is called a countersink. Standard countersinks have 60°, 82° or 90° included angle and the cutting edges of the tool are formed at the conical surface. The cutting speed in countersinking is 25% less than that of drilling.

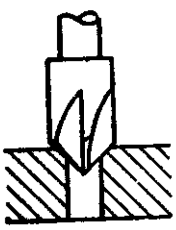


Figure 5.30 Countersinking operation

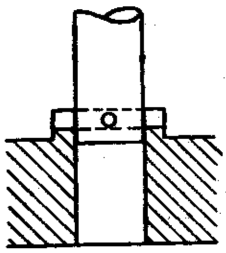


Figure 5.31 Spot facing operation

Spot facing : Spot facing shown in Fig.5.31 is the operation of smoothing and squaring the surface around a hole for the seat for a nut or the head of a screw. A counterbore or a special spot facing tool may be employed for this purpose.

Tapping : Tapping shown in Fig.5.32 is the operation of cutting internal threads by means of a cutting tool called a tap. A tap may be considered as a bolt with accurate threads cut on it. The threads act as cutting edges which are hardened and ground. 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.

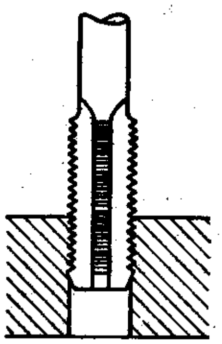


Figure 5.32 Tapping operation

Tap Drill size : The size of the tap being the outside diameter of its threads, it is evident that the drilled hole must be smaller than the tap by twice the depth of the thread. The amount to be subtracted from the tap diameter depends on the shape of the thread, e.g. B.S.W., B.S.F., Indian Standard Thread (IS) etc. Tap drill size may thus be derived from the following formula :

$$D = T - 2d$$

where D is the diameter of tap drill size, T diameter of tap or bolt to be used and d depth of thread.

For example :

In a tap or bolt of Indian Standard Specification, if

outside diameter $T = 10$ mm

pitch of the thread $p = 1.5$ mm

depth of the thread $d = 0.61\ p$ (Approx.)

then, tap drill $D = 10 - 2 \times 0.61 \times 1.5 = 10 - 1.83 = 8.17$ mm

Nearest drill size = **8.20 mm**

Tap drill size can also be worked out when applying the following "rule of thumb", which is sufficiently accurate for most cases.

Tap drill size = Outside diameter $\times$ 0.8

For example :

Tap drill size = 10×0.8 = 8 mm

Nearest drill size = 8.0 mm

For commerciai purposes a tapped thread need not be full depth thread. Tapping a thread by 75% of its full depth gives a satisfactory result.

Lapping : Lapping is the operation of sizing and finishing a small diameter hole already hardened by removing a very small amount of material by using a lap. There are many kinds of lapping tools. The copper head laps are commonly used. The lap fits in the hole and is moved up and down while it revolves.

Grinding : Grinding operation may be performed in a drilling machine to finish a hardened hole. The grinding wheel is made to revolve with the spindle and is fed up and down. A suitable grinding wheel may be selected for surface grinding operation. Grinding can also be done to correct out of roundness of the hole. The accuracy in grinding operation is quite high about ± 0.0025 mm.

Trepannings : Trepanning shown in Fig.5.33 is the operation of producing a hole by removing metal along the circumference of a hollow cutting tool. Trepanning operation is performed for producing large holes. Fewer chips are removed and much of the material is saved while the hole is produced. The tool may be operated at higher speeds as the variation in diameter of the tool is limited by the narrow cutting edge. The tool resembles a hollow tube having cutting edges at one end and a solid shank at the other to fit into the drill spindle. This is one of the efficient methods of producing a hole.

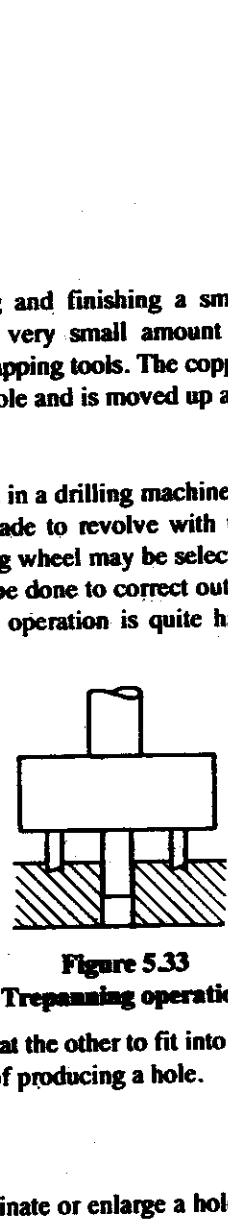


Figure 5.33
Trepanning operation

5.17 DRILLING MACHINE TOOLS

Drill : A drill is a fluted cutting tool used to originate or enlarge a hole in a solid material. Drills are manufactured in a wide variety of types and sizes. The types of the drill commonly used are :

1. Flat or spade drill
2. Straight fluted drill
3. Two-lip twist drill
    a. Parallel shank (short series or "Jobbers" twist drill)
    b. Parallel shank (stub series) twist drill
    c. Parallel shank (long series) twist drill
    d. Taper shank twist drill
4. Taper shank core drill (Three or four fluted)
5. Oil tube drill
6. Centre drill

Flat or spade drill : A flat drill is sometimes used when a same sized twist drill is not available. It is usually made from a piece of round tool steel which is forged to shape and ground to size, then hardened and tempered. The cutting angle varies from 90° to 120° and the relief or clearance at the cutting edge is 3° to 8°. The disadvantage of this type of drill is that each time the drill is ground the diameter is reduced. Further, it cannot be relied upon to drill a true straight hole, since the point of the drill has a tendency to run out of centre.

Another difficulty of using this type of drill is that the chips do not come out from the hole automatically, but tends to pack more or less tightly, if deep holes are to be drilled. Fig.5.34 illustrates a flat drill.

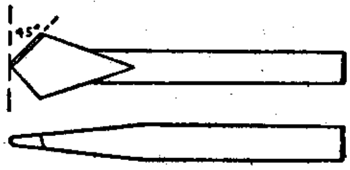


Figure 5.34 Flat drill

Straight fluted drill : A straight fluted drill has grooves or flutes running parallel to the drill axis. A straight fluted drill may be considered as a cutting tool having zero rake. This type of drill is inconvenient in standard practice as the chips do not come out from the hole automatically. It is mainly used in drilling brass, copper or other softer materials. In drilling brass, the twist drill tends to advance faster than the rate of feed and the drill digs into the metal.

