CHAPTER 02

Drilling Machine

Learning Objectives

- Students to understand how to drill the holes in work pieces, different types of machining operations related to drilling process and various uses of drilling process in industries and other fields in future life.

Thaam inburuvadhu ulagin purakandu
Kaamuruvar katrarinh dhaar. –Kural 399

When the learned see that their learning contributes to make the world happy. They are pleased and pursure their learning more.

CONTENTS

The inventor of basic drilling machine is Arthur James Arnot and William Blanch Brain of Melborne. Australia by using the electric motor, in the year of 1889.


Arthur James Arnot

2.1 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. It was designed to produce a cylindrical hole of required diameter and depth on work pieces.

Though holes can be made by different machine tools in a shop, drilling machine is designed specifically to perform the operation of drilling and similar operations. Drilling can be done easily at a low cost in a Shaffer period of time in a drilling machine.

Drilling can be called as the operation of producing a cylindrical hole of required diameter and depth by removing metal by the rotating the cutting edges of a drill bit.

2.2 Method of Drilling

The cutting tool known as drill bit is fitted into the spindle of the drilling machine. A mark of indentation is made at the required location with a center punch. The rotating drill is pressed at the location and is fed into the work. The hole can be made up to a required depth.

2.3 Structure of a drilling machine

The basic parts of a drilling machine are a base, column, drill head and spindle.


3D Method of Drilling

HVKC6

The base made of cast iron may rest on a bench, pedestal or floor depending upon the design. Larger and heavy duty machines are grounded on the floor. The column is mounted vertically upon the base. It is accurately machined and the table can be moved up and down on it. The drill spindle an electric motor and the mechanism meant for driving the spindle at different speeds are mounted on the top of the column. Power is transmitted from the electric motor to the spindle through a flat belt (or) a 'V' belt.

3D Structure of a drilling machine

2.4 Types of drilling machines

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

The different types of drilling machines are

1. Portable drilling machine (or) Hand drilling machine.
2. Sensitive drilling machine
3. Upright drilling machine
   a) Round column section
   b) Box column section
4. Radial drilling machine
5. Gang drilling machine
6. Multi – spindle drilling machine
7. Deep hole drilling machine.
   a) Vertical
   b) Horizontal
8. Automatic drilling machine.

Types of Drilling Machines

1. Portable Drilling Machine (or) Hand Drilling Machine
2. Bench Drilling Machine (or) Sensitive Drilling Machine
3. Upright Drilling Machine
   a. Box column
   b. Round column
4. Radial Drilling Machine
5. Gang Drilling Machine
6. Multi–Spindle Drilling Machine
7. Deep Hole Drilling Machine
   a) Vertical
   b) Horizontal
8. Automatic Drilling Machine

2.5 Portable drilling machine

The portable drilling machine is shown in the given figure.

Portable drilling machine can be carried and used anywhere in the workshop. It is used for drilling holes on work pieces in any position. Which is not possible in a standard drilling machine. The entire drilling mechanism is compact and small in size and so can be carried anywhere. This type of machine is widely adapted for automobile built – up work. The motor is generally universal type.

Portable drilling machine

These machines can accommodate drills from 12mm to 18 mm diameter. The machine is operated at high speed as smaller size drills are only used.

2.6 Sensitive drilling machine (or) Bench drilling machine

A sensitive drilling machine is shown in the given figure.

DO YOU KNOW?

The inventor of sensitive drilling machine is martin. D.Eliedge of USA. Year 1958.

It is designed for drilling small holes at high speeds in jobs. High speed and hand feed are necessary for drilling holes. The base of the machine is mounted either on a bench or on the floor. It can handle drills of diameter from 1.5mm to 1.55mm the drill is feed with work purely by hand. The operator can sense of the progress of the drill into work because of hand feed. So it is called sensitive drilling machine.

Super sensitive drilling machines are designed to drill holes as small as 0.35mm in diameter and the spindle of the machine is rotated at a high speed of 2000 rpm or above.

Base

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

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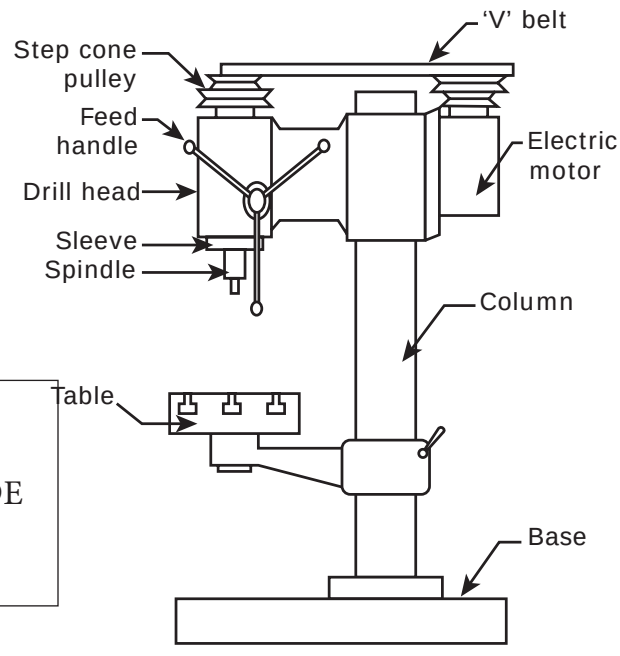


Bench Drilling Machine

Column

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

Work Table

The table is mounted on the vertical column and can be adjusted up and down on it. The table has T- slots on it for holding the wok pieces or to hold any other work holding device. The table can be adjusted vertically to accommodate work pieces of different heights and can be clamped at the required position.

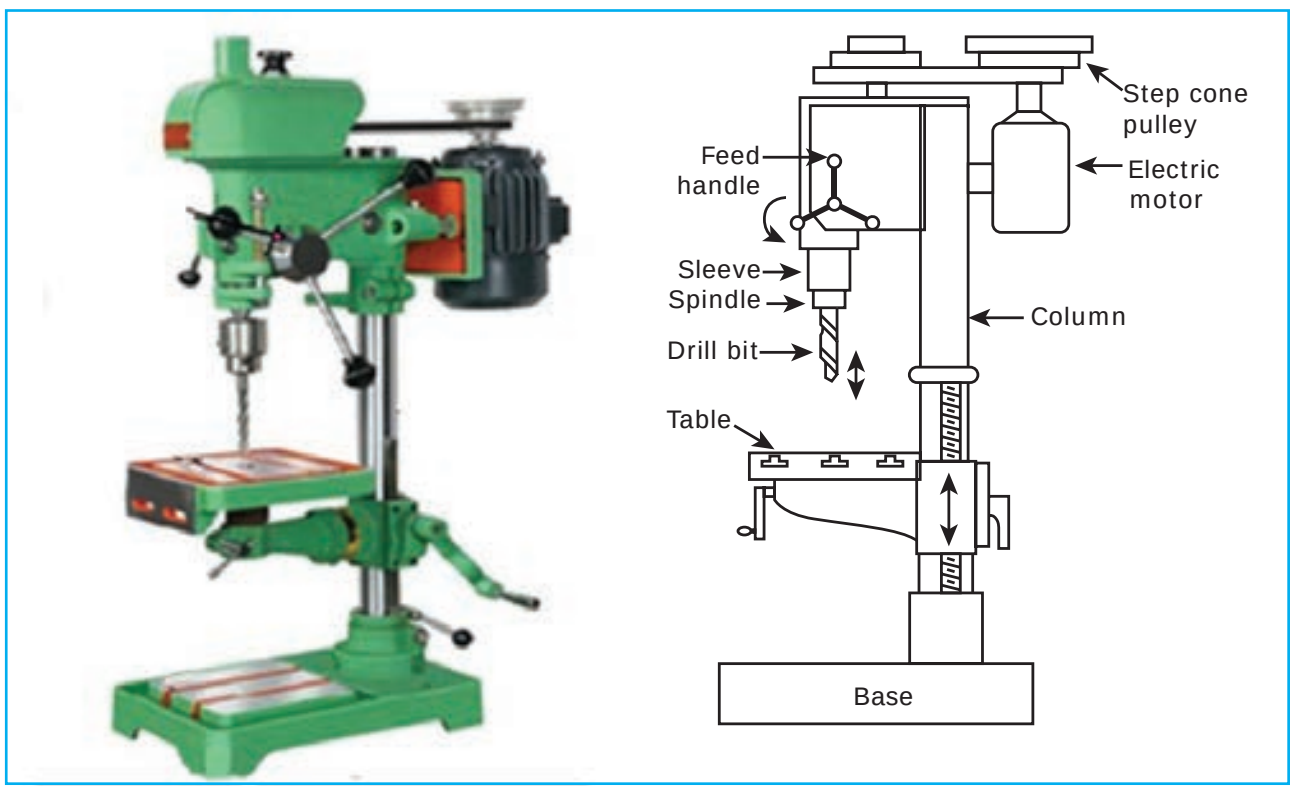
Drill head

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

2.7 Up right drilling machine

The upright drilling machine is designed for handling medium sized work pieces. Though it looks like a sensitive drilling machine, its vertical column is larger and heavier than a sensitive drilling machine. The maximum diameter of the hole size up to 50 mm can be made in this machine. Besides, it is supplied with power feed arrangement, for drilling different types of work, the machine is provided with a number of a spindle speeds and feed.

