3

Drilling Machine

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3.1 Introduction,purpose and field application of drilling machine

- Drilling is a process of making hole or enlarging a hole an object by forcing a rotating tool called "Drill".
- The drill is generally called as 'twist drill', since it has a sharp twisted edges formed around a cylindrical tool provided with a helical groove along its length to allow the cut material to escape through it. The sharp edges of the conical surfaces ground at the lower end of the rotating twist drill cut the material by peeling it circularly layer by layer when forced against a workpiece.

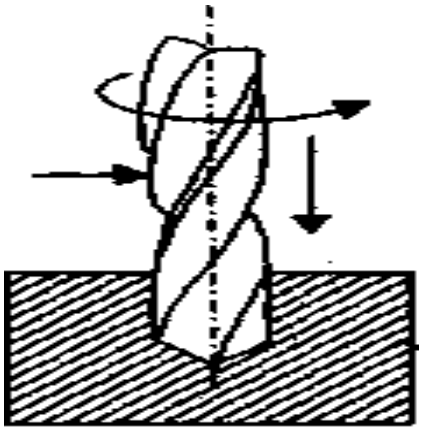


Fig.3.1 Drilling

- The removed material chips get curled and escape through the helical grooves provided in the drill. A liquid coolant is generally used while drilling to remove the heat of friction and obtain a better finish for the hole.
- A power operated machine tool which holds the drill in its spindle rotating at high speeds and when manually actuated to move linearly simultaneously against the workpiece produces a hole is called drilling machine.
- Drilling machine is one of the simplest, moderate and accurate machine tool used in production shop and tool room. It consists of a spindle which imparts rotary motion to the drilling tool, or mechanism for feeding the tool into the work, a table on which the work rests and a frame.

3.2 Classification of Drills

According to the type of shank :

- (i) Parallel shank. (ii) Taper shank.

According to the type of flutes.

- (i) Flat or spade drills (parallel longitudinal flutes) (ii)Twist drills (spiral/helical fultes)

According to length,

- (i) Short series drills. (ii) Stub series drills. (iii) Long series drills.

According to applications :

- *(i)* Core drills. *(ii)* Drills for long hole drilling. *(iii) Centre* drills. *(iv)* Masonry drills.

According to the tool material :

- *(i)* High speed steel drills. *(ii)* Carbide tipped drills.

3.3 Specifications of a Drilling Machine

- Size of the drilling machine table.
- Largest bit the machine can hold.
- Maximum size of the hole that can be drilled.
- Maximum size of the workpiece that can be held.
- Power of the motor, spindle speed or feed.

3.4 Various Types of Drilling Machine

- Portable drilling machine.
- Sensitive or bench drilling machine.
- Upright drilling machine.
- Radial drilling machine.
- Gang drilling machine.
- Turret machine.
- Deep hole drilling machine.
- Multiple spindle drilling machine.
- Automatic drilling machines.

3.4.1 Portable drilling machine

- Portable drilling machine is a very small, compact and self contained unit carrying a small electric motor inside it.

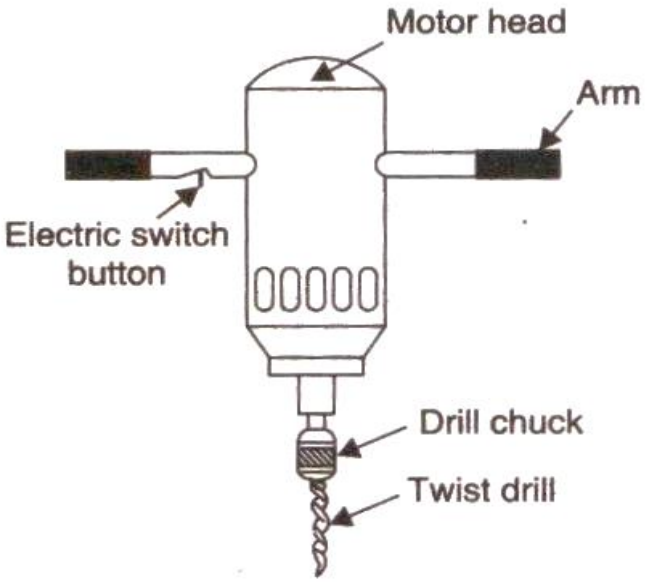


Fig.3.2 Portable Drilling

- It is very commonly used to drill holes in the following cases :
  i. when the component is bigger in size such that it can not be shifted to the shop floor ;
  ii. when the space is restricted so that no other type of drilling machine can be used.
- Usually they are made to hold drills upto a maxi-mum diameter of 12 mm. However, portable drills of upto 18 mm dia. capacity are available.

3.4.2 Sensitive or bench drilling machine :

- These are light duty machines used in workshops. They are normally mounted on work benches and hence the name. As the operator can feel the cutting operation while applying pres-sure using the feed lever, the machine is known as sensitive drilling machine.
- It consists of a cast iron base with a vertical column mounted over it. The vertical column is made of hollow steel pipe on which the table slides up and down. The table can be fixed to the required position by means of a table clamp.