No such difficulty occurs in the use of a straight fluted drill when drilling sheet metal. The straight fluted drill does not tend to lift the sheet as does the twist drill. Fig.5.35 illustrates a straight fluted drill.

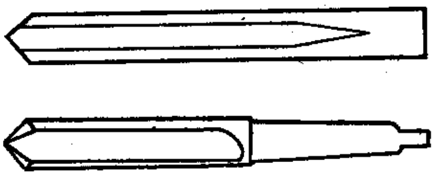


Figure 5.35 Straight fluted drill

Twist drills : The most common type of drill in use today is the twist drill. It was originally manufactured by twisting a flat piece of tool steel longitudinally for several revolutions, then grinding the diameter and the point. The present day twist drills are made by machining two spiral flutes or grooves that run lengthwise around the body of the drill.

Twist drill is an end cutting tool. Different types of twist drills are classified by Indian standard Institution according to the type of the shank, length of the flute and overall length of the drill.

***Parallel shank (short series or "jobbers") twist drill* :** The drill has two helical flutes with a parallel shank of approximately the same diameter as the cutting end. The diameter of the drill range from 0.2 to 16 mm increasing by 0.02 to 0.03 mm in lower series to 0.25 mm in higher series. Fig.5.36 illustrates the drill.

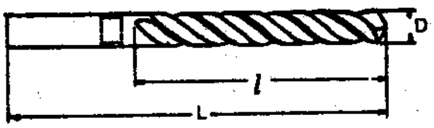


Figure 5.36 Parallel shank short series twist drill

1. Flute length, L. Overall length, D. Diameter

***Parallel shank (stub series) twist drill* :** The drill is a shortened form of the parallel shank twist drill, the shortening being on the flute length. The diameter of the drill ranges from 0.5 to 40 mm increasing by 0.3 mm in lower series to 0.25 to 0.5 mm in higher series. Fig.5.37 illustrates the drill.

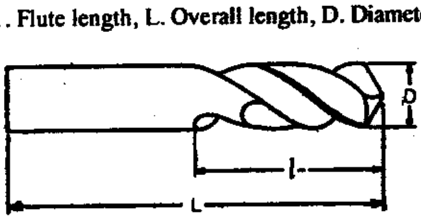


Figure 5.37 Parallel shank (stub series) twist drill

1. Flute length, L. Overall length, D. Diameter.

***Parallel shank (long series) twist drill* :** The drill have two helical flutes with a parallel shank of approximately the shank diameter as the cutting end, which however does not exceed the diameter at the drill point. The overall length of this drill is the same as that of a taper shank twist drill of corresponding diameter. The diameter varies from 1.5 to 26 mm increasing by 0.3 mm in lower series to 0.25 mm in higher series. Fig.5.38 illustrates the drill.

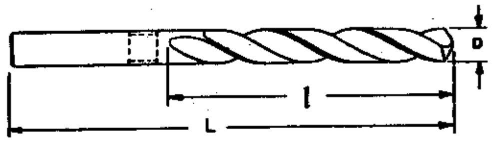


Figure 5.38 Parallel shank (long series) twist drill

1. Flute length, L. Overall length, D. Diameter

***Taper shank twist drill* :** The drill have two helical flutes with a taper shank for holding and driving the drill. The shank for these drills conform to Morse tapers. The diameter ranges from 3 to 100 mm. The diameter increases by 0.3 mm in lowest

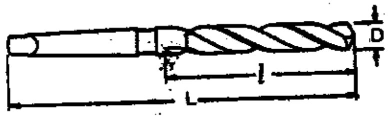


Figure 5.39 Taper shank twist drill

1. Flute length, L. Overall length, D. Diameter.

series having Morse taper shank No. 1, by 0.25 mm in Morse taper shank number 2 and 3, by 0.5 mm in Morse taper shank No. 4, and by 1 mm in Morse taper shank number 5 and 6. The use of Morse taper shank below 6 mm size is not preferred. A drill gauge enables any drill to be readily selected by trying in the holes of the gauge. Fig. 5.39 illustrates the drill.

Taper shank core drill (three or four fluted) : These drills are intended for enlarging cored, punched or drilled holes. These drills cannot originate a hole in solid material because the cutting edges do not extend to the centre of the drill. The metal is removed by a chamfered edge at the end of each flute. Cored drills produce better finished holes than those cut by ordinary two fluted drills. The cutting action of a core drill is similar to that of a rose reamer and it is often used as a roughing reamer. In some cases, a two fluted twist drill is chosen to originate a hole half the required size and the rest is finished by a three or four fluted drill. Fig.5.40 illustrates the drill.

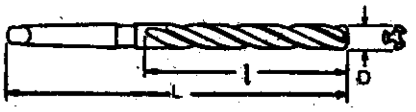


Figure 5.40 Taper shank core drill
(Three fluted)
1. Flute length, L. Overall length, D. Diameter

Oil tube drill : The oil tube drills are used for drilling deep holes. Oil tubes run lengthwise spirally through the body to carry oil directly to the cutting edges. Cutting fluid or compressed air is forced through the holes to the cutting point of the drill to remove the chips, cool the cutting edge and lubricate the machined surface. Fig.5.41 illustrates the oil tube drill.

Figure 5.41 Oil tube drill

Centre drills : The centre drills are straight shank, two fluted twist drills used when centre holes are drilled on the ends of a shaft. They are made in finer sizes. Fig.5.42 illustrates the drill.

Figure 5.42 Centre drill

5.18 TWIST DRILL NOMENCLATURE

The following are the nomenclature, definitions and functions of the different parts of a drill illustrated in Fig.5.43.