A round column section of up – right drilling machine is shown in the given figure.



Upright Drilling Machine

There are two different types of upright drilling machines according to the cross-section of the column and they are

- Round column section upright drilling machine.
- Box column section upright drilling machine.

Base

Base is made of cast iron as it can withstand vibrations set by the cutting actions. It is mounted on the floor of the shop by means of bolts and nuts. It is supporting member as it supports column and other parts on it. The top of the base is accurately machined and has T-slots. When large work pieces are to be held, they are directly mounted on the base.

Column

Column stands vertically on the base and supports the work table and all driving mechanisms. It is designed to withstand the vibrations set up due to the cutting action at high speeds.

Work Table

Table is mounted on the column and can be adjusted up and down on it. It is provided with T-slots for work pieces to be mounted directly on it. Table may have the following adjustments.

Vertical adjustment obtained by the rack on the column and a pinion in the table.

Circular adjustment about its own axis.

After the required adjustments are made, the table is clamped in position.

Drill head

The drill head is mounted on the top of the column. It houses the driving and feeding mechanism of the spindle. The spindle can be provided with hand (or) power feed. There are separate hand wheels for quick hand feed and sensitive hand feed. The handle is spring loaded so that the drill spindle is released from the work when the drilling operation is over.

2.8 Radial Drilling machine

The radial drilling machine is intended for drilling and tapping on medium to large and heavy work pieces. It is used in mass production factories and to drill the holes at a diameter of 50mm and above.

A radial drilling machines is illustrated the given figure.

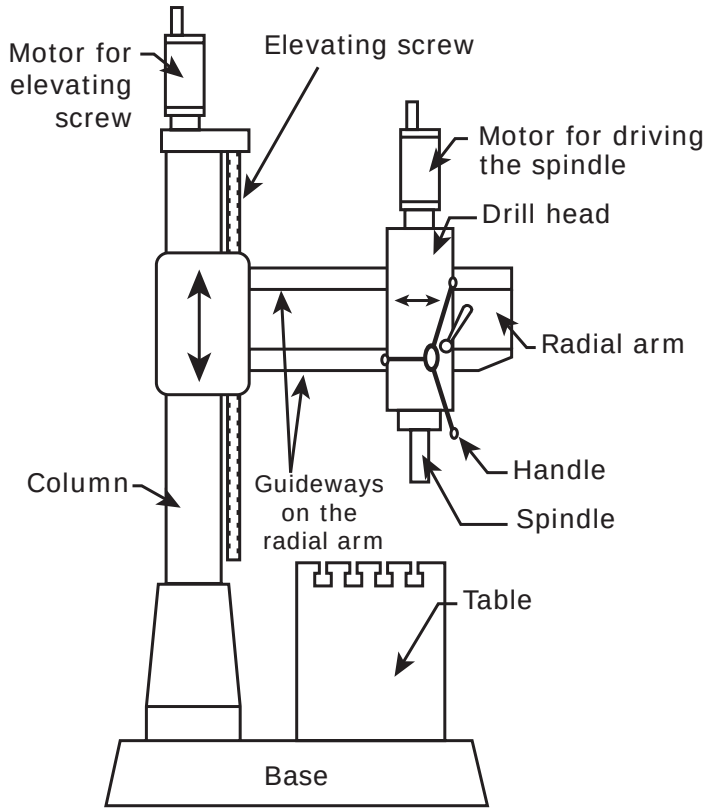
It consists of parts like base, vertical column, radial arm, Drill head. Elevating screw and driving mechanism of the spindle.

Base

The base is a large rectangular casting and mounted on the floor on the shop. Its top surface is accurately finished to support a column at one end and the table at the other end. T-slots are provided on it for clamping the work pieces.

Column

The column is a cylindrical casting which is mounted vertically at one end of the base. It supports the radial arm and allows it to slide up and down on its face. The vertical adjustment of the radial arm is effected by rotating a screw passing through a nut attached to the arm. An



Radial Drilling Machine

electric motor is mounted on the top of the column for rotating the elevating screw.

Radial arm

The radial arm is mounted on the column parallel to the base and can be adjusted vertically. The vertical front surface is accurately machined to provide guide ways for the drill head. The drill head can be adjusted along these guide ways according to the location of the work. The arm may be swing at 360° around the column. It can also be moved up and down according to the different heights of the work pieces.

Drill head

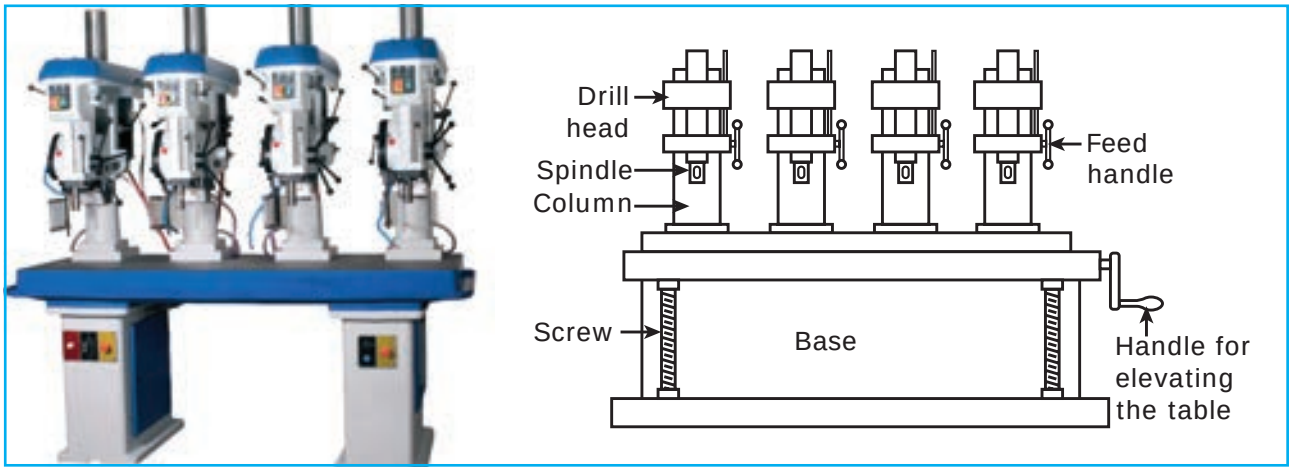
The drill head is mounted on the radial arm and houses all mechanism for driving the drill at different speeds and feed.

A motor is mounted on the top of the drill head for this purpose. To adjust the position of drill spindle with respect to the work, the drill head may be made to slide on the guide ways of the arm. The drill head can be clamped in position after the spindle is properly adjusted.

Special Features

- To drill holes at different places of the work pieces without any movement of the work.
- To drill inclined holes on the work piece with the help of tilting the drill head at an angle.
- To make internal threads in a hole by using tapping attachments.

The inventor of Radial drilling machine is Geoffry Reeves of Australlia, year 1890.



Gang drilling machine

2.9 Gang Drilling Machine

When a number of single spindle drilling machine columns are placed side by side an a common base and a work table, the machine is known as gang drilling machine. The drill heads have separate driving motors. This machine is used for production work.

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

The speed and feed of the spindles are controlled independently.

A gang drilling machine is shown in the given figure.

2.10 Multi – Spindle Drilling Machine

When a machine has two (or) more drill spindles driven by a single motor, is called multi-spindle drilling machine. The drill spindles are connected to the main drive by universal joints.

Multi – spindle Drilling Machine

All the spindles holding the drills are fed into the work at the same time. The distance between the spindles can be altered according to the locations where holes are to be drilled. Drill jigs are used to guide the drills. Feeding motion is usually obtained by raising the work table. A multi spindle drilling machines is shown in the given figure.