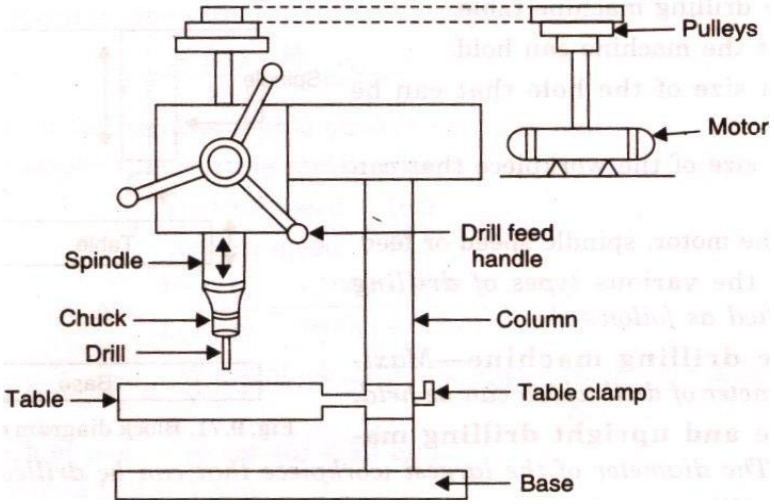


Fig.3.3 Sensitive or Bench Drilling Machine

- The table can also be swung radially at any desired position.The top of the column houses the drive consisting of endless belt running over the V-pulleys. Based on the speed of spindle required,V-belt can be shifted to different grooves of the pulleys.To drill small diameter holes, a twist-drill is fitted in the drill chuck, which in turn fits into the spindle of the machine. If the drill size is more, twist drill is directly fitted in the tapered portion of the spindle.The spindle can be moved up or down by means of drill feed handle or lever.
- This design is used to drill hole from 1.5 mm to 15 mm diameter.The controls are light and delicate speeds from 800 to 900 r.p.m. are a typical range.

3.4.3 Upright drilling machine

- Upright drills similar to sensitive drills have power-feed mechanisms for rotating drills and are designed for heavier work.
- A box column machine is more rigid than a round column machine and consequently, is adapted to heavier work. These drilling machines tap as well as drill.

3.4.4 Radial drilling machine

- A radial drilling machine is used to perform the drilling operations on the workpieces which are too heavy and also may be too large to mount them on the worktable of the vertical spindle drilling machine.
- It consists of a heavy base and a vertical column with a long horizontal/radial arm extending from it and can be rapidly raised, lowered and swing in horizontal plane about the main column to any

desired location.The drilling head can move to and fro along the arm and can be swivelled only in the universal radial drilling machines, to drill holes at an angle.

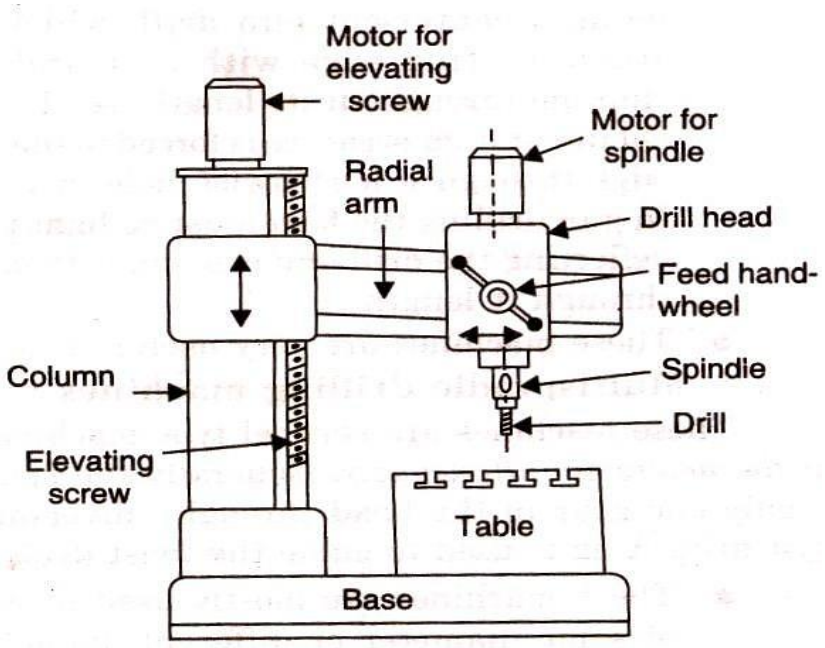


Fig.3.4 Radial Drilling Machine

- The combinations of motions of the radial arm and drilling head offer a great deal of flexibility in moving the drill to any position.
- The *main advantage* of the radial drilling machine is that the *drilling can be carried out on heavy workpieces in any position without moving them.*
- This type of drilling machine is used in *tool rooms and in large scale die manufacturing units.*

3.4.5 Gang Drilling Machine

- When several drilling spindles are mounted on a single table, it is known as a gang drill.
- In this type of drill, each of these spindles can be independently set for different speed and depth of cut.

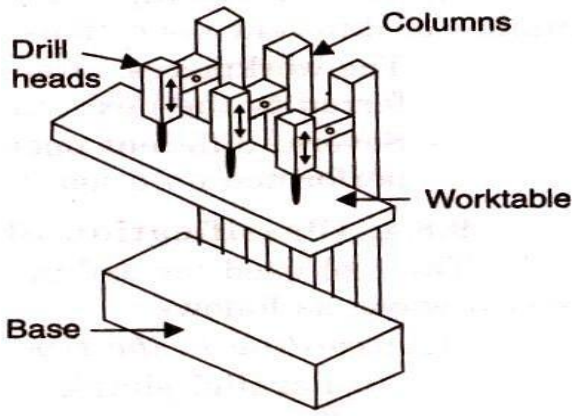


Fig.3.5 Gang Drilling Machine

- Such machines are useful when number of holes of different sizes are to be drilled on the same workpiece.
- Apart-from drilling, a number of other machining operations like reaming, counter boring, tapping etc. can also be performed at a time on this machine.