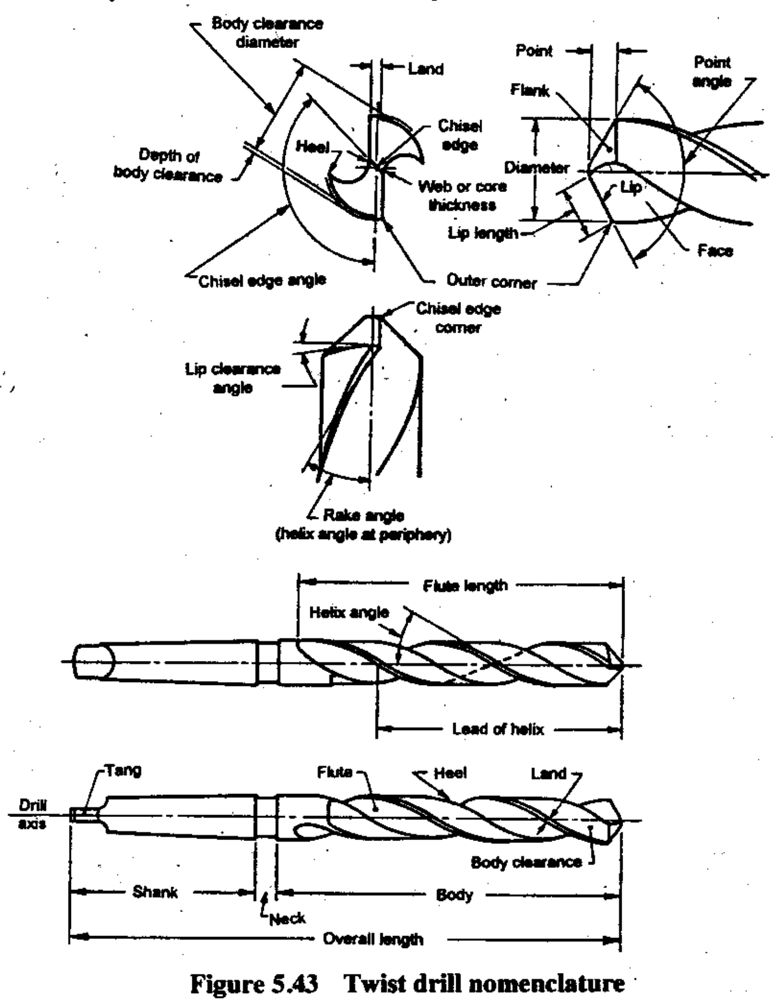


Figure 5.43 Twist drill nomenclature

Twist drill elements : The following are the twist drill elements.

Axis : The longitudinal centre line of the drill.

Body : That portion of the drill extending from its extreme point to the commencement of the neck, if present, otherwise extending to the commencement of the shank.

Body clearance : That portion of the body surface which is reduced in diameter to provide diametral clearance.

Chisel edge : The edge formed by the intersection of the flanks. The chisel edge is also sometimes called dead centre. The dead centre or the chisel edge acts as a flat drill and cuts its own hole in the workpiece. A great amount of axial thrust is required to cut a hole by the chisel edge. In some drills chisel edge is made spiral instead of a straight one. This reduces the axial thrust and improves the hole location. Chances of production of oversize holes is also reduced.

Chisel edge corner : The corner formed by the intersection of a lip and the chisel edge.

Face : The portion of the flute surface adjacent to the lip on which the chip impinges as it is cut from the work.

Flank : That surface on a drill point which extends behind the lip to the following flute.

Flutes : The groove in the body of the drill which provides lip
The functions of the flutes are :

1. To form the cutting edges on the point.
2. To allow the chips to escape.
3. To cause the chips to curl.
4. To permit the cutting fluid to reach the cutting edges.

Heel : The edge formed by the intersection of the flute surface and the body clearance.

Lands : The cylindrically ground surface on the leading edges of the drill flutes. The width of the land is measured at right angles to the flute helix. The drill is full size only across the lands at the point end. Land keeps the drill aligned.

Lip (cutting edge) : The edge formed by the intersections of the flank and face. The requirements of the drill lips are :

1. Both lips should be at the same angle of inclination with the drill axis, 59° for general work.
2. Both lips should be of equal length.
3. Both lips should be provided with the correct clearance.

Neck : The diametrically undercut portion between the body and the shank of the drill. Diameter and other particulars of the drill are engraved at the neck.

Outer corner : The corner formed by the intersection of the flank and face.

Point : The sharpened end of the drill, consisting of all that part of the drill which is shaped to produce lips, faces, flanks and chisel edge.

Right hand cutting drill : A drill which cuts when rotating in counter-clockwise direction viewed on the point end of the drill.

Shank : That part of the drill by which it is held and driven. The most common types of shank are the taper shank and the straight shank. The taper shank provides means of centering and holding the drill by friction in the tapered end of the spindle.

Tang : The flattened end of the taper shank intended to fit into a drift slot in the spindle, socket or drill holder. The tang ensures positive drive of the drill from the drill spindle.

Web : The central portion of the drill situated between the roots of the flutes and extending from the point toward the shank; the point end of the web or core forms the chisel edge.

Linear dimensions : The following are the linear dimensions of the drill.

Back taper (longitudinal clearance): It is the reduction in diameter of the drill from the point towards the shank. This permits all parts of the drill behind the point to clear and not rub against the sides of the hole being drilled. The taper varies from 1 : 4000 for small diameter drills to 1 : 700 for larger diameters.

Body clearance diameter : The diameter over the surface of the drill body which is situated behind the lands.

Depth of body clearance : The amount of radial reduction on each side to provide body clearance.

Diameter : The measurement across the cylindrical lands at the outer corners of the drill.

Flute length : The axial length from the extreme end of he point to the termination of the flute at the shank end of the body.

Lead of helix : The distance measured parallel to the drill axis between the corresponding point on the leading edge of the flute in one complete turn of the flute.

Lip length : The minimum distance between the outer corner and the chisel edge corner of the lip.

Overall length : The length over the extreme ends of the point and the shank of the drill.

Web (core) taper : The increase in the web or core thickness from the point of the drill lto the shank end of the flute. This increasing thickness gives additional rigidity to the drill and reduces the cutting pressure at the point end.

Web thickness : The minimum dimension of the web or core measured at the point end of the drill. Considerable power is required to force this portion through the work, and web thinning is employed to reduce the web thickness.

Drill angles : Following are the drill angles which are ground on a twist drill for efficient removal of metal.

Chisel edge angle : The obtuse angle included between the chisel edge and the lip as viewed from the end of the drill. The usual value of this angle varies from 120° to 135°.