2.11 Deep Hole Drilling Machine

A special machine and drills are required to drills deeper holes in barrels of gun, spindles, and connecting rods. The

Deep Hole drilling machine (Horizontal type)

machine designed for this purpose is known as deep hole drilling machine. High cutting speeds and less feed are necessary to drill deep holes. A non-rotating drill is fed slowly into the rotating work at high speeds. Coolant should be used while drilling. There are two different types of deep hole drilling machines.

1. Vertical type
2. Horizontal type

2.12 The size of a Drilling Machine

Drilling Machines are specified according to their type.

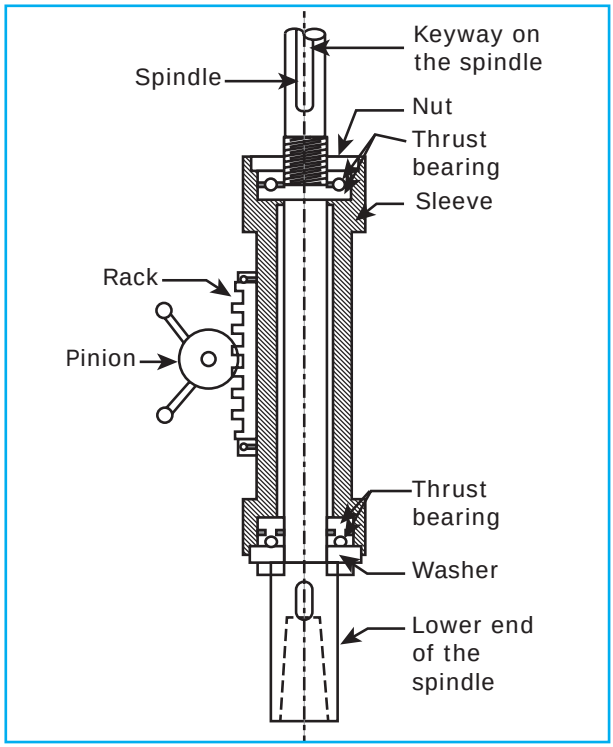
1. A portable drilling machine is specified by the maximum diameter of the drill that it can hold.
2. The size of the sensitive and upright drilling machines are specified by the size of the largest work piece that can be centered under the spindle. It is slightly smaller than twice the distance between the face of the column and the axis of the spindle.
3. The size of a radial drilling machine is specified by the diameter of the column and length of the arm, spindle speeds and feeds etc.
4. Gang and multi spindle drilling machines is specified by the number of spindles. Length of the work table and type of feed given to the work.
5. Generally a drilling machine is specified by the maximum diameter of the hole that it can drill in the machine, diameter of table, maximum travel of the spindle, numbers and range of spindle speeds and feeds available.
6. Morse taper number of the drill spindle, floor space required weight of the machine and horse power of the motor.

2.13 Drill spindle Assembly

A drill spindle assembly is illustrated shown in the given figure.

Drill spindle assembly

The spindle is a vertical shaft which holds the drill. A long keyway is cut on the spindle and a sliding key connects it with a bevel gear or a stepped cone pulley. It receives motion from the driving motor. The spindle and the sleeve are connected by a thrust bearing.



Rack teeth are cut on the outer surface of the sleeve. The sleeve may be moved up and down by rotating a pinion which meshes with the rack. This movement is given to the spindle for providing the required feed. As there is a long keyway on top of the spindle, it is connected to the driving mechanism even during the feed movement.

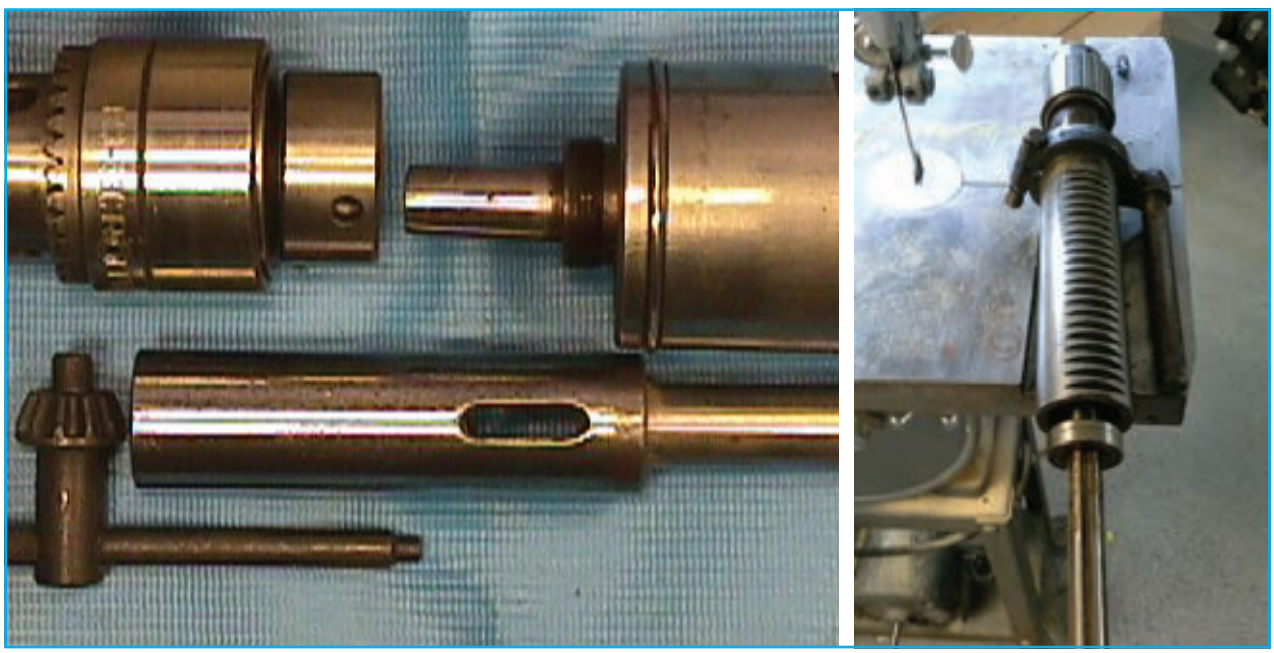
A morse taper hole is provided at the lower end of the spindle. It is useful in accommodating a taper shank drill. The tang of the drill fits into a slot provided at the end of the taper hole. To remove the drill from the spindle a drift may be pushed through the slot.

The spindle drive is obtained in three methods. They are

1. Step cone pulley drive
2. Step cone pulley with back gear arrangement.
3. Gear box drive.

2.14 Work Holding Devices

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



Working Principle of the Spindle

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

1. Drill vise
2. T-bolt, nut and clamps step block
3. Plain vise
4. V – block
5. Angle plate
6. Drill jigs.

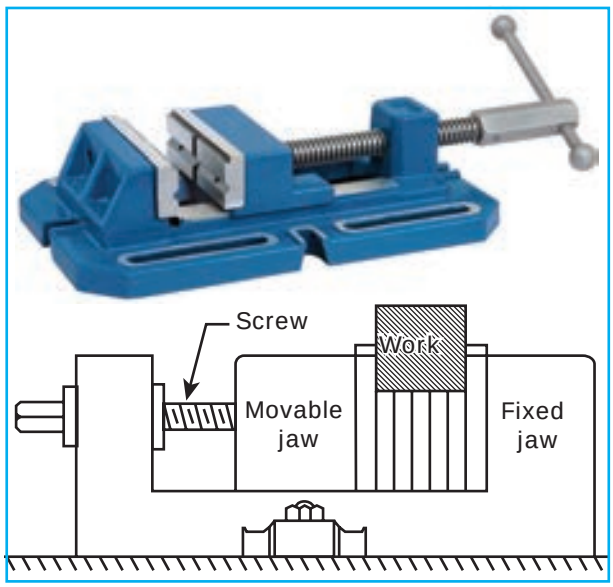
Drill vise

Vise is one of the most important devices used for holding work piece on a drilling machine table. The work is clamped in a vise between a fixed jaw and a movable jaw.