3.4.6 . Turret drilling machine

- A turret machine overcomes the floor space restric-tion caused by a gang drill press. A six-turret *NC* drill press.

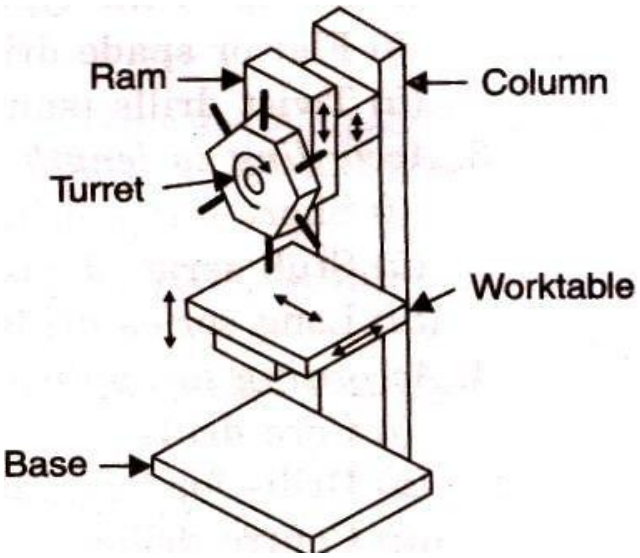


Fig.3.6 Turret Drilling Machine

- The stations are set up with a variety of tools. Numerical control is also available.
- Two fixtures can be located side by side on the worktable, thus permitting loading and unloading of one part while the other part is being machined ; this reduces the machine cycle.

3.4.7 Deep-hole drilling machines

- These machines are used for drilling holes whose depth exceed normal drill size.These machines are operated at high speed and low feed.
- These machines are either horizontal or vertical. The work or the drill may revolve. Most machines are of horizontal construction using a center-cut gun drill, which has a single cutting edge with a straight flute running throughout its length.

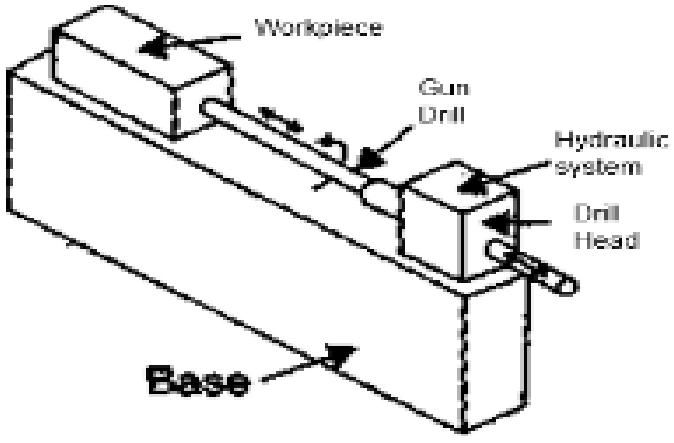


Fig.3.7 Deep Hole Drilling Machine

- Oil under high pressure is forced to the cutting edge through a lengthwise hole in the drill. In gun drilling the feed must be light to avoid deflecting the drill and causing it to meander through it length.
- These machines are very useful for drilling deep holes in rifle travels, crankshafts etc.

3.4.8 Multispindle drilling machines

- These machines are vertical type machines. They permit drilling of several holes of differ-ent diameters simultaneously.

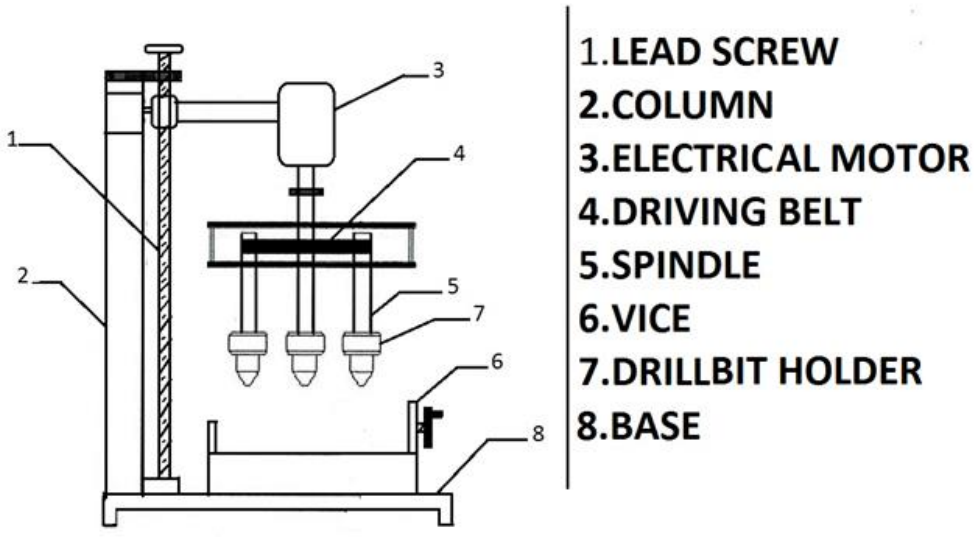


Fig.3.8 Multispindle Drilling Machine

- Generally the spindles numbering 2 or 3 or even more are driven by only one gear in the head through universal joint linkages. Each spindle is mounted with a twist drill. A jig is used to guide the twist drill.
- These machines are mostly used in continuous production shops where several holes of same diameter or different diameters are to be drilled simultaneously and accu-rately.