Helix angle or rake angle : The helix or rake angle is the angle formed by the leading edge of the land with a plane having the axis of the drill. If the flute is straight, parallel to the drill axis then there would be no rake; if the flute is right handed then it is positive rake; and if it is left handed then the rake is negative. The usual value of rake angle is 30°, although it may vary up to 45° for different materials. Smaller the rake angle, greater will be the torque required to drive the drill at a given feed.

Point angle : This is the angle included between the two lips projected upon a plane parallel to the drill axis and parallel to the two cutting lips. The usual point angle is 118°, but for harder steel alloys, the angle increases.

Lip clearance angle : The angle formed by the flank and a plane at right angles to the drill axis. The angle is normally measured at the periphery of the drill. Lip clearance is the relief that is ground to the cutting edges in order to allow the drill to enter the metal without interference. The lip clearance angle should increase towards the centre of the drill than at the circumference. This is due to the fact that different points on the drill cutting edge follow different helical paths. Any point on the cutting edge at the circumference moves through a smaller helical angle than a point on the cutting edge near the centre. This happens to be such due to the lead of the helix being same in each case and hence the clearance angle given to the drill cutting edge should increase towards the centre. The clearance angle is 12° in most cases. The clearance angle should be minimum to add rigidity and strength to the cutting edge.

Drill angles for different materials and coolants : The Table 5.1, gives different drill angles for different materials and coolants while using h.s.s. 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.

TABLE 5.1 DRILLING ANGLES AND COOLANTS USED IN DRILLING

Material	*Coolant*	*Point angle deg.*	*Lip clearance deg.*	*Chisel point deg.*	*Helix angle deg.*
Aluminium	$\frac{2}{3}$ lard oil, $\frac{1}{3}$ kerosene	90–140	12–17	125–135	24–48
Brass	$\frac{2}{3}$ lard oil, $\frac{1}{3}$ kerosene	118	12–15	125–135	0–17
Cast iron hard	soluble oil	118	10–12	125–135	24–32
Copper	soluble oil	100–118	12–15	125–135	28–40
Nickel pure	Lard oil	118	12	125–135	24–32
Stainless steel	Sulphur base oil	125–135	10–12	120–130	24–32
Steel	Soluble oil, mineral oil, sulphurised and chlorinated oil	118	12–15	125–135	24–32

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.

Fractional sizes : The drill sizes range from $\frac{1}{64}$ inch to 5 inch in steps of $\frac{1}{64}$ inch upto $1\frac{3}{4}$ inch, then the steps gradually increase.

5.20 DESIGNATION OF DRILL

In Indian standard system, twist drills are designated by the series to which they belong, the diameter, the I.S. number and the material of the drill. Unless mentioned in the designation, it should be presumed that the drill type is *N* and point angle 118°. The drills are made in three types, namely, normal (*N*), hard (*H*) and soft (*S*). These designation are based on the material to be cut and design requirements of the drill. Thus a parallel shank twist drill of long series, 10 mm dia, conforming to I.S. standard, made of carbon steel, of type *S* and point angle 80° is designated as :

Parallel shank twist drill (Long) 10.00 – IS : 599-*CS*–*S*-*80*

5.21 DRILL MATERIAL

The materials for the manufacture of twist drills are as follows :

1. One piece construction : High speed steel or carbon steel.
2. Two piece construction :
   Cutting portion– High speed steel.
   Shank portion – Carbon steel with a minimum tensile strength of 70 kg per sq mm.

High speed drills are more widely used due to its greater cutting efficiency. Cemented carbide tipped drills are also used in mass production work.

5.22 REAMER

A reamer is a tool used for enlarging or finishing a hole previously drilled, bored or cored to give a good finish and an accurate dimension. A reamer is a multi-tooth cutter which removes relatively small amount of material. There are various classifications of reamers depending upon the operation, purpose and shape. The commonly used reamers detailed in I.S. specifications are :

1. Chucking reamer with parallel or taper shank (a) Fluted reamer, (b) Rose reamer
2. Machine bridge reamer
3. Machine jig reamer
4. Parallel hand reamer with parallel shank
5. Parallel or taper shank socket head reamer

6. Shell reamer
7. Taper pin hand or machine reamer
8. Expansion reamer

Chucking reamer with parallel or taper shank (fluted) : The chucking reamer shown in Fig.5.44 is also known as machine reamer. The reamer has short virtually parallel cutting edges, with bevel lead, and long body recess between shank and cutting edges integral with a parallel or taper shank for holding and driving the reamer. The flutes are all straight but the shank may be straight or taper. The reamer is intended to be used in a drill press, turret lathe or screw cutting machine. It is driven at slow speed and the entire cutting is done along the flutes. The flutes are spaced irregularly around the circumference of the body of the reamer.

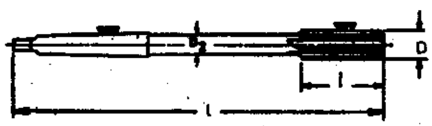


Figure 5.44 Chucking reamer with taper shank

This reduces the tendency to chatter. The fluted reamer is used for reaming more accurate work. The diameter of a straight shank chucking reamer varies from 1.5 to 32 mm and for taper shank from 5 to 32 mm.

Chucking reamer (rose) : It differs from the fluted type in that the cutting is all done by the beveled edges at the end. The chamfered cutting edges make an angle of 45°. The fluted body fits into the reamed hole. The body is slightly tapered, smaller towards the shank to prevent binding in the hole. This type of reamer can remove greater amount of metal than a fluted type. A chucking rose reamer is shown in Fig.5.45.

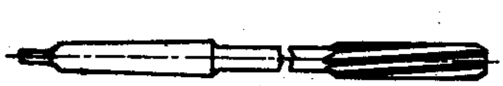


Figure 5. 45 Chucking rose reamer

Machine bridge reamer : A machine bridge reamer illustrated in Fig.5.46 (a) and (b) is used in portable electric or pneumatic tool for reaming in ship-building, structural, and plate work. This has parallel cutting edges, with a long lead integral with a taper shank for holding and driving the reamer. The flutes may be straight or helical. The diameter of reamer varies from 6.4 to 37 mm.