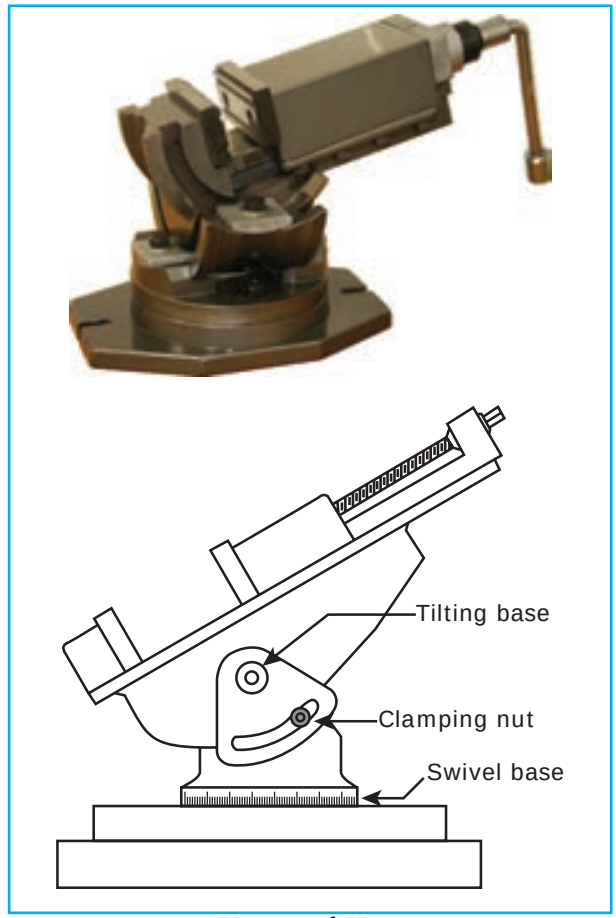
Parallel blocks are placed below the work. So that the drill may completely pass through the work without damaging the table. Different types of vises are used for holding different types of work and for performing different operations.

The different types of vises are

1. Plain vise
2. Swivel vise
3. Tilting vise
4. Universal vise



Plain Vise



Universal Vise

T-bolts, clamps and step blocks

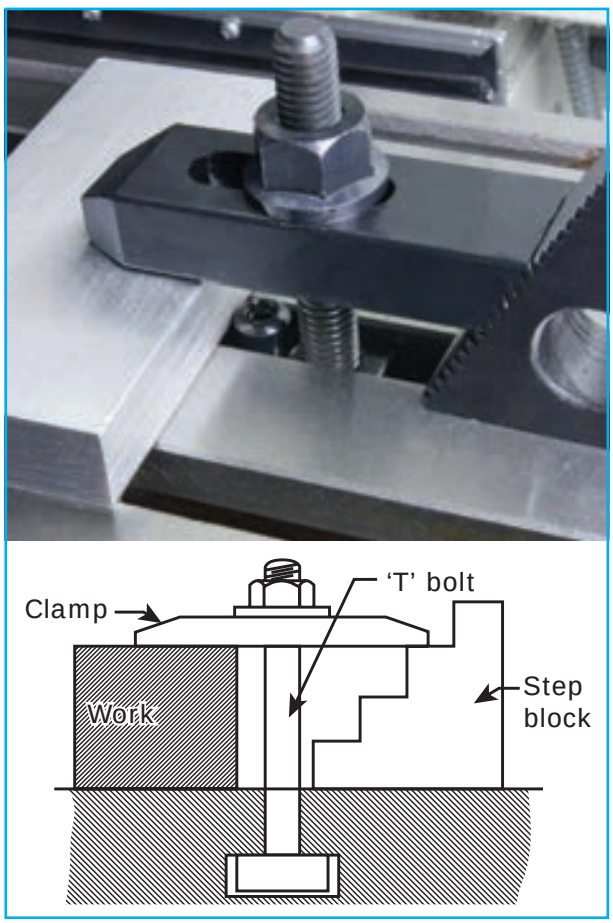
The work pieces can be held directly on the machine table by means of T-bolts clamps and step blocks. The top of the machine table has T-slots into which T-bolts may be fitted. The bolts of diameter 15 to 20 mm are used. The clamps and step – blocks are made of mild steel. T-bolts pass through a central hole on the clamp. The clamp is made to rest horizontally on the work surface by placing a suitable step block at the end of the work. Different height of the work pieces are held by levelling the clamp on different steps of the step block


Work holding devices
1
2
3
4
5
6
Vise
T- Bolt, Nut and Clamps
Step-block
V- Block
Angle Plate
Drilll Jig
a
Plain vise
b
Swivel vise
c
Tilting vise
d
Universal vise
Plate Jig
a
Channel Jig
b
Box Jig
c
Diameter Jig
d
Indexing Jig
e

Types of clamps

1. Plain
2. Slot clamp
3. Goose – neck clamp
4. Finger clamp

The following figure shows how to hold the work piece by means of T-slots, clamp and step-block.



T-bolt and clamp

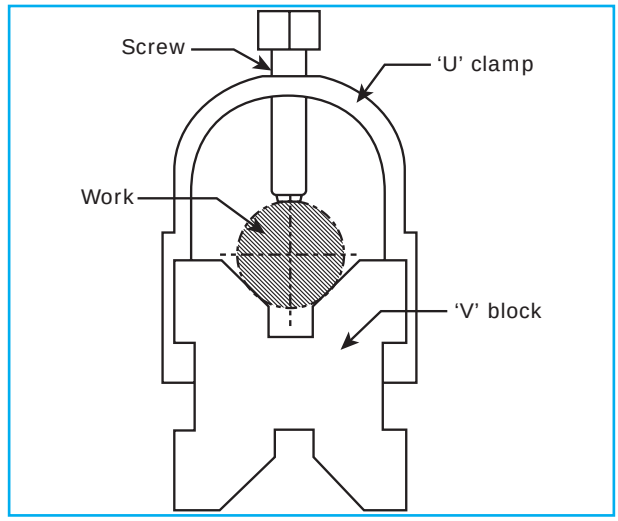
Step block

It has long steps formation. It is used to hold the work firmly while using the T-bolt and clamps the step block supports the other end of the clamp. Work pieces of different sizes are held by levelling the clamp on different steps of the step block.

V-block

V-block is used for holding cylindrical work pieces. The work may be supported on two (or) three V-blocks according to the length of the work. The work is held on the V-groove and is clamped by straps and bolts. They are made of cast iron (or) steel and are accurately machined.

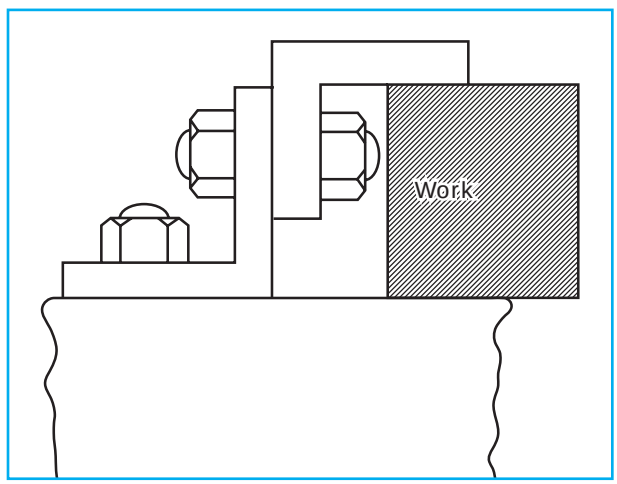
The following figure shows the use of a V-blocks.



V-block

Angle plate

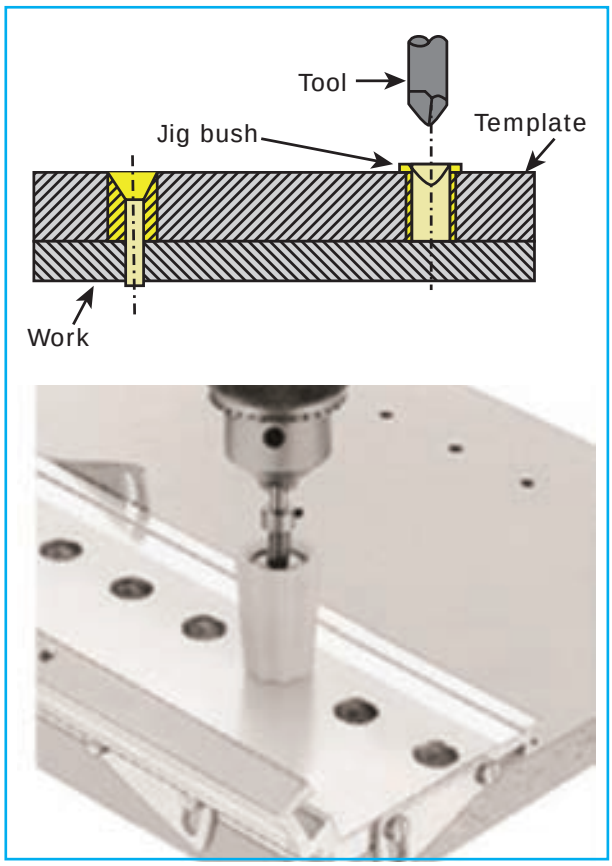
The angle plates have two faces at right Angle to each other and made of cast iron. All the sides of a angle plate are machined accurately. Slots and holes are provided on both the faces of the angle plate. Work is clamped on one of its faces by means of bolts and nuts. The use of angle plate is shown in figure.