3.4.9 Automatic Drilling Machine

- Automatic drilling machines are production machines arranged in series to perform a number of different operations in sequence at successive work stations.
- The workpieces, after completion of an operation at one station, are automatically trans-ferred to the next station for another operation. Thus, it works as a transfer line.
- Several different operations like drilling, boring, tapping, milling, housing, etc. can be performed on a job in succession on these machines.

3.5 Drilling and Allid Drilling Operation

- In addition to drilling, the following operations are carried out on a drilling machine.
- Reaming
- Boring
- Counter-boring
- Counter-sinking
- Spot facing
- Tapping
- Trepanning.
- Deep Hole Drilling.

3.5.1 Reaming

- Reaming is the operation of finishing an existing hole very smoothly and accurately in size.
- A drill will not produce a hole having sufficiently good qualities of finish and accuracy for many purposes.Therefore, when a very accurate, smooth hole is required the hole is first drilled a little undersize.Then it is reamed to the correct size.

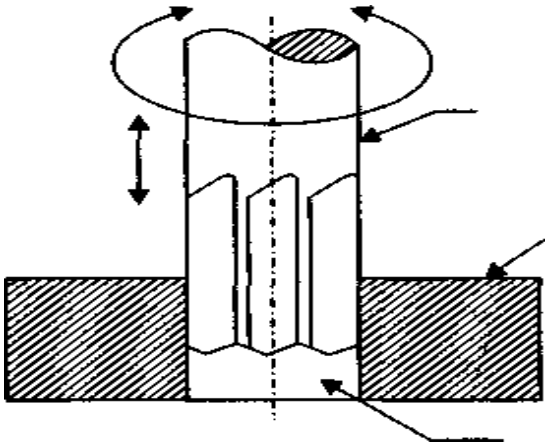


Fig.3.9 Reaming

- Reaming for finishing to size a drilled hole.
- The accuracy to be expected is within ± 0.005 mm.
- A reamer is a multi-tooth cutter which rotates and moves linearly into an already existing hole.
- The previous operation could be drilling or preferably boring. Reaming provides a smooth surface as well as close tolerance on the diameter of the hole. Generally the reamer follows the already existing hole and the, therefore, will not be able to correct the hole misalignment.

3.5.2 Boring

- It is an operation of enlarging an existing hole.

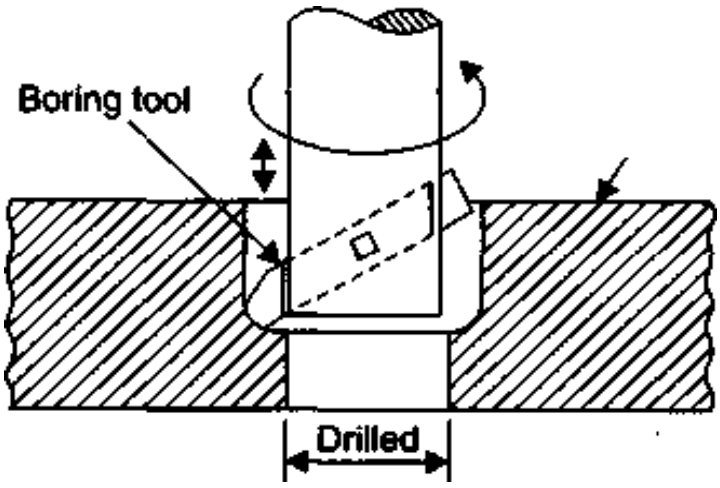


Fig.3.10 Boring

- When a suitable size drill is not available, initially a hole is drilled to the nearest size and using a single point cutting tool, the size of the hole is increased. By lowering the tool while it is continuously rotating, the size of the hole is increased to its entire depth.

3.5.3 Counter boring

- It is an operation of enlarging a drilled hole partially, that is for a specific length.
- The counter boring forms a large sized re-cess or a shoulder to the existing hole.

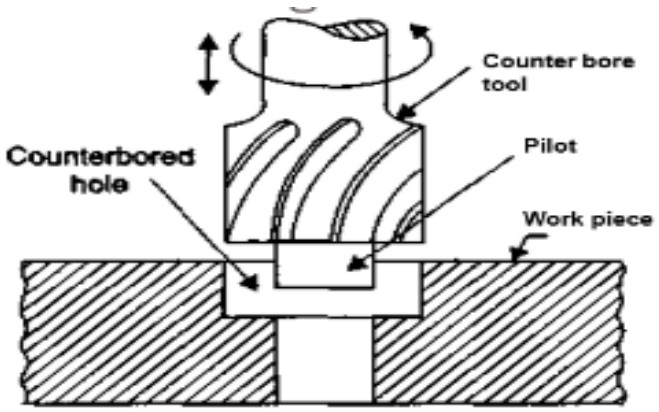


Fig.3.11 Counter Boring

- The cutting tool will have a small cylindri-cal projection known as *pilot* to guide the tool while counter boring. The diameter of the pilot will always be equal to diameter of the previously drilled hole. Interchange-able pilots of different diameters are also used for counter boring holes of different diameters.
- *The speeds for counter boring must be two thirds of the drilling speed of the corre-sponding size of the drilled hole.*
- Generally the counterboring is done on the holes to accommodate the socket head, screws or grooved nuts, or round head bolts.