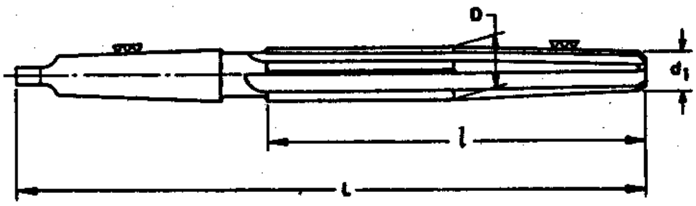


Figure 5. 46 (a) **Straight fluted machine bridge reamer**
l. Length of the cutting edge, L. Overall length, d_1. Diameter, D. Nominal diameter

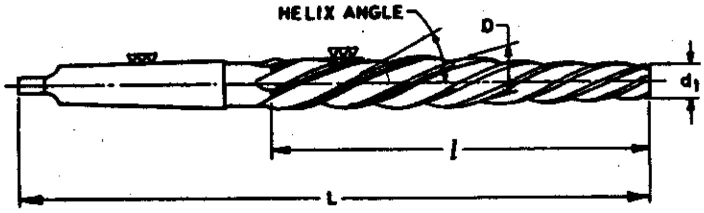


Figure 5. 46 (b) **Helical fluted machine bridge reamer**
l. Length of the cutting edge, L. Overall length, d_1. Diameter, D. Nominal diameter

Machine jig reamer : A machine jig reamer has short, virtually parallel cutting edges with bevel lead and guide between the shank and cutting edges integral with a taper shank for holding and driving. The flutes are helical. The plain part of the body fits into a bushing in the jig and accurately locates the reamer. The diameter of the reamer varies from 7 to 50 mm. The reamer is illustrated in Fig.5.47

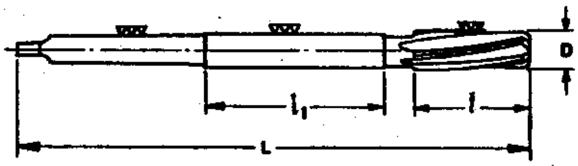


Figure 5.47 **Machine jig reamer**
l_1. Guide length, l. Cutting edge length, L. Overall length, D. Nominal diameter

Parallel hand reamer with parallel shank : This reamer has virtually parallel cutting edges with taper and bevel lead integral with a shank of the nominal diameter of the cutting edges, and with a square on the end. The flutes may be straight or helical. The hand reamer has square tang and is intended to be hand driven for accurately sizing the holes. The reamers are supposed to remove minimum amount of metal from 0.05 to 0.125 mm. It is slightly tapered towards the end for a distance equal to its diameter for easy starting. This type of reamer is shown in Fig.5.48.

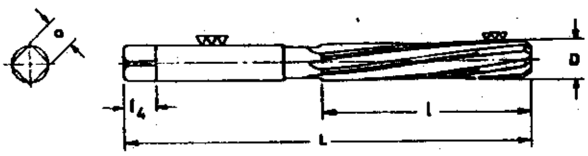


Figure 5.48 Parallel hand reamer with parallel shank
l. Length of cutting edge, L. Overall length, l_4. Length of driving square, D. Nominal diameter, a. Driving square sizing.

Socket reamer for Morse taper : This reamer may be straight or taper shank type and may be hand or machine driven. The reamers have taper cutting edges to suit Morse taper, integral with a parallel or taper shank. The flutes may be straight or helical. The reamers are available in a set of three : roughing, pre-finishing and finishing. The diameter of reamers are available for finishing Morse taper holes from No. 1 to 6. A socket reamer is shown in Fig.5.49.

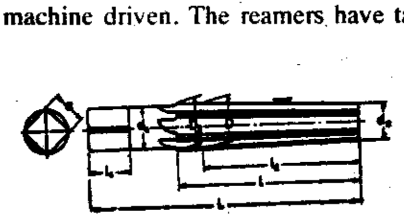


Figure 5.49 Parallel shank socket hand reamer for Morse tapers
l. Length of cutting edge, l_2. Small end to gauge plane, L. Overall length, l_4. Length of driving square, D. Diameter at gauge plane, D_2. Big end diameter, d_2. Small end diameter, a. Driving square size.

Shell reamer : A shell reamer shown in Fig.5.50 has an axial hole for use on an arbor, and has virtually parallel cutting edges with a sharpened bevel lead. Shell reamers are employed for finishing large holes to save the tool cost. Numerous sizes of shells

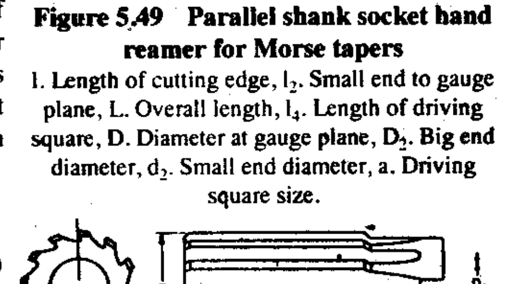


Figure 5.50 Shell reamer
l. Length of cutting edge, L. Overall length, D. Nominal diameter, D_1. Large end diameter.

can be interchanged with one arbor. This saves the cost of the solid shank in each case. The shell reamer may be either of the rose chucking type for truing the hole or fluted type for finishing. The flutes may be straight or helical. The diameter of the reamer varies from 24 to 100 mm.

Taper pin reamer : The reamer shown in Fig.5.51 may be hand or machine driven. This has taper cutting edges for holes to suit pins with a taper of 1 in 50, having a parallel or taper shank for holding and driving the reamer. The flutes may be straight or helical.

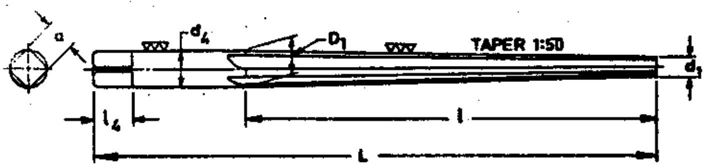


Figure 5.51 Taper pin hand reamer

l. Length of cutting edge, L. Overall length, l_4. Length of driving square, D_1. Big end diameter, d_1. Small end diameter, d_4. Shank diameter, a. Driving square size.

Expansion reamer : An expansion reamer is so made that it may be adjusted by very small amount to compensate for wear, or to accommodate some variation in hole size. As shown in the Fig.5.52, to effect expansion, the clamping nut is loosened and the plug *1* is pushed inward. This causes the expansion of the blades by a small amount.