Angle Plate

Drill Jig

Drill jigs are used for holding the work in mass production process. A jig is specially designed to hold the work securely and to guide the tool at any desired position. Holes may be drilled at the same relative positions on each of the identical work pieces.



Drill Jig

The work is clamped and removed easily. The cost of making a drill jig is more but a low order of skill is sufficient to work with a drill jig.

The following different types of jigs are used to hold the work pieces in drilling machine.

1. Pate Jig
2. Channel Jig
3. Diameter Jig
4. Box Jig
5. Indexing Jig

2.15 Tools used in a drilling machine

The following tools are used for performing different types of operations in a drilling machine. They are

1. Drill
2. Reamer
3. Counter bore
4. Counter sink
5. Tap

Drill

A drill is a tool used to originate a hole in a solid material. A helical groove known as 'flute' is cut along the length of the drill.

Drill Bit

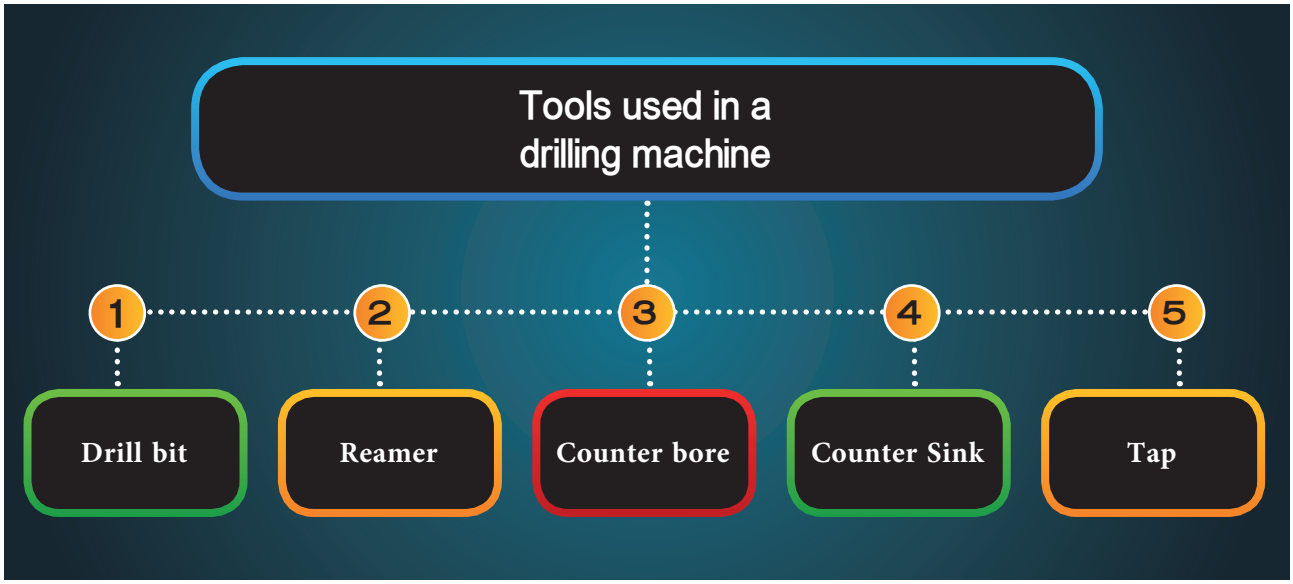
Different types of drills are,

1. Flat drill
2. Straight fluted drill
3. Twist drill
4. Centre drill

Twist drills are generally used in shop work. They are made of High speed steel (HSS), (or) High Carbon Steel (HCS).

There are two types of drills namely

1. Straight shank twist drill
2. Taper shank twist drill



The diameter of the straight shank drill ranges from 2 to 16mm. Taper shanks are provided on drills of larger diameter.

DO YOU KNOW?

The inventor of Twist drill is "Steve A. Morse" of England, year 1861.

Reamer

The tool used for enlarging and finishing a previously drilled hole is known as a reamer. It is a multi tooth cutter and removes smaller amount of material. It gives a better finish and accurate dimension.

Reamer

Counter bore

A counter bore is a multi tooth cutting tool used for enlarging the top of the previously machined hole. It has three or four cutting teeth.

Counter bore

The flutes on them may be straight or helical. Straight fluted tools are used for machining softer material like brass and aluminium and for short depth of cut. Helical fluted counter bores are used for longer holes.

Counter Sink

A counter sink has cutting edges on its conical surfaces. It has a similar construction of counter bore except for the angle of the cutting edges. The angle of counter sinks will generally be 60^0, 82^0 or 90^0. It is used for enlarging the top of the holes conically.

Counter sink

Tap

A tap has threads like a bolt. It has three or four flutes cut across the threads. It can cut threads on the inside of a hole. The flutes on the threads from the cutting edges. It is a multi point cutting tool. It will dig into the walls of the hole as the lower past of the tap is slightly tapered. The shank of the tap is square shaped to enable it to be held by a tap wrench.

Taps are made up of carbon steel (or) high speed steel. Two types of taps are used. They are (i) hand tap and (ii) machine tap

Tap

2.16 Twist drill nomenclature

Twist drill nomenclature is shown in the given figure.

Axis

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

Body

It is the part of the drill from its extreme point to the commencement of the neck. If present otherwise it is the part extending up to the commencement of the shank. Helical grooves are cut on the body of the drill.

Shank

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

Tang

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

Neck

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

Point

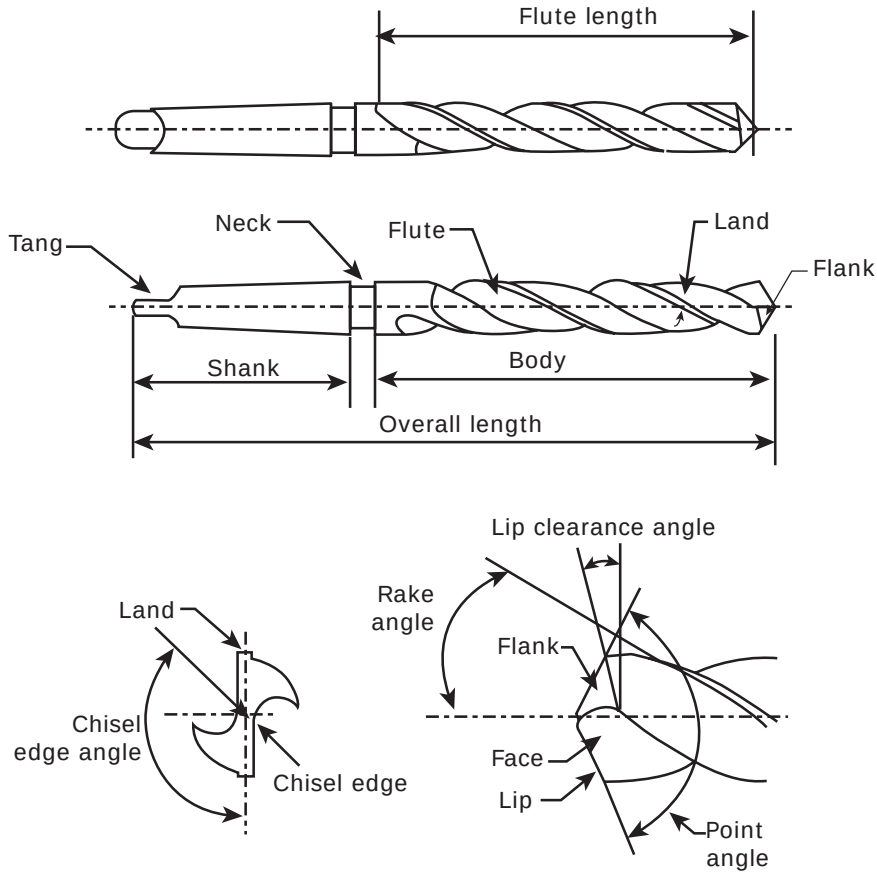
It is the sharpened end of the drill. It is shaped to produce lips. Faces, flanks and chisel edge.

Lip

It is the edge formed by the intersection of flank and face. There are two lips and both of them should be of equal length. Both lips should be at the same angle of inclination with the axis. (59^0).

Land

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



Twist Drill Nomenclature

Flutes

The grooves in the body of the drill are known as flutes.