3.5.4 Counter Sinking

- It is an operation of forming a conical shape at the end of a drilled hole. It is done using a countersink tool.
- The cutting speeds for countersinking must be about one-half of that used for similar size drill.

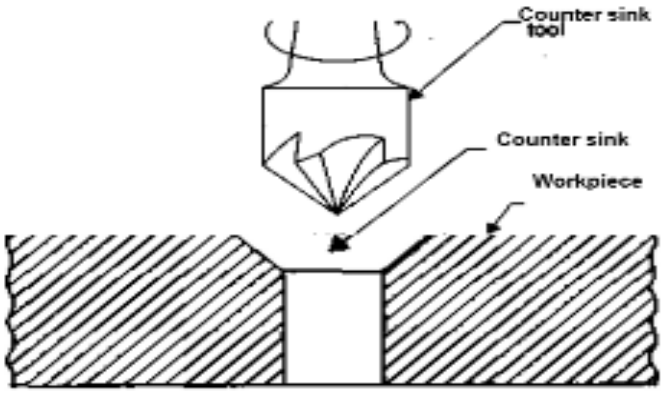


Fig.3.12 Counter Sinking

- The countersunk holes are used when the countersunk screws are to be screwed into the holes so that their top faces have to be in flush with the top surface of the workpiece.
- The countersinking process may also be employed for deburring holes.

3.5.5 Spot facing

- It is the operation of smoothing and squar-ing the surface around a hole for the seat for the nut or the head of a screw.

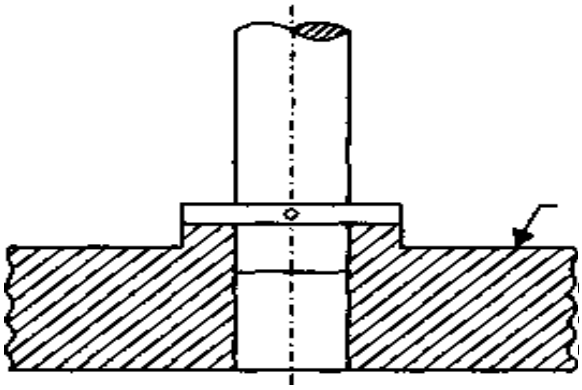


Fig.3.13 Spot Facing

- Spot facing may be done with a counter-boring tool or using a special spot facing toolTapping

3.5.6 Tapping

- It is an operation in which external threads are cut in the existing hole.
- Tapping operation which uses a fluted threaded tool called tap. A tap is a cutting tool with threads cut accurately on its periphery.These threads are hardened and ground and act a cutting edges. The tap removes metal when screwed into the hole and generates internal threads.

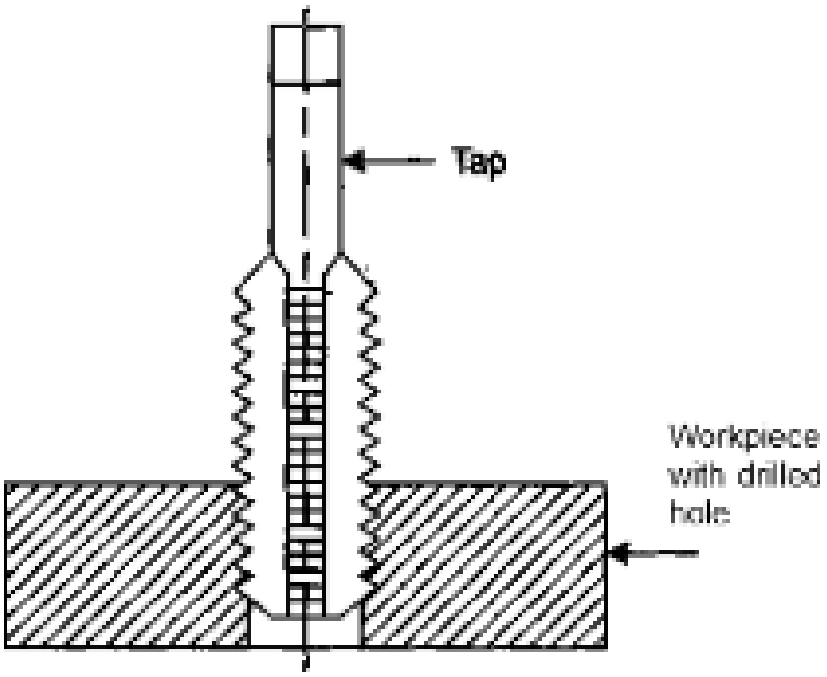


Fig.3.14 Tapping

- A hole of required size in which internal threads are to be generated is drilled using a twist drill.The drill spindle is fitted with a tap and the feeding is done by operating the feed lever similar to conventional drilling operation. During this operation spindle speed should be much lower than that used in conventional drilling.

3.5.7 Trepanning

- It is the operation of producing a hole by removing the metal along the circumference of a hollow cutting tool.