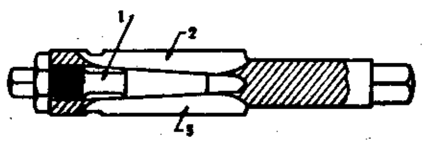


Figure 5.52 Expansion reamer

1. Adjusting plug, 2,3. Blades.

5.23 REAMER NOMENCLATURES

The following are the nomenclatures of a reamer illustrated in Fig.5.53 (a), (b), (c), and (d).

Elements of reamer : The reamer elements are described below :

Axis : The longitudinal centre line of the reamer.

Backer taper : The reduction in a diameter per 100 mm length of reamer from the entering end towards the shank.

Bevel lead : The angular cutting portion at the entering end to facilitate the entry of the reamer into the hole. It is not provide with a circular land.

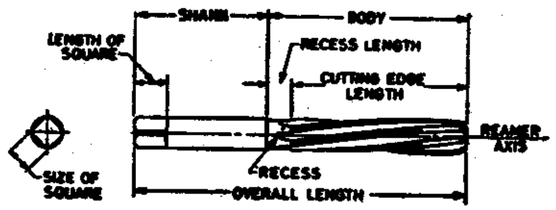


Figure 5.53(a) Reamer nomenclature for parallel hand reamer, right hand rotation with left hand helical flutes

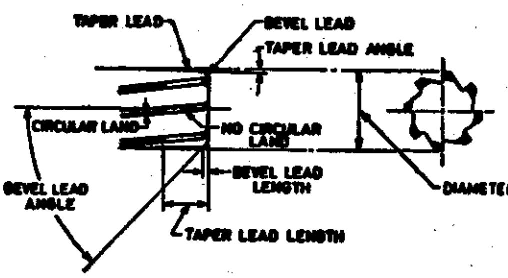


Figure 5.53(b) Reamer nomenclature: Entering end of a parallel hand reamer

Body : That portion of the reamer extending from the entering end of the reamer to the commencement of its shank.

Circular land : The cylindrically ground surface adjacent to the cutting edge, on the leading edge of the land.

Clearance :

1. Primary : That portion of the land removed to provide clearance immediately behind the cutting edge.
2. Secondary : That portion of the land removed to provide clearance behind the primary clearance or circular land.

Cutting edge : The edge formed by the intersection of the face and the circular land or the surface left by the provision of primary clearance.

Face : The portion of the flute surface adjacent to the cutting edge on which the chip impinges as it is cut from the work.

Flutes : The grooves in the body of the reamer to provide cutting edges, to permit the removal of chips and to allow cutting fluid to reach the cutting edges.

Heel : The edge formed by the intersection the surface left by the provision of secondary clearance and the flute.

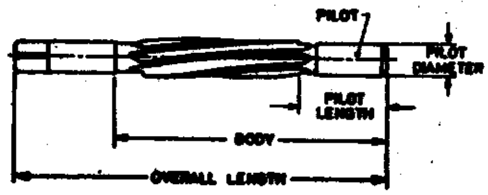


Figure 5.53(c) Reamer nomenclature : Heads reamer with pilot

Land : That portion of the fluted body left standing between the flutes, the surface or the surfaces included between the cutting edge and the heel.

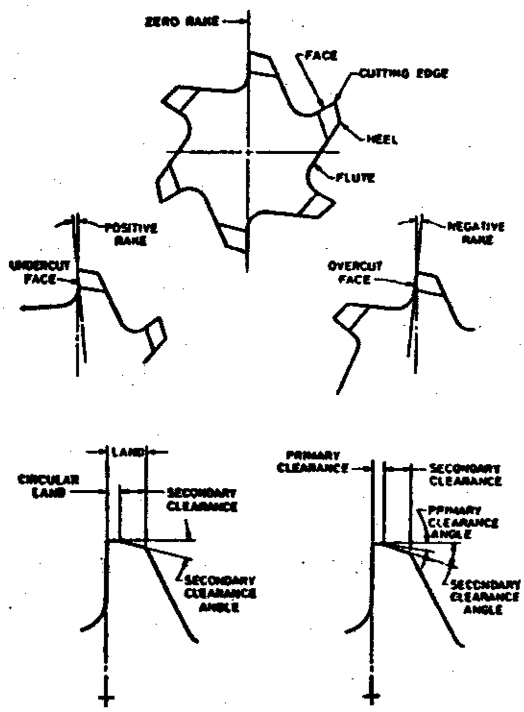


Figure 5.53(d) Reamer nomenclature: Terms relating to cutting characteristics of reamers

Pilot : A cylindrically ground portion of the body at the entering end of the reamer to keep the reamer in alignment.

Recess : That portion of the body which is reduced in diameter below the cutting edge, pilot or guided diameter.

Shank : That portion of the reamer by which it is held and driven.

Diameter : The maximum cutting diameter of the reamer at the entering end.

Rotation of cutting : A reamer is named, according to the direction of rotation, as :

Left hand cutting reamer : A reamer which cuts while rotating in a clockwise direction when viewed on the entering end of the reamer.

Right hand cutting reamer : A reamer which cuts while rotating in a anticlockwise direction when viewed on the entering end of the reamer.

Reamer angles : The reamer angles are given below.

Bevel lead angle : The angle formed by the cutting edges of the bevel lead and the reamer axis.

Clearance angles : The angles formed by the primary or secondary clearances and the tangent to the periphery of the reamer at the cutting edge.

Helix angle : The angle between the cutting edge and the reamer axis.

Rake angle: The angles, in a diametral plane, formed by the face and a radial line from the cutting edge.

1. If the face and the radial line coincide, the angle is zero degree and the face is called *radial.*
2. If the angle formed by the face and the radial line falls behind the radial line in relation to the direction of cut, the rake angle is positive, and the face is known as *undercut.*
3. If the angle formed by the face and the radial line falls in front of the radial line in relation to the direction of cut, the rake angle is negative, and the face is known as *over cut.*

Taper lead angle : The angle formed by the cutting edges of the taper lead and the reamer axis.