- Flutes form the cutting edges on the point.
- To allow the chips to escape
- To cause the chips to curl
- To permit the cutting fluid to reach the cutting edges.

Angles

Chisel edge Angle

The obtuse angle included between the chisel edge and the lips as viewed from the end of the drill. It's usual value of this angle various from 120^0 to 135^0 Helix angle (or) rake angle.

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 118^0 when hard alloys are drilled the value of angle increases.

Lip clearance Angle

The angle formed by the flank and a plane at right angle to the drill axis. The angle is normally measured at the periphery of the drill. The lip clearance angle ranges from 12^0 to 15^0.

2.17 Tool holding Devices

Different tools are used for performing different operations. They are fitted into the drill spindle by different methods. They are

1. directly fitting in the spindle
2. a sleeve
3. a socket
4. a drill chuck
5. special attachments
6. Tapping attachments
7. Floating holder.

Directly fitting in the spindle

The following figure shows the drill directly fit into the spindle.

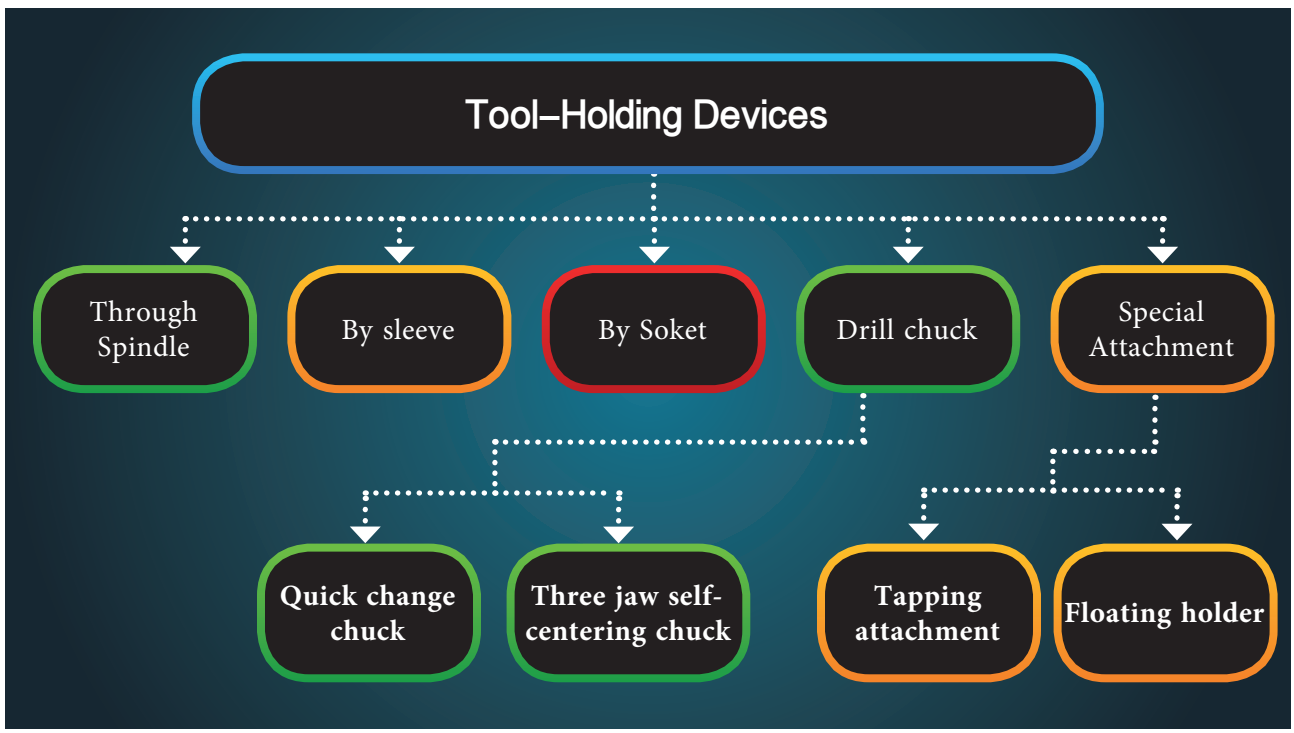
Almost all drilling machines have their spindle bored out to a standard taper (1:20) to receive the taper shank of the tool. While fitting the tool, the shank of the drill (or) any other tool is forced into the tapered hole and the tool is gripped by friction. The tool may be rotated with the spindle by friction between the tapered surface and the spindle. But to ensure a positive drive the tang 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 drift or key into the slotted hole of the spindle.

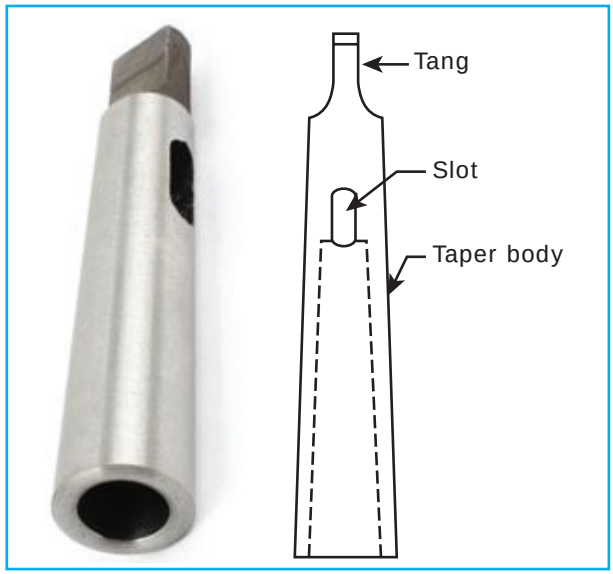
The drift is made up of hard steel.

Sleeve

The drill spindle is suitable for holding only one size of tool shank. If the shank of the tool is smaller than the taper in the spindle hole a taper sleeve is used. The outside taper of the sleeve confirms to the spindle taper and the inside taper holds the shanks of the smaller size tools. 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. Different sizes of tool shanks may be held by using different sizes of sleeve. In order to remove the drill from the



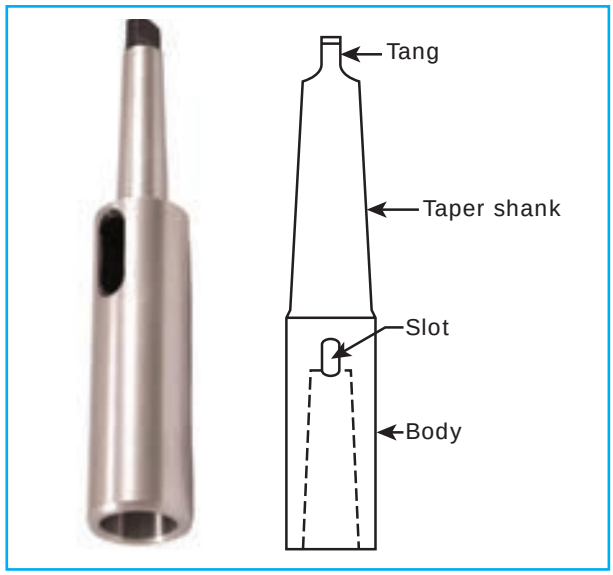
spindle, the drill along with the sleeve is removed with the help of a drift. The drill is then removed from the sleeve by the same method.



Sleeve

Socket

When the tapered tool shank is larger than the spindle taper, drill sockets are used to hold the tool.



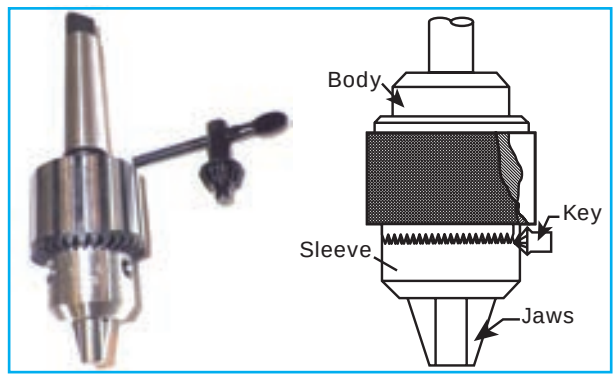
Socket

Drill sockets are much longer in size than the drill sleeves. A socket consists of a solid shanks attached to the end of a cylindrical body. The taper shank of the socket confirms 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 slot of the spindle and the tang of the tool fits slot of the socket.

Drill chuck

This type of chuck is particularly adapted for holding smaller size of drills having straight shanks. The drill chuck has a taper shank at top portion of the chuck, which fits into the taper hole of the spindle. Bevel teeth are cut round the sleeve body which locates at the centre portion of the chuck. At the bottom of the chuck, there are three jaws are fitted at 120^0 each other. It is used to hold the drill bit.