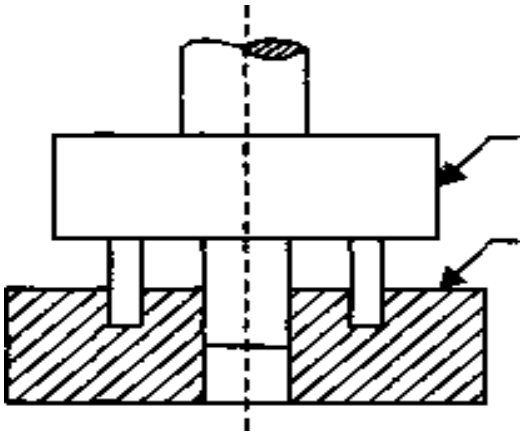


Fig.3.15 Trepanning

- This operation is performed for producing large holes & grooves around.

3.5.8 Deep Hole Drilling

Rotating Tool

- Typically used for non-symmetrical components, or round parts with off-center holes
- Cutting speed is determined by tool spindle speed
- Drill drift can be significant when compared to rotating workpiece, or counter-rotating process

Rotating Workpiece

- Typically used for round parts with a deep, on-center hole
- Cutting speed is determined by part, balanced to allow high rotating speeds
- Drill drift is reduced compared to rotating tool only

Counter-Rotating Tool and Workpiece

- Ideal process for round parts with a deep, on-center hole
- Cutting speed is determined by a combination of tool and workpiece rotation
- Provides optimal hole straightness and concentricity

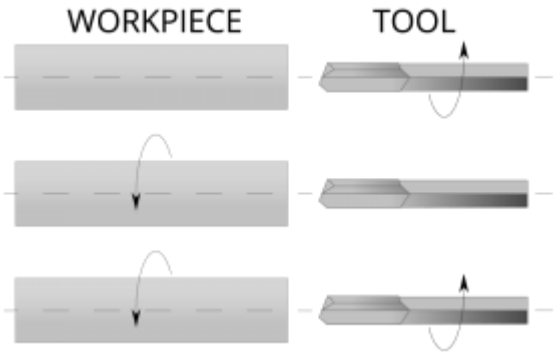
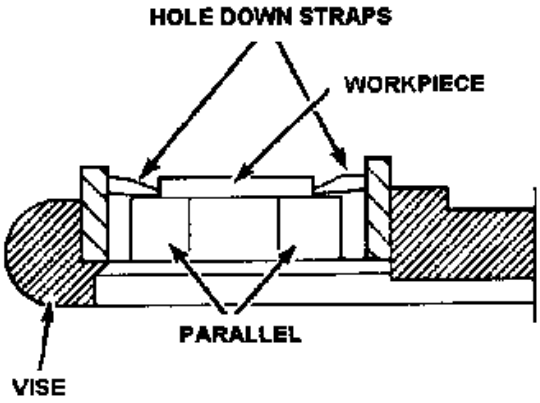


Fig.3.16 Deep Hole Drilling

3.6 Various Work Holding Device

- The type of work holding device used on drilling machines depends upon the shape and size of the workpiece, the required accuracy and the rate of production.

<table>
<tr><th>Machine Vice</th><th>V-Block</th></tr>
<tr><td>
- Used to hold round, square or odd-shaped rectangular pieces.
- Clamp vise to table for stability



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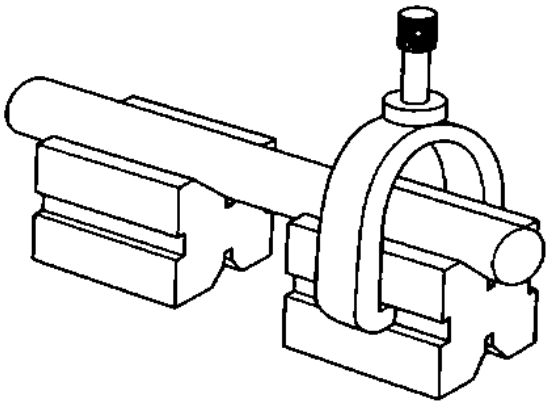
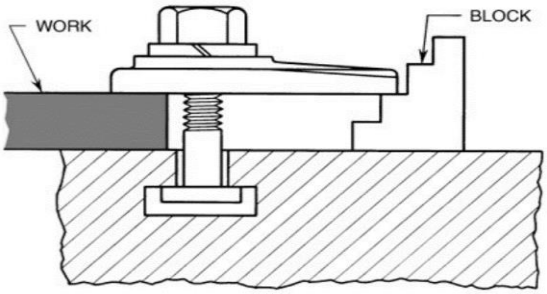
- Made of cast iron or hardened steel.
- Used in pairs to support round work for drilling.


</td></tr>
<tr><th>Step blocks</th><th>Angle plates</th></tr>
<tr><td>
- Used to provide support for outer end of strap clamps.



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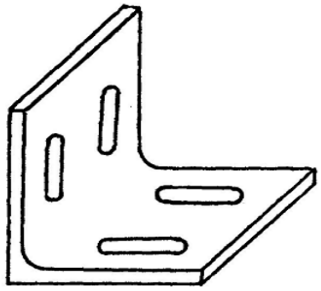
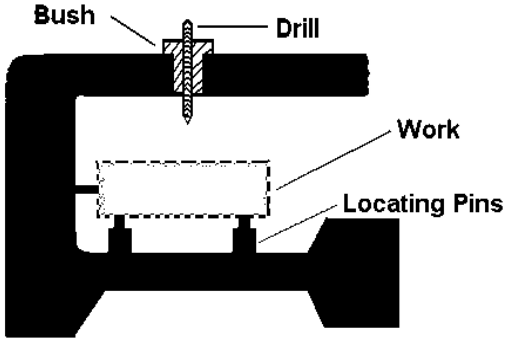
- L-shaped piece of cast iron or hardened steel machined to accurate 90º may be bolted or clamped to table.