5.24 COUNTERBORE

A counterbore is an end cutting tool with three or four cutting teeth, The counterbore may be straight or helical fluted. Straight fluted counterbores are used for short depth of cut and for machining softer materials like brass and aluminium. Helical fluted tools are used for counterboring larger holes. Counterbores may be carbide tipped for mass production work. Fig.5.54 illustrates a counterbore. Counterbores are classified as :

Figure 5.54
Counterbore

1. Solid 2. Shell 3. Insert type

Solid counterbore : The solid counterbore has the shank-cutter and pilot in one piece. This type of counterbore is used for enlarging holes for accommodating machine screw heads.

Inserted blade counterbore : The inserted blade counterbore is used for enlarging larger sizes of holes. The pilot may be solid with the body or it may be removable.

Shell counterbore : This is a three piece counterbore consisting of holder, cutter and pilot. Different sizes of counterbore cutter may be fitted in the holder. Pilots are also interchangeable.

5.25 COUNTERSINKS AND SPOT FACERS

Except for the angle of the cutting edges, counterbores, spot facers and countersinks are of similar construction. They are all end cutting tools and made with two or more flutes with a right hand helix. Countersinks have edges on a conical surface.

5.26 TAPS

A tap is a screw-like tool which has threads like a bolt and three or four flutes cut across the thread. It is used to cut threads on the inside of a hole, as in a nut. The edges of the thread formed by the flutes are the cutting edges. The lower part of the tap is somewhat tapered so that it can well dig into the walls of the drilled hole. The upper part of the tap consists of a shank ending in a square for holding the tap in the machine spindle or by a tap wrench. Taps are made from carbon steel or high speed steel and are hardened and tempered.

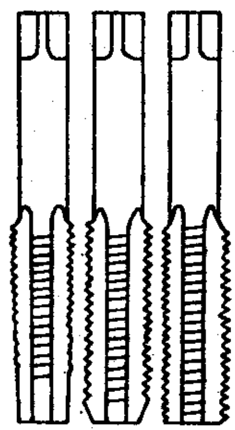
Taps are classified as (1) hand tap and (2) machine tap.

Hand tap : The hand taps illustrated in Fig.5.55 are usually made in sets of three : (1) taper tap, (2) second tap, and (3) bottoming tap. According to IS specification they are called Rougher, Intermediate and Finisher respectively. All hand taps are straight fluted.

The end of the *rougher* has about six threads tapered. This is used to start the thread so that the threads are formed gradually as the tap is turned into the hole.

The *intermediate* is tapered back from the edge about three or four threads. This is used after the rougher tap has been used to cut the thread as far as possible.

The *finisher* has full threads for the whole of its length. This is used to finish the work prepared by the other two taps.



(a) (b) (c)

Figure 5.55 Hand taps
(a). Taper tap, (b). Second tap.
(c). Bottoming tap

Machine tap : Machine taps have straight or helical flutes. In machine tapping it is necessary to see that the chips always clear the cutting edges.

5.27 TAP NOMENCLATURE

The following are the tap nomenclature illustrated in Fig.5.56.

Elements of tap : The elements of a tap are described below :

Axis : The longitudinal centre line of the tap.

Body : The threaded portion extending from the entering end of the tap to the shank.

Chamfer or tapered lead : The taper cutting portion provided with cutting clearance at the entering end of the tap to distribute the cutting action over several thread forms and to facilitate the entry of the tap into the hole.

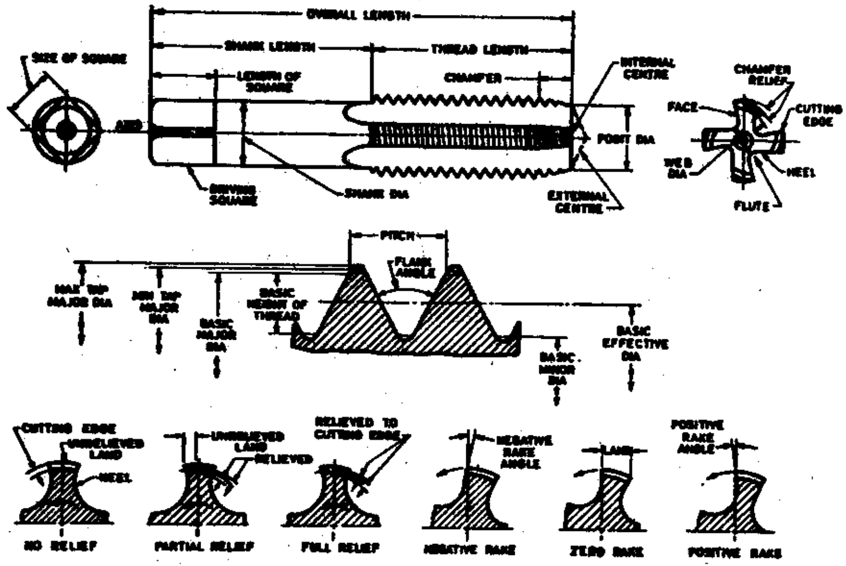


Figure 5.56 Tap nomenclature

Chamfer relief : The gradual decrease in land height from the cutting edge to heel on the chamfered portion of the land to provide radial clearance for the cutting edge.

Cutting edge : The edge formed by the intersection of the flute face and the form of the thread, imposed on the land.

Driving square : That portion of the extreme end of the tap shank by which the tap is held and driven.

Face : That portion of the flute surface adjacent to the cutting edge upon which the chip impinges as it is cut from the work.

Flute : The grooves in the body of the tap to provide cutting edges, permit the removal of chips and to allow lubricant or coolant to reach the cutting edges.

Flute relief : Radial relief in the thread form starting at the cutting edge and continuing to the heel.

Heel : The edge formed by the intersection of the relieved surface behind the cutting edge and the flute.

Land : The portion of the body of the tap left standing between the flutes, also the surface between the cutting edge and the heel.

Radial relief : Radial relief in the thread form provided behind the unrelieved land.

Shank : That portion of the tap by which it is held or located and driven.

Thread relief : The clearance produced on a tap land by reducing the diameter of the entire thread form between the cutting edge and the heel.

Web : The central portion of the tap situated between the roots of the flutes and extending along the fluted portion of the tap.

Web taper : The increase of the web thickness from the entering end of the tap towards the shank end of the flutes.

Back taper : The reduction in diameter of the tap body of the threaded portion from the entering end towards the shank.

Effective or pitch diameter : On a tap having a parallel threaded portion, the effective diameter is the diameter of an imaginary coaxial cylinder which would pass through the threads at such points as to make the width of the threads and the width of the spaces between the threads equal at those points, measured at the cutting edge.