The jaws are made of spring steel.



Drill Chuck

There are two types of chucks

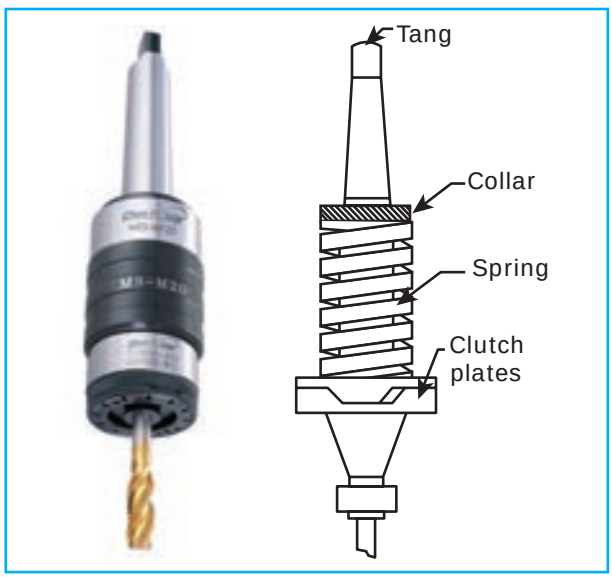
1. Quick change chuck
2. Three jaw self-centering chuck

Special Attachment

Tapping attachment

The tapping attachment is used to hold the tool known as tap. It serves as a flexible connection between the spindle and the tap. The taper shank of the attachment

is fitted into the drill spindle. The tap is fitted at the bottom of the attachment. The tap is fed into the specific hole by the spindle. Rotating it in clockwise direction. After the threads are cut, the spindle is released from the hole. The bottom of the attachment rotates in anti-clockwise direction causing no damage to the tapped hole. Tapping attachments are used during production work.



Tapping Attachment

2.18 Drilling Machine Operations

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

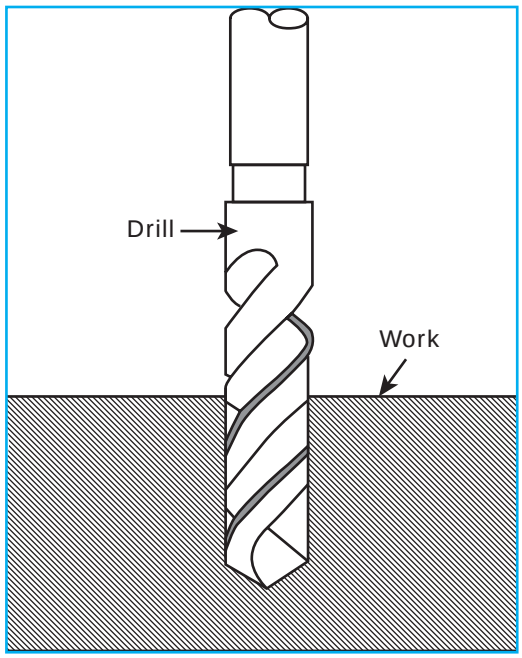
1. Drilling
2. Reaming
3. Boring
4. Counter-boring
5. Counter-sinking
6. Spot-facing
7. Tapping
8. Trepanning

Drilling

Drilling is the operation of producing a new cylindrical hole of required diameter and depth by removing metal by the rotating edge of a cutting tool called drill. Drilling is one of the simplest methods of a producing a hole. Drilling does not produce an accurate hole in a work piece. The internal surface of the hole generated by drilling becomes rough and the hole is always slightly oversize due to vibration of the spindle and the drill. A 12 mm drill bit may produce a hole of size 12.125 mm.

Before making a new hole by using on the work piece, first draw two lines at right angle to each other. Then a centre punch is used to make a centre on the work piece accurately.

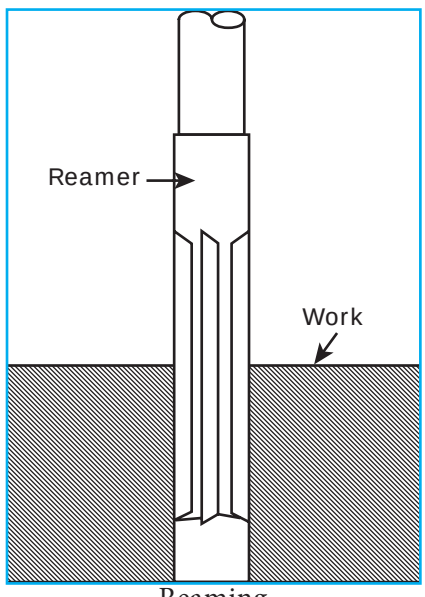
The figure shows the drilling operation



Drilling

Reaming

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



Reaming

Boring

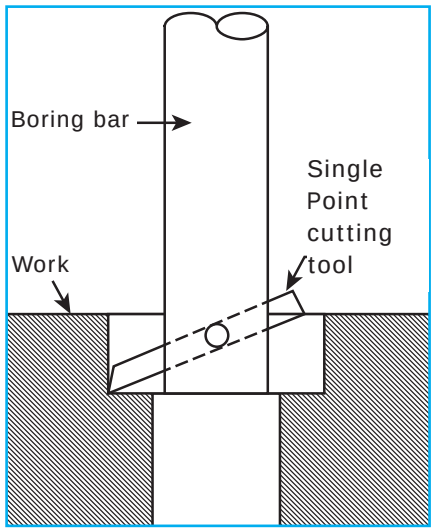
Boring is the operation enlarging the diameter of the hole previously made. It is done for the following reasons.

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

1. To finish a hole accurately and bring it to the required size.
2. To machine the internal surface of the hole already produced in casting.
3. To correct out of roundness of the hole.
4. To correct the location of the hole as the boring tool follows independent path with respect to the hole.

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

The figure illustrates the boring operation.

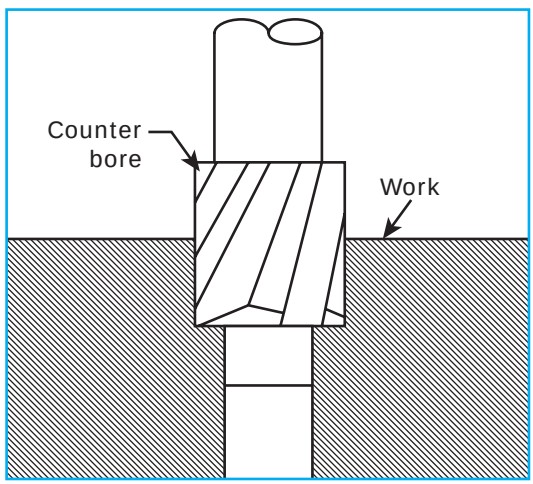


Boring

Counter boring

Counter boring is the operation of enlarging the end of the hole cylindrically. The enlarged hole forms a square shoulder with the original hole. This is necessary in some cases to accommodate the heads of bolts, studs and pins. The tool used for counter boring is known as counter bore.

The counter bores are made with cutting edges which may be straight (or) spiral. The cutting speed for counter boring is at least 25% lesser than that of drilling.

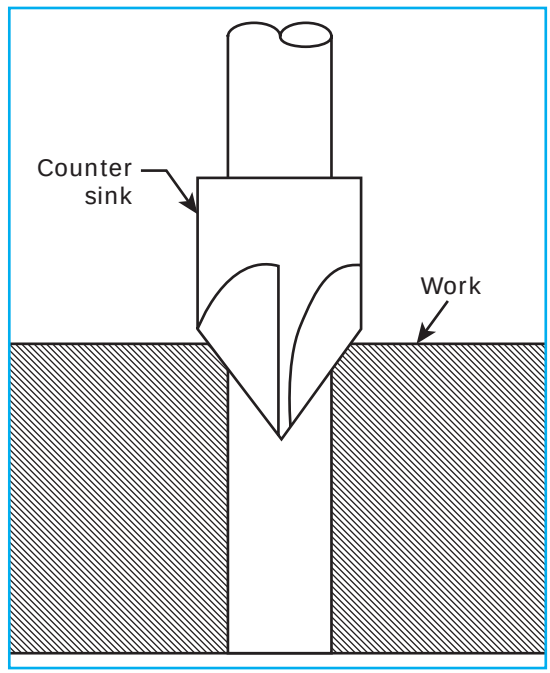


Counter Boring

Counter Sinking

Counter sinking is the operation of making a cone shaped enlargement at the end of the hole. The included angle of the conical surface may be in the range of 60^0 82^0 (or) 90^0. It is used to provide recess for a flat headed screw or a counter sunk rivet fitted into the hole. The tool used for counter sinking is known as a counter sink. It has multiple cutting edges on its conical surface. The cutting speed for counter sinking is 25% lesser than that of drilling.