</td></tr>
<tr><th>Jigs</th><th>Clamps or straps</th></tr>
<tr><td>
- Used in production for drilling holes in large number of identical parts and Eliminate need for laying out a hole location.



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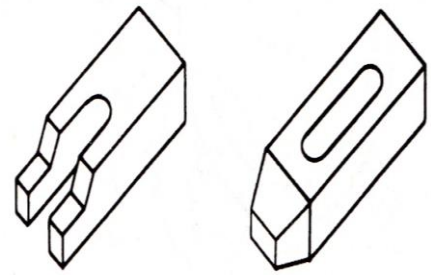
- Used to fasten work to table or angle plate for drilling.
- Usually supported at end by step block and bolted to table by T-bolt that fits into table T-slot.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3.7 Various Tool Holding Device

3.7.1 Drill Chucks

- Most common devices used for holding straight-shank cutting tools.
- Most contain three jaws that move simultaneously when outer sleeve turned
- Hold straight shank of cutting tool securely.

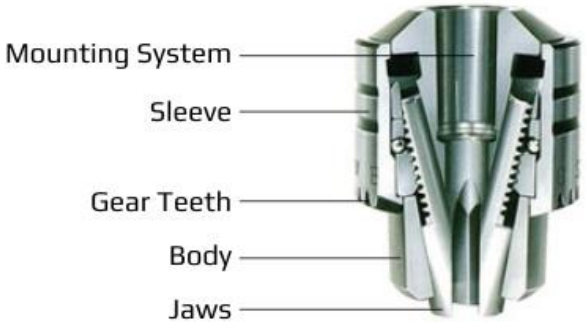

Fig.3.17 Drill Chuck

Two common types

- Keyed and Keyless

Keyed

- Three jaws move simultaneously when outer sleeve turned
- Tighten with key
- Different size keys for different size chucks.

Keyless

- Chuck loosened or tightened by hand without key
- Holds smaller drills accurately.

3.7.2 Drill Sleeves and socket

Drill Sleeves

- Used to adapt drill shank to machine spindle if taper on tool is smaller.
- than taper in spindle.

Drill Socket

- Used when hole in spindle of drill press too small for taper shank of drill.
- Used often as extension sockets.

Fig.3.18 Drill Socket and Sleeve

3.7.3 Drill Drift

- Used to remove tapered-shank drills or accessories from drill press spindle.
- Always place rounded edge up so this edge will bear against round slot in spindle.
- Use hammer to tap drill drift and loosen tapered drill shank.
- Use board or piece of pressed-wood to protect table or vise.

Fig.3.19 Drift

3.8 Allignment Test in Drilling Machine

- All machine tools used for production need to be tested at the time of their first installation and periodically during use to ensure that they have the capability to produce the accuracy and finish expected from them and continue to have such capability even after use.
- So geometrical characteristics and various movements test are carried out for machine tools.

3.8.1 Perpendicularity of drill head guide with table.

- This test is carried out with help of block square (frame level) as shown in fig, 3.20 in two planes.
  a. In a vertical plane passing through the axes of both the spindle and column
  b. A plane at right angle to the above plane.
- A block square or frame level with graduations from 0.03 mm 0.05 mm/meter is placed on the guide column and the table and level reading are noted. Permissible error.
- For (a) 0.25 mm/1000 mm with column inclined at upper end towards the front.
- For (b) 0.15 mm/1000 mm.

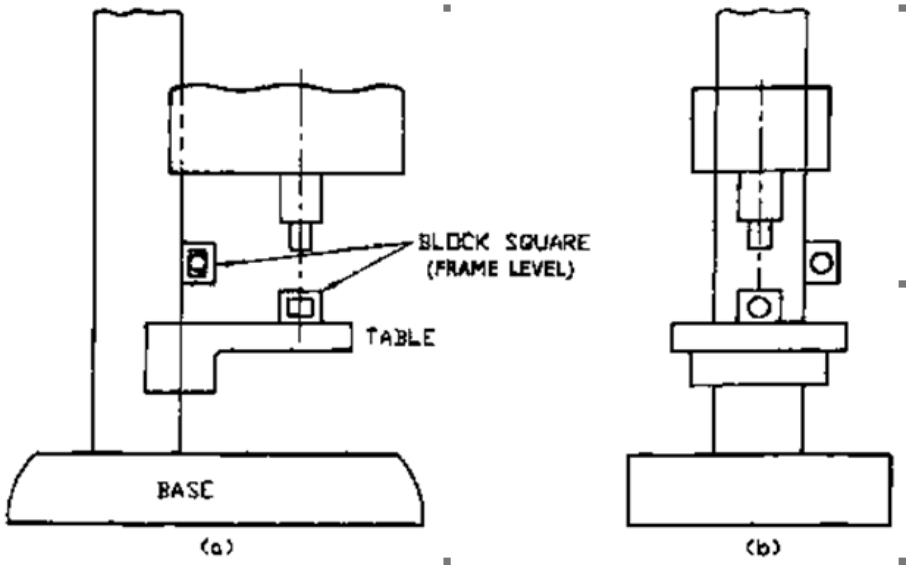

Fig.3.20 Perpendicularity of drill head guide with table

3.8.2 True running of spindle taper.

- This test is carried out with taper test mandrel attached to tapered bored spindle. As shown in fig. 3.21 dial indicator is kept on the table and plunger is in touch of the mandrel.
- Rotate the spindle slowly and note the dial reading
- Permissible error 0.03 mm/100 mm for machine having taper up to morse taper No.2.