Major diameter : On a tap having a parallel threaded portion, the major diameter is the diametral measurement over the crests of the thread form at the cutting edge.

Minor diameter : On a tap having a parallel threaded portion, the minor diameter is the diametrical measurement over the roots of the thread form at the cutting edge.

Overall length : The axial length over the extreme ends of taps.

Rotation of cutting : A tap is named, according to the direction of rotation as :

Left hand tap : A tap which cuts while rotating in a clockwise direction when viewed from the entering end of the tap.

Right hand tap : A tap which cuts while rotating in an anticolckwise direction when viewed from the entering end of the tap.

Angles : The tap angles are given below :

Chamfer angle : The angle formed by the cutting edges of the taper lead and the tap axis.

Flank angle : The angle included between the flanks of the thread, measured in an axial plane.

Flute helix angle : The angle formed between the leading edge of the land and the tap axis.

Radial rake angle : The angle formed in a diametral plane between the face and a radial line from the cutting edge at the crest of the thread form :

1. *Zero rake :* If the face and the radial line coincide, the angle is zero, and the face is *radial.*
2. *Positive rake :* If the angle formed by the face and the radial line falls behind the radial line in relation to the direction of cut, then the radial angle is positive and the face is known as *undercut.*
3. *Negative rake :* If the angle formed by the face and the radial line falls in front of the radial line in relation to the direction of cut, then the radial angle is negative and the face is known as *overcut.*

Relief angle : The equivalent angle between a relieved land surface and the cutting diameter circle of the tap thread form.

5.28 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 metres per minute. The cutting speed (v) may be calculated as :

$$v = \frac{\pi dn}{1{,}000} = m \text{ per min.} \qquad 5.3$$

where, d is the diameter of the drill in mm and n is the r.p.m. of the drill spindle.

Thus it is evident that a small drill must rotate faster than a large drill to maintain the same cutting speed. Unlike the turning tool of a lathe, cutting speed of a drill varies from point to point on the cutting edges of the drill. The cutting speed is maximum at the periphery and it is zero at the centre of the drill. This results inefficient cutting towards the centre. The cutting speed of a drill depends, as in other machining processes, upon several factors which include mainly the following :

1. The kind of material being drilled. Softer the material the higher the speed.
2. The cutting tool material. High speed steel drills can be operated at about twice the speed of high carbon steel drills

3. The quality of surface finish desired.
4. The efficient use of cutting fluid.
5. The method of holding the work.
6. The size, type, and rigidity of the machine.

5.29 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 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 (s_m) per minute may be calculated as :

$$s_m = s_r \times n \qquad 5.4$$

where, s_m = Feed per minute in mm.
s_r = Feed per revolution in mm.
n = r.p.m. of the drill.

The amount of feed, as in the cutting speed, is dependent upon several machining conditions, such as :

1. Material being cut, e.g. hard, tough, etc.
2. Rigidity of the job and machine.
3. Depth of hole.
4. Type of finish desired.
5. Power available.
6. Range of feeds available.

Too great a feed may split the drill in the web, The feed per revolution usually increases with the increase in size 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 :

$$t = \frac{d}{2} mm \qquad 5.5$$

5.31 MACHINING TIME IN DRILLING

Machining time in drilling is determined by the formula :

$$T = \frac{L}{n \times s_r} \text{ min.} \qquad 5.6$$

where, n = r.p.m. of the drill

s_r = Feed per revolution of the drill in mm

L = Length of travel of the drill in mm

and T = Machining time in min.

$$L = l_1 + l_2 + l_3 + l_4$$

where, l_1 = length of the workpiece

l_2 = approach of the drill,

l_3 = length of the drill point (0.29d)

l_4 = overtravel

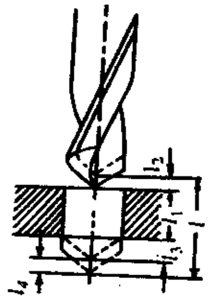


Figure 5.57 Drilling

Example 5.1 : At what speed a 20 mm drill will run for cutting steel at 25 m per min surface speed ?

$$v = \frac{\pi d n}{1{,}000}$$

so $$25 = \frac{\pi \times 20n}{1{,}000} \quad \text{or} \quad n = \frac{25 \times 1000}{\pi \times 20} = \mathbf{398\ r.p.m.}$$

TABLE 5.2 CUTTING SPEEDS FOR DRILLING IN M PER MIN

	h.s.s drills	*C.S. drills*
Soft cast iron	30 - 45	12.0 - 23
Medium cast iron	21 - 30	9.0 - 15
Malleable iron	24 - 27	9.0 - 14
Mild steel	24 - 45	9.0 - 17
Stainless steel	18 - 21	7.5 - 10.5
Aluminium and alloys	60 - 90	24.0 - 45
Brass and Bronze	60 - 90	24.0 - 45
Copper	18 - 30	7.5 - 15

REVIEW QUESTIONS

1. Name different types of drilling machines ?
2. Sketch and describe in brief of a radial drilling machine.
3. How the size of a drilling machine is specified ? Discuss.
4. Name various work holding devices of drilling machine. Describe one with sketch.
5. Explain the construction of the following parts of a drilling machine : (a) Base, (b) Drill head, (c) Spindle drive and feed mechanism.
6. What are different tool holding devices in drilling machine ?
7. Describe of a tapping attachment in drill machine.
8. List various drilling machine operations.
9. How the drill size for tapping is fixed ? Explain.
10. What is a spade drill ? When is it used ? Sketch one.
11. What is trepanning ? Describe.
12. Explain counter-boring and counter sinking operations.
13. List various types of drill.
14. Describe twist drill nomenclature using sketches.
15. How is the drill size specified ? Discuss of the codification of drill sizes and types.
16. Draw a sketch of a simple twist drill with tapered shank and show its various elements.
17. Name drill bit materials. Which material is mostly used ?
18. What is a reamer ? When it is used ? List various types of reamers.
19. Describe various elements of a reamer.
20. Discuss reamer nomenclatures.
21. What is a tap ? How taps are classified ?
22. How tap nomenclature is described ?
23. List and describe elements of taps.
24. At what speed a 20 mm drill will run for a cutting sheet at 30 m per min surface speed. (Ans 477 r.p.m.)