The figure illustrates counter sinking operation.

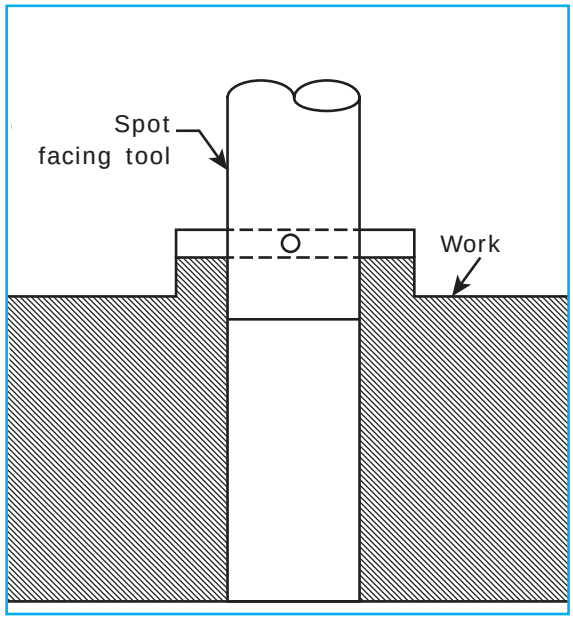


Counter sinking

Spot facing

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

The following figure illustrates spot facing operation.

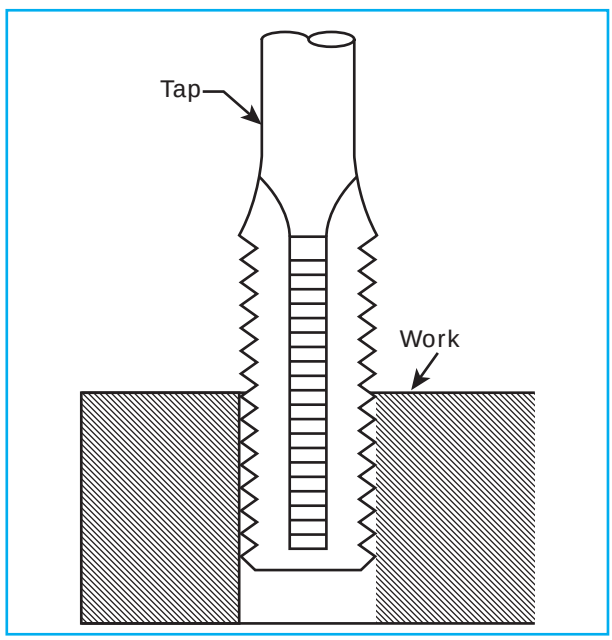


Spot Facing

Tapping

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

The following figure illustrates tapping operation.



Tapping

Calculation of the Tap drill size

Tap drill size may be derived from the following formula.

Tap drill size 'D'= T-2d

Where 'T' is the outer diameter of tap to be used. And 'd' is depth of the thread.

Tap drill size can also be calculated the following formula.

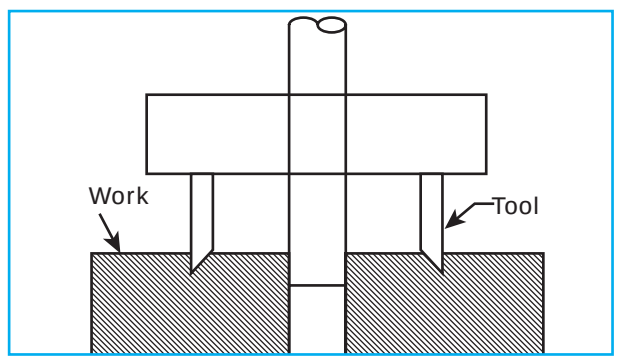
D=0.8T

Example:

Calculate the tap drill size. When outside diameter of the tap is 10mm the pitch of the thread is 1.5 mm and depth is 0.61mm.

Trepanning

Trepanning is the operation of producing a hole in sheet metal by removing metal along the circumference of a hollow cutting tool. Trepanning operation is performed for producing large holes. Fever chips are removed and much of the material is saved while the hole is produced. The tool may be operated at higher speeds. The speed depends upon the diameter of the hole to be made. 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.



Trepanning

The other operations can be performed in drilling machine are lapping and grinding.

2.19 Cutting speed, feed and depth of cut

Cutting speed

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

Cutting speed (c.s) $V = \frac{\pi dn}{1000}$ m/min.

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

'n' is the speed of the spindle in rpm and

$\pi = \frac{22}{7}$ (or) 3.14.

Example:

A drill of diameter 20mm makes a hole on a steel part at a cutting speed of 25m/min.

Find out the spindle speed.

Cutting speed (c.s) $V = \frac{\pi dn}{1000}$ m/min

$25 = \pi \times 20xn/1000$

$n = 25x1000/ \pi \times 20 = 398$ rpm.

Spindle speed 'n' = 398 rpm.

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 millimetres. The feed may also be expressed as feed per minute. The feed per minute may be defined as the axial distance moved by the drill into the work per minute. Feed depends upon factors like the material to be drilled. The rigidity of the machine, power, depth of the hole and the type of finish required.

Depth of cut

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

2.20 Safety precautions

It is necessary that no damage is done to the operator, the machine parts and the cutting tool. To ensure this the following points are to be remembered.

1. The work should not be held by hand in any case.
2. Proper work holding device should be used to hold the work. If the work is not held properly. The work tends to rotate along with the drill causing damage to the operator, the machine tool and the cutting tool.
3. The shank of the drill and taper hole of the spindle should be cleaned before it is fitted into the spindle.
4. The shank of the drill should confirm with the spindle hole.
5. Cutting speed, feed and depth of cut should be selected according to the prescribed range.
6. Care should be taken to ensure whether the belt and gears are connected properly.
7. Proper safety plates should be installed around rotating parts like belt, drive and gears.
8. The operator should wear safety goggles while operating the drilling machine.
9. The machine should be disconnected from electric terminals when repairs are under taken. In general we should ensure the proper functioning of the machine tools.

ACTIVITIES

1. To make an arrangement the students to visit the workshop, polytechnic and engineering colleges, to observe the various operations performed by drilling machines.
2. To give more exercises to the students, to make holes by using drilling machine and Lathe machine in school practical Laboratory.

Questions

Part I

Choose the correct option **1 Mark**

1. The inventor of first electric drilling machine is.
   a) Henry Maudslay
   b) Arthur James Arnot
   c) Eli whitney
   d) James Nasmith

2. The drilling machine used in constructional work is,
   a) Bench drilling machine
   b) Portable drilling machine
   c) Gang drilling machine
   d) Multi spindle drilling machine
3. Counter – bore is a
   a) Multi – point cutting tool
   b) Single point cutting tool
   c) Parting tool
   d) Saw teeth cutting tool
4. The size of the hole can be drilled in up right drilling machine is
   a) up to 10mm
   b) up to 12 mm
   c) up to 50mm
   d) up to 70 mm
5. The lip clearance angle of a drill is,
   a) 59^0 b) 118^0
   c) 12^0 to 15^0 d)135^0
6. The name of the groove in drill is,
   a) V-type groove
   b) U-type groove
   c) Flute
   d) Straight type groove

Part II

Answer the following questions in one or two sentences. **3 Marks**

7. Define – "Drilling"
8. Mention any four types of drilling machine
9. What are the different types of drills?
10. What are the uses of "Flute" in a drill?
11. Mention any four types of tool – holding devices in drilling machine.
12. State any two differences between the process of reaming and boring.
13. In which situation boring is needed?
14. What is the need of spot facing?
15. Define "Cutting speed" of a drilling machine.

Part III

Answer the following questions in about a page **5 Marks**

16. Draw and explain a bench drilling machine.
17. How is the size of a drilling machine specified?
18. Explain any two types of drill holding devices.
19. Mention the differences between Gang drilling machine and multi spindle drilling machine.

Part IV

Answer the following questions in detail. **10 Marks**

20. Draw a neat diagram of a upright drilling machine and explain.
21. Explain the working principle of a drill spindle with a diagram.
22. Explain the construction of a radial drilling machine.
23. Explain any two work – holding devices used in a drilling machine.
24. Sketch the Nomenclature of a twist drill with a diagram.
25. Explain any two operations performed in a drilling machine.