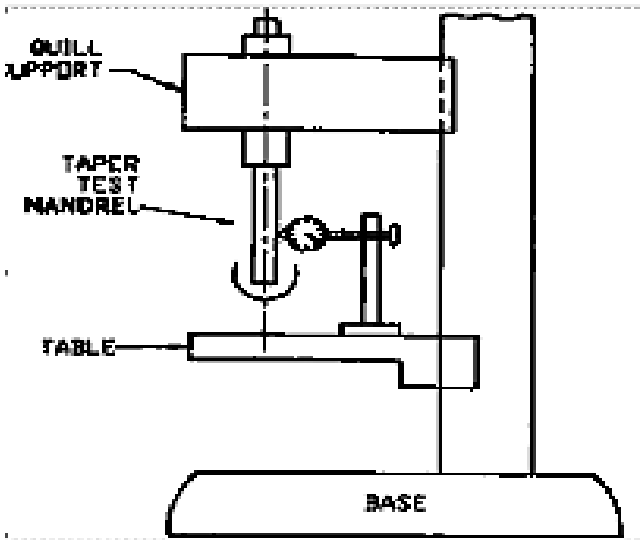

Fig.3.21 True Running of Spindle Taper

3.8.3 Parallelism of spindle axis with its vertical movement.

- In this test mandrel is attached to spindle as shown in Fig. 3.22.
- Keeping plunger in touch with mandrel, spindle is moved up and down with slow vertical feed motion. This test is performed in two mutually perpendicular planes A and B. and note the dial reading
- Permissible error for both plane A and B is 0.03 mm/100 mm.

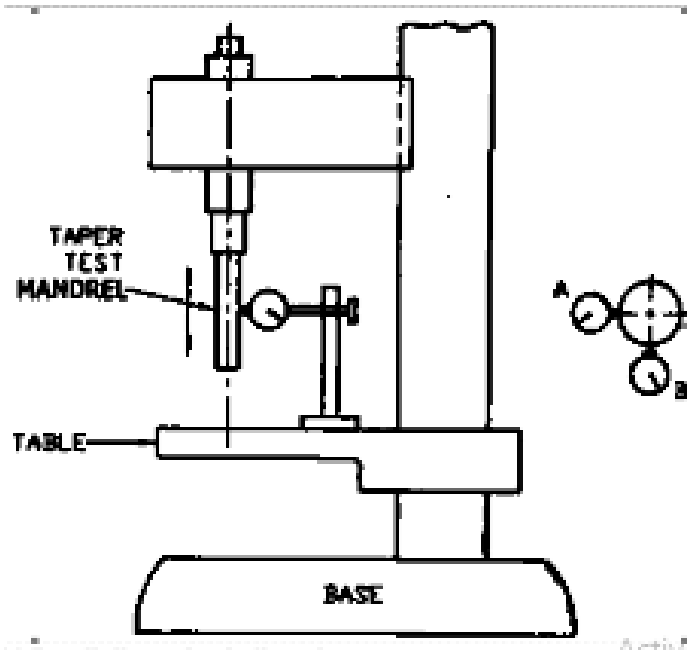

Fig.3.22 Parallelism of spindle axis with its vertical movement

3.8.4 Squareness of spindle axis with table.

- In this test dial is set as shown in fig. 3.23. Table is kept in middle of its travel and plunger of dial is ke] at position P on straight edge PQ on the table. Take the reading for position P. Then rotate the spindle throug 180° so that dial gauge is now at position Q and again take the reading
- The difference between these two reading is the error in squareness of the spindle axis with table Shift the straight edge to position RS and again take the readings Permissible error : 0.08 mm/300 mm for position PQ 0.05 mm/300 mm for position RS.

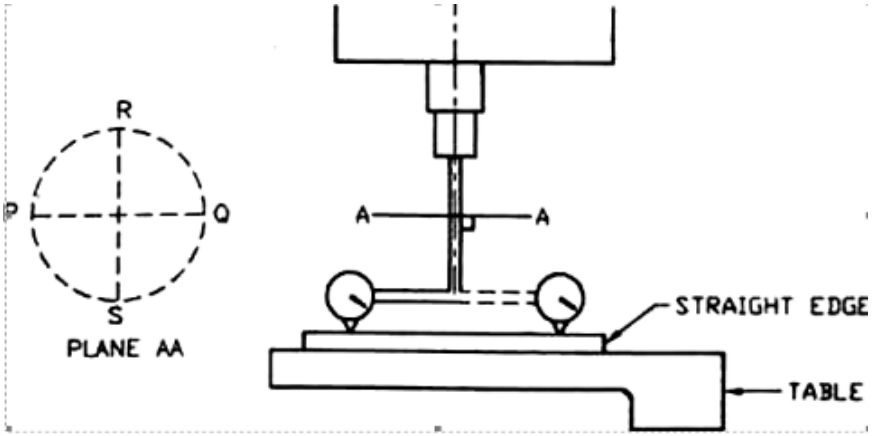

Fig.3.23 Squareness of spindle axis with table

3.9 Reference

1) R.K.Rajput,"Manufacturing Technology",Lakshmi publication (P) Ltd.
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